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Joel M. Moskowitz, Ph.D.
School of Public Health
University of California, Berkeley

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Cell Phone Radiation Exposure Limits and Engineering Solutions (ICBE-EMF review)

Héroux P, Belyaev I, Chamberlin K, Dasdag S, De Salles AAA, Rodriguez CEF, Hardell L, Kelley E, Kesari KK, Mallery-Blythe E, Melnick RL, Miller AB, Moskowitz JM, on behalf of the International Commission on the Biological Effects of Electromagnetic Fields (ICBE-EMF). Cell Phone Radiation Exposure Limits and Engineering Solutions. *International Journal of Environmental Research and Public Health*. 2023; 20(7):5398. doi: 10.3390/ijerph20075398.

Abstract

In the 1990s, the Institute of Electrical and Electronics Engineers (IEEE) restricted its risk assessment for human exposure to radiofrequency radiation (RFR) in seven ways: (1) Inappropriate focus on heat, ignoring sub-thermal effects. (2) Reliance on exposure experiments performed over very short times. (3) Overlooking time/amplitude characteristics of RFR signals. (4) Ignoring carcinogenicity, hypersensitivity, and other health conditions connected with RFR. (5) Measuring cellphone Specific Absorption Rates (SAR) at arbitrary distances from the head. (6) Averaging SAR doses at volumetric/mass scales irrelevant to health. (7) Using unrealistic simulations for cell phone SAR estimations. Low-cost software and hardware modifications are proposed here for cellular phone RFR exposure mitigation: (1) inhibiting RFR emissions in contact with the body, (2) use of antenna patterns reducing the Percent of Power absorbed in the Head (PPHead) and body and increasing the Percent of Power Radiated for communications (PPR), and (3) automated protocol-based reductions of the number of RFR emissions, their duration, or integrated dose. These inexpensive measures do not fundamentally alter cell phone functions or communications quality. A health threat is scientifically documented at many levels and acknowledged by industries. Yet mitigation of RFR exposures to users does not appear as a priority with most cell phone manufacturers.

Conclusions

Protection measures against wireless RFR exposures need considerable improvement due to the parochial positions adopted in the IEEE-ICNIRP risk assessments. The expanding modern needs for data communications

are obviously best served by established optical fiber solutions [141,142] which, in contrast to wireless, offer complete confinement, energy efficiency, and privacy.

Engineering can contemplate many technically practical solutions aimed at reducing cell phone users' RFR exposures. Software-based solutions controlling RFR emissions, as well as hardware changes to antenna designs, should not be expensive to implement, and would only mildly influence the habits of cell phone users. Although these solutions are available, it seems that in many cases, the industry has either not implemented them, or, in some cases, has even fought exposure abatements by preventing public education about RFR exposures [143,144].

The charters of professional organizations in the world, including engineering, usually state that they place human safety above all other considerations.

We firmly believe that RFR exposures to living tissues should be avoided when possible and that RFR power absorbed by the user's body is wasted and harmful to health. In all likelihood, our recommendations for cell phone alterations would improve the lifespan of both humans and batteries.

Open access paper: https://www.mdpi.com/1660-4601/20/7/5398

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Cellular and molecular effects of non-ionizing electromagnetic fields

Lai H, Levitt B. Cellular and molecular effects of non-ionizing electromagnetic fields. *Reviews on Environmental Health*. 2023. doi: 10.1515/reveh-2023-0023.

Abstract

The way that living cells respond to non-ionizing electromagnetic fields (EMF), including static/extremely-low frequency and radiofrequency electromagnetic fields, fits the pattern of 'cellular stress response' – a mechanism manifest at the cellular level intended to preserve the entire organism. It is a set pattern of cellular and molecular responses to environmental stressors, such as heat, ionizing radiation, oxidation, etc. It is triggered by cellular macromolecular damage (in proteins, lipids, and DNA) with the goal of repairing and returning cell functions to homeostasis. The pattern is independent of the type of stressor encountered. It involves cell cycle arrest, induction of specific molecular mechanisms for repair, damage removal, cell proliferation, and cell death if damage is too great. This response could be triggered by EMF-induced alternation in oxidative processes in cells. The concept that biological response to EMF is a 'cellular stress response' explains many observed effects of EMF, such as nonlinear dose- and time-dependency, increased and decreased risks of cancer and neurodegenerative diseases, enhanced nerve regeneration, and bone healing. These responses could be either detrimental or beneficial to health, depending on the duration and intensity of the exposure, as well as specific aspects of the living organism being exposed. A corollary to electromagnetic hypersensitivity syndrome (EHS) could be an inappropriate response of the hippocampus/limbic system to EMF, involving glucocorticoids on the hypothalamic-pituitary-adrenal axis.

Open access paper and 5 supplementary documents:
https://www.degruyter.com/document/doi/10.1515/reveh-2023-0023/html

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Nordic Appeal: More Stringent Regulatory Framework on Microwave Radiation from Wireless Technologies is Needed - Stop Further Rollout of 5G

Nilsson M, Hardell L, Ketti M, Wells N, Nyberg R, Halmøy S, Midelthon TJ, Glomsrød S, Schriver P. Nordic Appeal: More Stringent Regulatory Framework on Microwave Radiation from Wireless Technologies is Needed - Stop Further Rollout of 5G. Ann Clin Med Case Rep. 2023; V10(13): 1-4.

Abstract

In recent years, people's exposure to pulsed radiofrequency (RF) or microwave radiation from wireless technologies has exploded, mainly due to the roll-out of 5G. In addition to more base stations, millions of so-called smart water and electricity meters are being installed. This technology is forced upon people near or in their own homes, despite a complete lack of research showing that 5G and wireless water and electricity meters are not harmful to human health. At the same time, the first two studies to date on the effects of 5G have shown that 5G base stations cause adverse health effects in humans and that radiation similar to 5G damages neurons in the brain in animal experiments. The brain damage observed could eventually lead to Alzheimer's and other neurological diseases. In parallel with this explosion in radiation exposure, guidelines for permissible radiation are still being applied based on a seriously outdated approach. These guidelines only protect humans from harmful effects resulting from extreme intensive exposure that causes acute warming of the body. This means that people are completely unprotected from a range of harmful effects, such as cancer, DNA damage, oxidative stress and neurological effects that the science has repeatedly shown occur at levels well below these guidelines. They offer no protection whatsoever against harmful effects on biodiversity. Given what is known today about the risks of this technology, it must be considered a violation of human rights to impose this harmful radiation on people in their own homes without their informed consent. More stringent regulatory framework on microwave radiation from wireless technologies is urgently needed. In the meantime, further rollout of 5G must be stopped.

Conclusion

There is now clear evidence that the ICNIRP guidelines [13,14] are not adequate scientific basis for the protection of health and the environment for exposure to RF radiation. Not only heating (thermal) but also non-thermal effects need to be taken into account in risk evaluation. RF radiation not only causes tissue heating, as ICNIRP claims, but many other serious biological effects far below ICNIRP's tissue heating thresholds. New policy must consider long term total radiation and signal complexity including aggregations of pulses [18], and taking full account of long term, non-thermal harmful effects. For a sound scientific evaluation, a new committee comprised of qualified scientists independent of industry is urgently needed.

Open access paper: https://acmcasereport.com/pdf/ACMCR-v10-1909.pdf

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The need for consensus guidelines to address the mixed legacy of genetic damage assessments for radiofrequency fields

Vijayalaxmi, Foster KR. The need for consensus guidelines to address the mixed legacy of genetic damage assessments for radiofrequency fields. Int J Radiat Biol. 2023 Apr 10:1-11. doi: 10.1080/09553002.2023.2188936.

Abstract

Purpose: This review considers issues related to interpreting the mixed legacy of >300 papers published during the past three decades on possible genotoxic effects of exposure of human and animal tissues to radiofrequency electromagnetic fields (RF-EMF). The main paper reviews the evolution of consensus guidelines for genotoxicity testing and the increasing emphasis on systematic reviews for evaluation of scientific studies for use in health risk assessments. An Appendix considers some issues in assessing the bioeffects literature by examining a subset of genotoxicity publications that employed the comet assay. While most studies found no statistically significant effects of exposure, a significant minority of studies (chiefly, in vivo studies) reported statistically significant effects of exposure. The quality of the studies was highly variable; while several studies were meticulously done and documented, none of these studies were compliant with currently accepted guidelines such as those of the Organization for Economic Cooperation and Development (OECD). Evaluation of the studies using risk of bias (RoB) criteria showed that, in this sample of studies, higher quality studies were less likely to find statistically significant results than those of lower quality.

Conclusion: The authors conclude that statistical significance should be only one consideration in evaluation of bioeffects studies. Simply listing 'statistically' significant effects identified using null hypothesis testing and the criterion $p < 0.05$ for statistical significance is misleading and uninformative in assessing health risks of exposure. A careful synthesis of evidence is needed, including assessment of study validity, biological significance of reported effects, and coherence of study results with those of other related studies.The authors recommend that all future RF genotoxicity studies intended for use in human health risk assessments and evaluations of the literature should be done in compliance with accepted quality guidelines, i.e. OECD or equivalent guidelines for genotoxicity screening studies and PRISMA or other accepted guideline for reviews of the literature. The positive studies in this group should be redone with tighter quality control to establish the reliability of the findings.

https://pubmed.ncbi.nlm.nih.gov/37036431/

Excerpts

From 1990 to 2020, more than 300 genetic damage studies have been reported (Table1) and the literature has been repeatedly reviewed (Table 2).This work, by many investigators in many different coun-tries, has led to an extensive but highly inconsistent body of studies, both with respect to quality of studies and the results themselves....

Reviews that evaluated the strength of evidence for genotoxic effects of RF-EMF and considered study validity and consistency of results across studies have found the evidence for genotoxic effects of RFexposure at‘nonthermal’ (not producing damaging heating) levels of exposure to be mixed and overall unpersuasive

(Brusick et al.1998; Verschaeve and Maes1998; Vijayalaxmi and Prihoda 2008, 2012, 2019; Verschaeve 2009; Verschaeve et al. 2010). Other, less critical, reviews have concluded that RF-EMF exposure causes genetic damage (Ruediger 2009; Lai 2021) (Table 3)....

Many or most RF-EMF genotoxicity studies reported to date have generally followed protocols published in scientific papers, but lacked the rigorous quality control measures that are typically employed in studies done for regulatory pur-poses. In recent years, largely after the reviews cited inTable 3were completed, the standards for conduct and evaluation of science have been raised, particularly for stud-ies to be considered in health risk assessments....

Much of the public debate about safety of RF-EMF energy turns on the many reports of statistically significant effect of exposure. Indeed, a large fraction if not the majority of all RF bioeffects studies report statistically significant effects of exposure over all frequency ranges and exposure levels examined, which gives the impression of biological activity of RF-EMF at all frequencies and exposure levels.Most of these reported effects were identified using null hypothesis significance testing (NHST) and the criterion $p<0.05$ - despite repeated warnings by statisticians of the limitations of this approach for scientific inferences (Wasserstein and Lazar 2016)....

In contrast to some commentators on the RF-EMF literature that list many statistically significant results of RF-EMF bioef-fects studies, expert groups have stressed the need to go beyond statistical significance and synthesize and critically review the evidence. For example, the [European Commission] Scientific Committee on Health, Environmental and EmergingRisks (SCHEER 2018) outlines key issues to be evaluated when reviewing the literature. These include

- Characterization of the stressor
- Soundness and appropriateness of the methodology and models
- Extent to which the full details of methodology are provided
- Reproducibility of findings between experiments/observations
- Relevance of a set of data for a particular endpoint.

For genotoxic screening studies, OECD guidelines provide much more detailed advice aimed at achieving these broadly stated objectives.

In 2016 the American Statistical Association published a statement that expresses the caution of statisticians about NHST and p-value (Wasserstein and Lazar 2016):

...A conclusion does not immediately become true on one side of the divide [of statistical significance] and false on the other. Researchers should bring many contextual factors intoplay to derive scientific inferences, including the design of study, the quality of the measurements, the external evidence for the phenomenon under study, and the validity of assumptions that underlie the data analysis.

The statistically significant increases in genetic damage,albeit with modest effect size, in several invivo studies is striking. Perhaps invivo studies simply present more opportunities for experimental error than invitro studies, or

perhaps something more interesting is occurring. These studies should be redone with more rigorous quality controls, i.e.complaint with OECD guidelines. There is no point in doing studies that are intended to inform health risk assessments that do not meet current standards of quality. Simply listing statistically significant results without an appropriate evaluation of study quality and synthesis of evidence across related studies is neither reliable nor informative

https://www.tandfonline.com/doi/abs/10.1080/09553002.2023.2188936?journalCode=irab20

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Impact of comorbidity on symptomatology in various types of environmental intolerance in a general Swedish and Finnish adult population

Nordin S, Köteles F, Witthöft M, Van den Bergh O, Nyback MH, Sainio M. Impact of comorbidity on symptomatology in various types of environmental intolerance in a general Swedish and Finnish adult population. Environ Res. 2023 Apr 18:115945. doi: 10.1016/j.envres.2023.115945.

Highlights

- A broad range of symptoms are reported in common types of environmental intolerance.
- Certain body system symptoms are associated with certain environmental intolerances.
- Comorbidity can explain many body system symptoms in environmental intolerance.

Abstract

Comorbidity with various health conditions is common in environmental intolerances (EIs), which restricts understanding for what symptoms that are associated with the intolerance per se. The present objectives were to study (i) prevalence of a broad range of specific symptoms in chemical, building-related, electromagnetic field- (EMF) related, and sound EI, irrespective of comorbidity, (ii) prevalence of symptoms in body systems in exclusive EIs, and (iii) increased risk of symptoms in body systems in exclusive EIs that cannot be referred to functional somatic syndromes, inflammatory diseases or mental disorders. Cross-sectional data (n = 4941) were used from two combined population-based surveys, the Västerbotten (Sweden) and Österbotten (Finland) Environmental Health Studies. Categorization of EI cases and controls were based on self-reports. Symptoms were assessed with the Environmental Hypersensitivity Symptom Inventory, and these were converted to 27 symptoms of the International Classification of Primary Care, 2nd edition, in eight chapters of body systems. The results showed, with few exceptions, that all assessed specific symptoms were significantly more prevalent in all four EIs than in referents. Although a large overlap between EIs, characteristic body system symptoms were eye and respiratory symptoms in chemical and building-related intolerance, skin symptoms in EMF-related intolerance, and general and unspecified, digestive, eye, cardiovascular, neurological, and psychological symptoms in sound intolerance. After controlling for various comorbidities, all studied body system symptoms were positively associated with chemical intolerance, fewer with sound intolerance, only one with building-related intolerance, and none with EMF-related EI. In conclusion, a broad range of symptoms are reported in all four EIs implying common mechanisms, but symptoms of certain body systems are more likely to be reported in a certain EI that cannot be explained by comorbidity.

https://pubmed.ncbi.nlm.nih.gov/37080270/

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The association between real-life markers of phone use and cognitive performance, health-related quality of life and sleep

Eeftens M, Pujol S, Klaiber A, Chopard G, Riss A, Smayra F, Flückiger B, Gehin T, Diallo K, Wiart J, Mazloum T, Mauny F, Röösli M. The association between real-life markers of phone use and cognitive performance, health-related quality of life and sleep. Environ Res. 2023 Apr 29:116011. doi: 10.1016/j.envres.2023.116011.

Abstract

Introduction: The real-life short-term implications of electromagnetic fields (RF-EMF) on cognitive performance and health-related quality of life have not been well studied. The SPUTNIC study (Study Panel on Upcoming Technologies to study Non-Ionizing radiation and Cognition) aimed to investigate possible correlations between mobile phone radiation and human health, including cognition, health-related quality of life and sleep.

Methods: Adult participants tracked various daily markers of RF-EMF exposures (cordless calls, mobile calls, and mobile screen time 4 h prior to each assessment) as well as three health outcomes over ten study days: 1) cognitive performance, 2) health-related quality of life (HRQoL), and 3) sleep duration and quality. Cognitive performance was measured through six "game-like" tests, assessing verbal and visuo-spatial performance repeatedly. HRQoL was assessed as fatigue, mood and stress on a Likert-scale (1-10). Sleep duration and efficiency was measured using activity trackers. We fitted mixed models with random intercepts per participant on cognitive, HRQoL and sleep scores. Possible time-varying confounders were assessed at daily intervals by questionnaire and used for model adjustment.

Results: A total of 121 participants ultimately took part in the SPUTNIC study, including 63 from Besancon and 58 from Basel. Self-reported wireless phone use and screen time were sporadically associated with visuo-spatial and verbal cognitive performance, compatible with chance findings. We found a small but robust significant increase in stress 0.03 (0.00-0.06; on a 1-10 Likert-scale) in relation to a 10-min increase in mobile phone screen time. Sleep duration and quality were not associated with either cordless or mobile phone calls, or with screen time.

Discussion: The study did not find associations between short-term RF-EMF markers and cognitive performance, HRQoL, or sleep duration and quality. The most consistent finding was increased stress in relation to more screen time, but no association with cordless or mobile phone call time.

https://pubmed.ncbi.nlm.nih.gov/37127107/

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Evaluation of the Genotoxic Effects of Mobile Phone Radiation Using Buccal Micronucleus Assay

Kadeh H, Saravani S, Moradi M, Alimanesh N. A Comparative Evaluation of the Genotoxic Effects of Mobile Phone Radiation Using Buccal Micronucleus Assay. J Dent (Shiraz). 2023 Mar;24(1 Suppl):118-124. doi: 10.30476/dentjods.2022.92515.1656.

Abstract

Statement of the problem: Mobile usage has increased worldwide over the past two decades. There are conflicting reports about the carcinogenic effects of cell phone radiation on the oral mucosa. Micronucleus (MN) is considered a reliable marker for genotoxic damage.

Purpose: This study aimed to identify the impact of mobile phone radiation on the MN frequency in oral mucosal cells.

Materials and method: In this descriptive-analytical study, 50 mobile phone users between the age group of 20-38 years were included. Samples were obtained from the right and left cheek mucosa of each subject (a total 100 cell samples). Every participant filled out a questionnaire about his or her cell phone usage habits. Additionally, personal information such as age, gender, and body mass index (BMI) were assessed. The Feulgen and Papanicolaou staining methods were used for staining of the cell samples. A total of 1000 cells in each sample were evaluated for MNs.

Results: The mean number of MN in exposed and non-exposed mucosa by Feulgen method was 0.71±1.13 and 0.57±1.36, respectively. Also in Papanicolaou staining, the mean number of MN in the exposed mucosa and non-exposed mucosa was 6.94±6.61 and 6.54±6.88, respectively, but these differences were not significant ($p > 0.05$). The frequency of MN in non-specific DNA staining was significantly (5- to 6-fold) higher than DNA-specific staining. We observed no statically significant differences between MN frequency according to age, gender, BMI, and other cell phone usage habits ($p > 0.05$).

Conclusion: This study showed that cell phone use does not cause genotoxic effects in the buccal mucosa in the oral cavity. Moreover, using non-specific DNA staining methods can increase the frequency of MN by more than 5- to 6-fold.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10084556/

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Statistical Characterization and Modeling of Indoor RF-EMF Down-Link Exposure

Mulugeta BA, Wang S, Ben Chikha W, Liu J, Roblin C, Wiart J. Statistical Characterization and Modeling of Indoor RF-EMF Down-Link Exposure. Sensors (Basel). 2023 Mar 29;23(7):3583. doi: 10.3390/s23073583.

Abstract

With the increasing use of wireless communication systems, assessment of exposure to radio-frequency electromagnetic field (RF-EMF) has now become very important due to the rise of public risk perception. Since people spend more than 70% of their daily time in indoor environments, including home, office, and car, the efforts devoted to indoor RF-EMF exposure assessment has also increased. However, assessment of indoor exposure to RF-EMF using a deterministic approach is challenging and time consuming task as it is affected by uncertainties due to the complexity of the indoor environment and furniture structure, existence of multiple reflection, refraction, diffraction and scattering, temporal variability of exposure, and existence of many obstructions with unknown dielectric properties. Moreover, it is also affected by the existence of uncontrolled factors that can influence the indoor RF-EMF exposure such as the constant movement of people and random movement of furniture and doors as people are working in the building. In this study, a statistical approach is utilized to characterize and model the total indoor RF-EMF down-link (DL) exposure from all cellular bands on each floor over the length of a wing since the significance of distance is very low between any two points on each floor in a wing and the variation of RF-EMF DL exposure is mainly influenced by the local indoor environment. Measurements were conducted in three buildings that are located within a few hundred meters vicinity of two base station sites supporting several cellular technologies (2G, 3G, 4G, and 5G). We apply the one-sample Kolmogorov-Smirnov test on the measurement data, and we prove that the indoor RF-EMF DL exposure on each floor over the length of a wing is a random process governed by a Gaussian distribution. We validate this proposition using leave-one-out cross validation technique. Consequently, we conclude that the indoor RF-EMF DL exposure on each floor over the length of a wing can be modeled by a Gaussian distribution and, therefore, can be characterized by the mean and the standard deviation parameters.

Conclusions

This paper analyzes the indoor RF-EMF DL exposure with outdoor cellular antennas located more than 200 m from the buildings. In the three buildings, 1176 measurements have been performed with a broadband probe at both corridors and offices on different floors. With the base station antenna far away, the exposure is well below 1% of the ICNIRP reference levels as expected.

A statistical approach has been implemented to characterize and model the indoor RF-EMF DL exposure. The measurement data were analyzed and the *p*-values of the one-sample K-S test are above 0.05. Therefore, it has been statistically proved that the indoor RF-EMF DL exposure on each floor over the length of a wing can be modeled by a Gaussian distribution when the size of the building is small compared to the distance to the base station antennas. In such case, the mean and the standard deviation characterize the RF-EMF DL exposure distribution in the indoor environment.

Finally, the result of this work can be used as a step-stone to install a global indoor RF-EMF DL exposure monitoring system in ATOS via the implementation of measurements carried out by RF sensors distributed in the buildings.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10099088/

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Large-Area Monitoring of RF EMF from Mobile Phone Base Stations and Broadcast Transmission Towers by Car-Mounted Measurements around Tokyo

Onishi T, Esaki K, Tobita K, Ikuyo M, Taki M, Watanabe S. Large-Area Monitoring of Radiofrequency Electromagnetic Field Exposure Levels from Mobile Phone Base Stations and Broadcast Transmission Towers by Car-Mounted Measurements around Tokyo. *Electronics*. 2023; 12(8):1835. https://doi.org/10.3390/electronics120818365.

Abstract

Car-mounted measurements of radiofrequency electromagnetic exposure levels were carried out in a large area around Tokyo. Prior to the electric field (E-field) measurements using a car, the effect of the car body was evaluated in an anechoic chamber. The measurements between May 2021 and February 2022 were carried out within a radius of 100 km centering on Nihonbashi, Tokyo, with a measurement distance of about 13,800 km. The measurement results were averaged in the reference area mesh (1 km^2). It was found that the E-field strengths of FM/TV frequency bands are lower than that of mobile phone base stations. It was also found that the E-field strength of only the 5G frequency band is approximately 20–30 dB lower than that of all mobile phone systems. However, note that it is possible to depend on the data traffic of 5G. The E-field strength of all bands is higher in Tokyo than in other prefectures. Additionally, repeated measurements were carried out to investigate the reproducibility of the measured E-field. The standard deviation is less than 3 dB along the same route, and a similar tendency of E-field strength by the car to the time-averaged results of spot measurements in the past was confirmed. Finally, the relationship of E-field strength with population density was investigated. It was found that the E-field strength from mobile phone base stations has a positive relationship with population density.

Open access paper: https://www.mdpi.com/2079-9292/12/8/1835

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Effects of mobile phone electromagnetic radiation on thyroid glands and hormones in *Rattus norvegicus* brain

Zufry H, Rudijanto A, Soeatmadji DW, Sakti SP, Munadi K, Sujuti H, Mintaroem K. Effects of mobile phone electromagnetic radiation on thyroid glands and hormones in *Rattus norvegicus* brain: An analysis of thyroid function, reactive oxygen species, and monocarboxylate transporter 8. J Adv Pharm Technol Res 2023;14:63-8.

Abstract

The aim of this study was to investigate the effects of [GSM] mobile phone electromagnetic radiation (MP-EMR) on the thyroid glands and hormones in *Rattus norvegicus* brain in term of thyroid function, reactive oxygen species (ROS), and monocarboxylate transporter 8 (MCT8) concentration. Forty rats were divided into different groups: control (without EMR exposure), EMR1 (120-min/day exposure), EMR2 (150-min), and EMR3 (180-min). The levels of serum thyroid stimulating hormone (TSH), thyroxine (T_4), and malondialdehyde (MDA) and brain and MCT8 were measured using enzyme-linked immunosorbent assay. One-way analysis of variance followed by the Duncan test was used to analyze the data. Our data indicated that the levels of serum TSH and T_4 in all the EMR groups were lower significant postexposure compared to the control with $P < 0.01$ (EMR1 and EMR2) and $P < 0.001$ (EMR3), suggesting hypothyroidism due to MP-EMR exposure. Increased MDA and decreased MCT8 levels were also observed following the intervention; however, the changes in both concentrations were notably

significant after being subjected to 150-min and 180-min of exposure. In conclusion, a significant reduction in TSH, T_4, and MCT8 levels indicated thyroid dysfunction due to MP-EMR exposure.

Conclusions

MP-EMR exposure at the frequency of 1800 MHz has caused significant changes in the levels of serum TSH, T4, MDA, and MCT8 concentration in the Wistar rats. The levels of TSH, T4, and MCT8 decreased in a direct proportion to the EMR exposure duration, whereas MDA levels increased along with the increase of exposure period (after 150-min and 180-min exposure). These suggest that MP exposure could affect thyroid either directly or indirectly via HPT axis.

Open access paper: https://www.japtr.org/temp/JAdvPharmTechRes14263-7004769_192727.pdf

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900 MHZ electromagnetic field exposure relieved Alzheimer's Disease-like symptoms on APP/PS1 mice

Zhi W, Zou Y, Ma L, He S, Guo Z, Zhao X, Hu X, Wang L. 900 MHZ electromagnetic field exposure relieved AD-like symptoms on APP/PS1 mice: A potential non-invasive strategy for AD treatment. Biochemical and Biophysical Research Communications. 658:97-106. 2023. doi: 10.1016/j.bbrc.2023.03.083.

Abstract

Background Evidence shows that microwaves radiation may have various biological effects on central nervous system. Role of electromagnetic fields in neurodegenerative diseases, especially AD, has been widely studied, but results of these studies are inconsistent. Therefore, the above effects were verified again and the mechanism was preliminarily discussed.

Methods Amyloid precursor protein (APP/PS1) and WT mice were exposed to long-term microwave radiation for 270 days (900 MHz, SAR: 0.25–1.055 W/kg, 2 h/day, alternately), and related indices were assessed at 90, 180 and 270 days. Cognition was evaluated by Morris water maze, Y maze and new object recognition tests. Congo red staining, immunohistochemistry and ELISA were used to analyze Aβ plaques, Aβ40 and Aβ42 content. Differentially expressed proteins in hippocampus between microwave-exposed and unexposed AD mice were identified by proteomics.

Results Spatial and working memory was improved in AD mice after long-term 900 MHz microwave exposure compared with after sham exposure. Microwave radiation (900 MHz) for 180 or 270 days did not induce Aβ plaque formation in WT mice but inhibited Aβ accumulation in the cerebral cortex and hippocampus in 2- and 5-month-old APP/PS1 mice. This effect mainly occurred in the late stage of the disease and may have been attributed to downregulation of apolipoprotein family member and SNCA expression and excitatory/inhibitory neurotransmitter rebalance in the hippocampus.

Conclusions The present results indicated that long-term microwave radiation can retard AD development and exert a beneficial effect against AD, suggesting that 900 MHz microwave exposure may be a potential therapy

for AD.

https://www.sciencedirect.com/science/article/pii/S0006291X23003832

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Teratogenic effects of radiofrequency electromagnetic radiation on the embryonic development of chick: A study on morphology and hatchability (2G and 4G study)

Augustianath T, Evans DA, Anisha GS. Teratogenic effects of radiofrequency electromagnetic radiation on the embryonic development of chick: A study on morphology and hatchability. Res Vet Sci. 2023 Apr 23;159:93-100. doi: 10.1016/j.rvsc.2023.04.015.

Abstract

The present study was aimed at studying the effects of RF-EMR in causing teratogenic changes in the embryonic development of organisms using chick embryo as a model. The fertilized eggs of the hen were incubated in a digital humidified incubator and exposed to RF-EMR from 2G and 4G mobile phones by ringing at regular time intervals. The dose of RF-EMR was varied by increasing the call duration and number of calls per day, with the lower dose being a call duration of 50 min/day and the higher dose being 90 min/day. The phone kept had a range of radiofrequency between 900 and 1800 MHz and SAR (Specific Absorption Rate) 1.355 (2G) and 1.12 (4G) watts/ kg respectively. The batch of eggs incubated without any exposure to RF-EMR was taken as control. The hatchability of 2G and 4G experimental groups were respectively, 65% and 75% at lower radiation exposure and 40% and 55% at higher radiation exposure. The teratogenic effects of RF-EMR on the morphology of chick embryos manifested as the cross beak, non-retracted yolk sac, macrocephaly, malformed legs and toes, disability in standing and balancing the body and variations in body weight, body length and beak length. The results indicate that the RF-EMR poses potential threats to the developing stages of organisms.

https://pubmed.ncbi.nlm.nih.gov/37104994/

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Biological effects of exposure to 2650 MHz electromagnetic radiation on the behavior, learning, and memory of mice

Zheng R, Zhang X, Gao Y, Gao D, Gong W, Zhang C, Dong G, Li Z. Biological effects of exposure to 2650 MHz electromagnetic radiation on the behavior, learning, and memory of mice. Brain Behav. 2023 Apr 28:e3004. doi: 10.1002/brb3.3004.

AbstractBackground: With the development of communication technology, the public is paying increasing attention to whether electromagnetic radiation is harmful to health. Mobile phone communication has entered the 5G era, and there are almost no reports on electromagnetic radiation at 2650 MHz. Therefore, it is necessary to evaluate the risk of adverse effects of 5G mobile phone EMR exposure on the human brain.

Methods: Male animals were continuously exposed to 2650 MHz-EMR for 28 days with a whole-body averaged specific absorption rate (WBSAR) of 2.06 W/kg for 4 h per day. Mouse behavior was assessed using the open-field test (OFT), elevated-plus maze (EPM), and tail suspension test (TST). The Morris water maze (MWM), HE staining, and TUNEL staining were used to evaluate the spatial memory ability and pathological morphology of hippocampal dentate gyrus cells. Additionally, the expression levels of brain-derived neurotrophic factor (BDNF), aminobutyric acid (GABA), and glucocorticoid (GR) in the hippocampus were detected by western blotting and immunohistochemistry, while the corticosterone (CORT) level in serum was detected by ELISA.

Results: In the OFT, the total distance traveled, central distance traveled, and residence time significantly decreased in the EMR exposure group ($p < .05$). In EPM, the percentage of the number of times to open the arm and the percentage of time to open the arm significantly decreased in the EMR exposure group. However, in the TST, the two groups had no significant difference in the 4-min immobility time. In the MWM, the escape latency of the EMR exposure group was shorter than that of the control group, with no significant difference. Furthermore, CORT levels in serum were significantly increased in the EMR exposure group ($p < .05$), while the expression of BDNF and GR proteins in the hippocampus was reduced ($p < .05$), but there was no significant difference in GABA expression.

Conclusions: Our results indicate that exposure to 2650 MHz-EMR (WBSAR: 2.06 W/kg, 28 days, 4 h per day) had no significant effect on the spatial memory ability of mice (in comparison to little effect). The exposure may be associated with anxiety-like behavior in mice but not related to depression-like behavior in mice.

Open access paper: https://onlinelibrary.wiley.com/doi/10.1002/brb3.3004

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Myrtenal improves memory deficits in mice exposed to radiofrequency radiation during gestational & neonatal development *via* enhancing oxido-inflammatory, and neurotransmitter functions

Akefe IO, Nyan ES, Adegoke VA, Lamidi IY, Ameh MP, Chidiebere U, Ubah SA, Ajayi IE. Myrtenal improves memory deficits in mice exposed to radiofrequency-electromagnetic radiation during gestational and neonatal development *via* enhancing oxido-inflammatory, and neurotransmitter functions. Heliyon. 2023 Apr 8;9(4):e15321. doi: 10.1016/j.heliyon.2023.e15321

Abstract

Objective: Radiofrequency-electromagnetic radiation (RF-EMR) exposure during gestational and neonatal development may interact with the foetus and neonate considered hypersensitive to RF-EMR, consequently resulting in developmental defects associated with neuropsychological and neurobehavioral disorders, including learning and memory impairment. This study assessed the potential of Myrtenal (Myrt) to improve memory deficits in C57BL/6 mice exposed to RF-EMR during gestational and neonatal development.

Method: Thirty-five male mice were randomly allocated into 5 cohorts, each comprising of 7 mice. Group I was administered vehicle, Group II: RF-EMR (900 MHz); Group III: RF-EMR (900 MHz) + 100 mg/kg Myrt; Group IV:

RF-EMR (900 MHz) + 200 mg/kg Myrt; and Group V: RF-EMR (900 MHz) + donepezil 0.5 mg/kg.

Results: Myrt treatment improved short-term memory performance in RF-EMR (900 MHz)-exposed mice by augmenting activities of endogenous antioxidant enzymes and proinflammatory cytokines, thereby protecting the brain from oxido-inflammatory stress. Additionally, Myrt restored the homeostasis of neurotransmitters in RF-EMR-exposed animals.

Conclusion: Results from the present study shows that exposure to RF-EMR impaired short-term memory in animals and altered the response of markers of oxido-inflammatory stress, and neurotransmitters. It is therefore conceivable that the recommendation of Myrt-enriched fruits may offer protective benefits for foeti and neonates prone to RF-EMR exposure.

https://pubmed.ncbi.nlm.nih.gov/37123912/

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3.5 GHz radiofrequency radiation may affect biomechanics of bone and muscle of diabetics

Bektas H, Dasdag S, Nalbant A, Akdag MB, Demir C, Kavak S. 3.5 GHz radiofrequency radiation may affect biomechanics of bone and muscle of diabetics. Biotechnology & Biotechnological Equipment, 37:1, 2023. doi: 10.1080/13102818.2023.2199096.

Abstract

With the developments in wireless technologies, living beings are increasingly exposed to electromagnetic fields (EMFs). EMFs are known to affect bone metabolism and muscle tissue. However, their effects on bones and skeletal muscles are controversial, as some studies have reported positive effects while others have reported adverse effects. In this study, the effects of radiofrequency radiation (RFR) on bone biomechanics and skeletal muscle tissues were investigated in diabetic and healthy rats. Rats were exposed to 3.5 GHz RFR for 2 h per day for 30 days. Bone biomechanics measurements were taken to evaluate the effects of RFR on bone quality, flexibility and durability. The whole-body specific absorption rate (SAR) was found to be 37 mW/kg. The results showed that RFR exposure had adverse effects on bone biomechanics, including decreased elasticity coefficient and Young's modulus, increased maximum displacement and decreased maximum force. However, oxidative stress parameters in diabetics were also altered by 3.5 GHz RFR to a greater extent than in healthy rats. In conclusion, 3.5 GHz RFR may have potential to alter bone quality and structural integrity including muscle oxidative stress parameters in rats. It should be emphasized that the observed changes were more obvious in diabetic rats. In addition, the changes observed in healthy and diabetic rats exposed to RFR showed a statistically significant difference according to the sham groups.

https://www.tandfonline.com/doi/full/10.1080/13102818.2023.2199096

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Physiological and Psychological Stress of Microwave Radiation-Induced Cardiac Injury in Rats

Li D, Xu X, Yin Y, Yao B, Dong J, Zhao L, Wang H, Wang H, Zhang J, Peng R. Physiological and Psychological Stress of Microwave Radiation-Induced Cardiac Injury in Rats. Int J Mol Sci. 2023 Mar 25;24(7):6237. doi: 10.3390/ijms24076237.

Abstract

Electromagnetic waves are widely used in both military and civilian fields, which could cause long-term and high-power exposure to certain populations and may pose a health hazard. The aim of this study was to simulate the long-term and high-power working environment of workers using special electromagnetic radiation occupations to clarify the radiation-induced stress response and cardiac damage and thus gain insights into the mechanisms of injuries caused by electromagnetic radiation. In this study, the combination of microwave and stress was an innovative point, aiming to broaden the research direction with regard to the effect and mechanism of cardiac injury caused by radiation. The myocardial structure was observed by optical and transmission electron microscope, mitochondrial function was detected by flow cytometry, oxidative-stress markers were detected by microplate reader, serum stress hormone was detected by radioimmunoassay, and heart rate variability (HRV) was analyzed by multichannel-physiological recorder. The rats were weighed and subjected to an open field experiment. Western blot (WB) and immunofluorescence (IF) were used to detect the expressions and distributions of JNK (c-Jun N-terminal kinase), p-JNK (phosphorylated c-Jun N-terminal kinase), HSF1 (heat shock factor), and NFATc4 (nuclear factor of activated T-cell 4). This study found that radiation could lead to the disorganization, fragmentation, and dissolution of myocardial fibers, severe mitochondrial cavitation, mitochondrial dysfunction, oxidative-stress injury in myocardium, increase to stress hormone in serum, significant changes in HRV, and a slow gain in weight. The open field experiment indicated that the rats experienced anxiety and depression and had decreased exercise capacity after radiation. The expressions of JNK, p-JNK, HSF1, and NFATc4 in myocardial tissue were all increased. The above results suggested that 30 mW/cm^2 of S-band microwave radiation for 35 min could cause both physiological and psychological stress damage in rats; the damage was related to the activation of the JNK pathway, which provided new ideas for research on protection from radiation.

Excerpt

To sum up, electromagnetism is used for long-term and high-power applications in communication, medical, and military fields, and the modeling conditions designed in this experiment were designed to simulate the long-term working environment of special electromagnetic occupational groups, expecting to provide new ideas for research on protection. After 35 min of long-term exposure, rats showed an increase in serum hormone, myocardial structural damage, abnormal HRV, myocardial mitochondrial dysfunction, and oxidative-stress damage. The above results demonstrated that physiological stress injury occurred in this model; the psychological stress in this model animal was confirmed by the results of weight and the open field experiment simultaneously; and the mechanism of cardiac injury caused by electromagnetic radiation might be closely related to the activation of JNK pathway. We have plotted the results of this study in Figure 18.

Therefore, this study, from the perspective of stress, investigated the relationship between stress and changes in cardiac structure and function after electromagnetic radiation, and then explored its possible mechanism of

injury, which expanded a new orientation for the study of effects in the field, and contributed to providing a new target for protection from radiation. Our study suggested that the cause of cardiac injury from long-term and high-power microwave radiation might be the result of a combination of the thermal and non-thermal effects; therefore, the possibility of cardiac injury from microwaves should be minimized in certain special occupational groups involved in the above environment by shortening the length of a single exposure or extending the interval between exposures as much as possible. In addition, in the study of early warning functional indicators, heart rate variability should be used as a breakthrough with clinical interface for in-depth validation in order to promote application.

Open access paper: https://www.mdpi.com/1422-0067/24/7/6237

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Non-thermal disruption of β-adrenergic receptor-activated Ca^{2+} signalling and apoptosis in human ES-derived cardiomyocytes by microwave electric fields at 2.4 GHz

Williams CF, Hather C, Conteh JS, Zhang J, Popa RG, Owen AW, Jonas CL, Choi H, Daniel RM, Lloyd D, Porch A, George CH. Non-thermal disruption of β-adrenergic receptor-activated Ca2+ signalling and apoptosis in human ES-derived cardiomyocytes by microwave electric fields at 2.4 GHz. Biochem Biophys Res Commun. 2023 Apr 17;661:89-98. doi: 10.1016/j.bbrc.2023.04.038.

Highlights

Microwaves at 2.4 GHz are fundamental to today's wireless communication (e.g., 4G, WiFi).
The non-thermal effects of 2.4 GHz microwaves on biological systems are controversial.
2.4 GHz microwaves eliminated the response of human heart cells to β-AR stimulation.
Microwave-disrupted calcium signalling promoted spatially-clustered apoptosis.
The destructive effects of 2.4 GHz microwaves were mediated by non-thermal mechanisms.

Abstract

The ubiquity of wireless electronic-device connectivity has seen microwaves emerge as one of the fastest growing forms of electromagnetic exposure. A growing evidence-base refutes the claim that wireless technologies pose no risk to human health at current safety levels designed to limit thermal (heating) effects. The potential impact of non-thermal effects of microwave exposure, especially in electrically-excitable tissues (e.g., heart), remains controversial. We exposed human embryonic stem-cell derived cardiomyocytes (CM), under baseline and beta-adrenergic receptor (β-AR)-stimulated conditions, to microwaves at 2.4 GHz, a frequency used extensively in wireless communication (e.g., 4G, Bluetooth™ and WiFi). To control for any effect of sample heating, experiments were done in CM subjected to matched rates of direct heating or CM maintained at 37 °C. Detailed profiling of the temporal and amplitude features of Ca2+ signalling in CM under these experimental conditions was reconciled with the extent and spatial clustering of apoptosis. The data show that exposure of CM to 2.4 GHz EMF eliminated the normal Ca2+ signalling response to β-AR stimulation and

provoked spatially-clustered apoptosis. This is first evidence that non-thermal effects of 2.4 GHz microwaves might have profound effects on human CM function, responsiveness to activation, and survival.

Excerpt

To maximize the likelihood of eliciting a measurable thermal and non-thermal effect on the biological processes that modulate cellular Ca^{2+} signals, our study used microwave power levels equivalent to an absorption of approximately 3 W/g. This is more than 1000-times higher than the recommended specific absorption rate (SAR) safety threshold in Europe and the US. It is unlikely that exposure to microwaves at this power will be encountered in everyday life.

Open access paper: https://www.sciencedirect.com/science/article/pii/S0006291X23004473?via%3Dihub

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Effect of 2.45 GHz Electromagnetic Fields on Fear Memory Extinction in Male Rats

Dehghani Z, Mahdavi SM, Modarresi Chahardehi A, Mansouri V, Jahani Sherafat S. The Effect of 2.45 GHz Electromagnetic Fields on Fear Memory Extinction in Male Rats. J Lasers Med Sci. 2022 Nov 28;13:e52. doi: 10.34172/jlms.2022.52.

Abstract

Introduction: Fear memories are influenced by psychological and environmental variables. We evaluated the effect of 2.45 GHz microwave radiation on rats' fear learning and memory ability to determine the potential risks. The present study aimed to assess the impacts of corticosterone (CORT) levels on the consolidation and reconsolidation of fear conditioning memories.

Methods: The rats were evaluated in contextual fear conditioning using foot shocks in both short-term (7 days) exposure and long-term (30 days) exposure. Young male Wistar rats were continually exposed to radio frequency electromagnetic field radiation for 5-6 weeks (1 h/day) with a frequency, power density, and pulse width of 2.45 GHz, 6.0 mW/cm2, and 2 ms, respectively. Several animals housed in identical conditions without exposure to radiation were monitored.

Results: Based on the results, a significant increase and decrease in body weight and percentage of the freezing time were observed after the short-term group respectively. However, in the long term, we observed no significant difference in body weight, and the freezing time decreased substantially.

Conclusion: As CORT levels were analyzed, long-term radiation might increase stress, which was associated with significant weight loss in rats.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10082905/

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Effects of 2600 Mhz RF Radiation and Melatonin on Skin and Liver Tissue Hydroxyprolin Levels of Male Rats

Oruc S, Delen K, Yardim A, Aral BS, Kuzay D, Ceyman CM, Kaplanoglu GT. Effects of 2600 Mhz Radiofrequency Radiation and Melatonin on Skin and Liver Tissue Hydroxyprolin Levels of Male Rats. Gazi Med J 2023; 34 (2): 141-144.

Abstract

Objective: In the present study, the effect of 2600 MHz radiofrequency radiation (RFR) exposure, and melatonin treatment on skin and liver tissue hydroxyproline (Hyp) levels were evaluated.

Methods: In the study, 2600 MHz RFR application was performed by Rohde & Schwartz Radiofrequency signal generator via ETS-Lindgren horn antenna. 36 Wistar albino male rats were randomly divided into 6 groups (n = 6); Control, sham, RFR, control + Melatonin, Sham + Melatonin, RFR+ Melatonin. RFR was applied to the related groups for 30 days (5 days/week) for 30 minutes a day. Average electric field value is 21.74 V / m. Melatonin groups were subcutaneously injected with melatonin (10 mg/kg) for 30 days. At the end of the experiment, Hyp levels were measured in the skin and liver tissues.

Results: Hyp levels in skin tissue decreased significantly in RFR treated groups compared to the control and sham groups ($p < 0.05$). Also, Hyp levels in skin tissue decreased significantly in RFR + melatonin treated group compared to the control, sham and sham+melatonin groups. No changes in Hyp levels in liver tissue were determined.

Conclusion:In this study, RFR exposure leads to significant changes in skin Hyp levels but not liver tissue. This effect is thought to be due to the closer the skin tissue to the surface.

Open access paper: https://medicaljournal.gazi.edu.tr/index.php/GMJ/article/view/3069/2662

https://medicaljournal.gazi.edu.tr/index.php/GMJ/article/view/3069/2662

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Specific Absorption Rate Variability in Long Term Exposure In Vivo Experiments

Rosu G, Tuta L, Spandole-Dinu S, Catrina AM, Calborean O, Andone A, Fichte LO, Baltag O. Specific Absorption Rate Variability in Long Term Exposure In Vivo Experiments. 2023 13th International Symposium on Advanced Topics in Electrical Engineering (ATEE), Bucharest, Romania, 2023, pp. 1-7, doi: 10.1109/ATEE58038.2023.10108118.

Abstract

There is no specific methodology for exposing animals to non-ionizing electromagnetic fields, especially regarding the technical setup, the generator parameters, and the duration of exposure. The scientific literature displays a vast range of experiment designs and technical setups when scrutinized. Most studies that examine the biological effects of non-ionizing electromagnetic exposure use laboratory setups that address the

controllability aspect, therefore having strict parameters. On the other hand, the relevance of these laboratory experiments with respect to real-life exposure scenarios is reduced for the sake of controllability and replicability, differing from environmental exposure to radiofrequency radiation in real-life settings. Recent reviews indicate that real-life signals are more bioactive, meaning that the high and unpredictable variability of real-life exposure sources (represented by telecommunication devices) induce stronger biological effects. Another aspect of in vivo experiments on animals using long-term exposure is that any motion restriction induces a significant animal stress in the long run, especially for experiments lasting months or years. Therefore, long-term exposure setups must allow the free movement of laboratory animals, which only adds to its variability. One of the quality criteria imposed to in vivo animal exposure is accurate dosimetry. It is the scope of this paper to discuss the variability of the specific absorption rate in long-term exposure of in vivo experiments on animals with respect to the animal's position in the electromagnetic fields.

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=10108118&isnumber=10108087

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Effects of Power-Frequency Magnetic Field Exposure on B-Cell Differentiation From Human Hematopoietic Stem/Progenitor Cells

Takahashi M, Furuya N. Evaluation of the Effects of Power-Frequency Magnetic Field Exposure on B-Cell Differentiation From Human Hematopoietic Stem/Progenitor Cells. Bioelectromagnetics. 2023 Apr 18. doi: 10.1002/bem.22447.

Abstract

The causal relationship between exposure to power-frequency magnetic fields (MFs) and childhood leukemia has long been controversial. The most common type of childhood leukemia is acute B-lymphoblastic leukemia caused by abnormal proliferation of B cells in the early differentiation process. Here, we focused on B-cell early differentiation and aimed to evaluate the effects of exposing cells to power-frequency MF. First, we optimized an in vitro differentiation protocol of human hematopoietic stem/progenitor cells (HSPCs) to B-cell lineages. Following validation of the responsiveness of the protocol to additional stimulations and the uniformity of the experimental conditions, human HSPCs were continuously exposed to 300 mT of 50 Hz MF for 35 days of the differentiation process. These experiments were performed in a blinded manner. The percentages of myeloid or lymphoid cells and their degree of differentiation from pro-B to immature-B cells in the MF-exposed group showed no significant changes compared with those in the control group. Furthermore, the expression levels of recombination-activating gene (RAG)1 and RAG2 in the B cells were also similar to those in the control group. These results indicate that exposure to 50 Hz MF at 300 mT does not affect the human B-cell early differentiation from HSPCs.

https://pubmed.ncbi.nlm.nih.gov/37070790/

Excerpt

In conclusion, we exposed human HSPCs to 50 Hz MF at 300 mT throughout B-cell early differentiation using an optimized in vitro protocol, which has reasonable responsiveness (positive or negative) against additional

stimulations. We found that exposure to 50 Hz MF at 300 mT may not affect the human B-cell early differentiation from HSPCs and the RAG1 and RAG2 expression in B cells. Given that B-cell differentiation from hCD34+ cells is supported by hMSCs and mesenchymal cells derived from hMSCs via physical contact and production of cytokines [Ichii et al., 2010], the results of this study may also indicate that exposure to 50 Hz MF at 300 mT does not affect the abilities of hMSCs and mesenchymal cells. In conjunction with our previous report [Takahashi and Furuya, 2022], we determined the influence of 50 Hz MF on the differentiation from human mesodermal cells to B-cell lineages. These findings will be useful to draw conclusions regarding the causal relationship between exposure to power-frequency MFs and childhood leukemia. It is known that the risk for leukemogenesis in children under a preleukemic state, although clinically healthy, increases 100 times [Mori et al., 2002]. Hence, evaluation of the effects of exposure to power-frequency MFs on children under a preleukemic state becomes essential, and studying the hiPS cell line harboring the leukemia-specific fusion gene ETV6-RUNX1 [Takahashi and Yamazaki, 2019] would be useful to better understand this aspect.

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Extremely Low Frequency-Electromagnetic Fields (ELF-EMF) Can Decrease Spermatocyte Count and Motility and Change Testicular Tissue

Karbalay-Doust S, Darabyan M, Sisakht M, Haddadi G, Sotoudeh N, Haghani M, Mortazavi SMJ. Extremely Low Frequency-Electromagnetic Fields (ELF-EMF) Can Decrease Spermatocyte Count and Motility and Change Testicular Tissue. J Biomed Phys Eng. 2023 Apr 1;13(2):135-146. doi: 10.31661/jbpe.v0i0.2011-1234.

Abstract

Background: Substantial evidence indicates that exposure to extremely low frequency-electromagnetic fields (ELF-EMFs) affects male reproductive system.

Objective: The goal of this study was to evaluate the effects of long-term irradiation with ELF-EMF on sperm quality and quantity and testicular structure.

Material and methods: In this case-control study, sixty male Sprague-Dawley rats were randomly divided into six groups. Experimental groups were exposed to ELF-EMF (50 Hz EMF, 100 μT) for either 1 h/day for 52 days (Group 1), 4 h/day for 52 days (Group 3), 1 h/day for 5 days (Group 5), 4 h/day for 52 days (Group 7). Groups 2, 4, 6 and 8 were only sham exposed at durations equal to Groups 1, 3, 5 and 7, respectively.

Results: Both count and motility of sperms were significantly decreased in animals exposed to ELF-EMF (1 h/day for 52 days, 4 h/day for 52 day, and 4 h/day for 5 days) compared to the sham-exposed groups ($P<0.05$). Serum testosterone levels showed a significant decrease in the animals exposed to ELF-EMF (4 h/day for 5 days) compared to the control groups ($P<0.05$). A significant decrease was observed in the volume of the seminiferous tubules, seminiferous tubules epithelium and interstitial tissue in the animals exposed to ELF-EMF for 4 h/day for 5 days. Tubules length was also reduced by 18% in animals exposed to ELF-EMF (4 h/day for 5 days).

Conclusion: Our results show that ELF-EMF can reduce spermatocyte count and motility and is able to induce structural changes in testicular tissue.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10111108/

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Calculated residential exposure to power frequency magnetic fields for an epidemiological study in France and comparison to measurements

Deschamps F, Deambrogio V. Calculated residential exposure to power frequency magnetic fields for an epidemiological study in France and comparison to measurements. J Radiol Prot. 2023 Apr 27. doi: 10.1088/1361-6498/acd0b9.

Abstract

The GEOCAP epidemiological study of paediatric cancers in relation with various environmental factors is currently being carried out in France. Proximity to high voltage overhead lines (63-400kV) related to exposure to extremely low frequency magnetic field (ELF-MF) is one of studied factors. The study covers the mainland French territory and includes 4174 leukaemia cases and 45,000 controls recruited from 2002 to 2010. Residential exposure was calculated for 1124 subjects whose distance to power lines was small enough for their residential exposure to possibly exceed the background reference level 0.1µT. Residential exposure was calculated by modelling all the influencing spans close to the subjects' residences. At final, 371 subjects out of 1124 have a calculated exposure over 0.1µT, including 123 subjects over 0.4µT, i.e. 0.25% of the study population. These 371 calculated exposures exceeding 0.1µT have been matched to an existing database of ELF-MF measurements performed in inhabited areas crossed by power lines, and measurements were found for 206 subjects. Comparison was possible for 156 of them. After extrapolation of the measured values to match to calculation conditions, the difference between calculations and adjusted measurements was lower than 30% for 124 subjects (80%), with no clear tendency for over/under estimation. Differences higher than 30% have been analysed and explained.

https://pubmed.ncbi.nlm.nih.gov/37105165/

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Extremely Low Frequency Electric and Magnetic Fields Exposure: Survey of Recent Findings

Bonato M, Chiaramello E, Parazzini M, Gajšek P, Ravazzani P. Extremely Low Frequency Electric and Magnetic Fields Exposure: Survey of Recent Findings. *IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology*, doi: 10.1109/JERM.2023.3268555.

Abstract

Extremely Low Frequency Electric (ELF-EF) and Magnetic Field (ELF-MF) exposure is caused by different types of sources, from those related to the production, transmission, and distribution of electric currents, to technologies of common use, such as domestic appliances or electric transportation. Establishing the levels of

exposure for general public is a fundamental step in the health risk management process but could be challenging due to differences in the approaches used in different studies. The goal of this study is to present an overview of the last years research efforts (from 2015 to nowadays) about ELF-EF and MF exposure in everyday environments, considering different sources and different approaches used to assess the exposure. All ELF-EMF exposure levels were found to be below the ICNIRP guidelines for general public exposure. The higher MF levels were measured in apartments very close to built-in power transformers. Household electrical devices showed high levels of MF exposure in their proximity, but the duration of such exposure is extremely limited.

Conclusion

The observed ranges of exposure levels to ELF-EMF were coherent with the values observed in [9] about the exposure levels of general public in European countries, and all the mea- sured levels of exposure were below the ICNIRP guidelines for general public exposure [29]. Furthermore, even if the validity of the attention level of long-term time-average exposures of 0.3–0.4 μT is still deeply debated, the studies collected about personal exposure measurements showed always GM values lower than 0.4 μT. As observed in [9], higher MF exposure levels have been measured in apartments closed to built-in power transformers, and the major part of exposure to ELF and IF EMF originates from electric devices, but the duration of such exposure is extremely limited.

In [16] the authors classified the exposure of European pop- ulation to ELF-EMFs in three main classes, i.e., (i) intermittent variable partial body exposure; (ii) continuous elevated level whole body (WB) exposure and (iii) continuous low level background exposure.

This classification can be assumed to be still valid considering the findings of the studies analyzed in this work. Even with the advent of new technologies, it is still possible to classify the exposure scenarios in non-spatially uniform ELF-MF, due to sources relatively close to the exposed subject, and spatially uniform ELF-MF with high or low amplitude, depending on the distance from the sources. This type of classification, combined with the information arising from new studies focusing on ELF-EMF biological effects [85] will be useful for achieving an effective and reliable estimation of the potential health impact of exposure to ELF-EMF in incoming exposure scenarios. Future studies should be even more focused on assessing ELF-EMF exposure due to the new emerging technologies, such as electric transportation and new energy distribution systems.

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=10113779&isnumber=8000303

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Static electric field inhibits the proliferation and secretion functions of splenic lymphocytes in mice

Dong L, Wu J, Di G. Static electric field inhibits the proliferation and secretion functions of splenic lymphocytes in mice. Int J Environ Health Res. 2023 Apr 18:1-11. doi: 10.1080/09603123.2023.2202900.

Abstract

In recent years, the effects of static electric field (SEF) generated by ultra-high voltage (UHV) direct current (DC) transmission lines on health has drawn public attention. To study the effects of SEF on the spleen, mice were

exposed to 56.3 ± 1.4 kV/m SEF. Results showed that on the 28th day of SEF exposure, the contents of IL-10 and IFN-γ in the supernatant of homogenate, the proliferation levels of lymphocytes and the content of intracellular ROS decreased significantly, while the activity of SOD increased significantly. Meanwhile, the rupture of cellular membrane, the deficiency of mitochondrial cristae and the vacuolization of mitochondria appeared in lymphocytes. Analysis showed that the rupture of the cellular membrane caused the death of T lymphocytes, which would lead to the reduction of IL-10 and IFN-γ secretions. The damage of mitochondria could reduce the production of ATP and the content of ROS, which could inhibit the proliferation of splenic lymphocytes.

https://pubmed.ncbi.nlm.nih.gov/37070850/

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Exposure to a static magnetic field attenuates hepatic damage and function abnormality in obese and diabetic mice

Lv H, Wang Y, Liu J, Zhen C, Zhang X, Liu Y, Lou C, Guo H, Wei Y. Exposure to a static magnetic field attenuates hepatic damage and function abnormality in obese and diabetic mice. Biochim Biophys Acta Mol Basis Dis. 2023 Apr 26;1869(6):166719. doi: 10.1016/j.bbadis.2023.166719.

Abstract

Static magnetic fields (SMFs) exhibit significant effect on health care. However, the effect of SMF on hepatic metabolism and function in obesity and diabetes are still unknown. Liver is not only the main site for glucolipid metabolism but also the core part for iron metabolism regulation. Dysregulations of iron metabolism and redox status are risk factors for the development of hepatic injury and affect glucolipid metabolism in obesity and diabetes. Mice of HFD-induced obesity and HFD/streptozocin-induced diabetes were exposed to a moderate-intensity SMF (0.4-0.7 T, direction: upward, 4 h/day, 8 weeks). Results showed that SMF attenuated hepatic damage by decreasing inflammation and fibrosis in obese and diabetic mice. SMF had no effects on improving glucose/insulin tolerance but regulated proteins (GLUT1 and GLUT4) and genes (G6pc, Pdk4, Gys2 and Pkl) participating in glucose metabolism with phosphorylation of Akt/AMPK/GSK3β. SMF also reduced lipid droplets accumulation through decreasing Plin2 and Plin5 and regulated lipid metabolism with elevated hepatic expressions of PPARγ and C/EBPα in obese mice. In addition, SMF decreased hepatic iron deposition with lower FTH1 expression and modulated systematic iron homeostasis via BMP6-mediated regulation of hepcidin. Moreover, SMF balanced hepatic redox status with regulation on mitochondrial function and MAPKs/Nrf2/HO-1 pathway. Finally, we found that SMF activated hepatic autophagy and enhanced lipophagy by upregulating PNPLA2 expression in obese and diabetic mice. Our results demonstrated that SMF significantly ameliorated the development of hepatic injury in obese and diabetic mice by inhibiting inflammatory level, improving glycolipid metabolism, regulating iron metabolism, balancing redox level and activating autophagy.

https://pubmed.ncbi.nlm.nih.gov/37116230/

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Introducing energy into marine environments: A lab-scale static magnetic field submarine cable simulation and its effects on sperm and larval development on a reef forming serpulid

Oliva M, De Marchi L, Cuccaro A, Fumagalli G, Freitas R, Fontana N, Raugi M, Barmada S, Pretti C. Introducing energy into marine environments: A lab-scale static magnetic field submarine cable simulation and its effects on sperm and larval development on a reef forming serpulid. Environ Pollut. 2023 Apr 19;328:121625. doi: 10.1016/j.envpol.2023.121625.

Abstract

Non-chemical sources of anthropogenic environmental stress, such as artificial lights, noise and magnetic fields, are still an underestimate factor that may affect the wildlife. Marine environments are constantly subjected to these kinds of stress, especially nearby to urbanized coastal areas. In the present work, the effect of static magnetic fields, associated with submerged electric cables, was evaluated in gametes and early life stages of a serpulid polychaete, namely Ficopomatus enigmaticus. Specifically, biochemical/physiological impairments of sperm, fertilization rate inhibition and incorrect larval development were assessed. We evaluated differences between two selected magnetic field induction values (0.5 and 1 mT) along a range of exposure times (30 min-48 h), for a sound evaluation on this species. We found that a magnetic induction of 1 mT, a typical value that can be found at distance of tens of cm from a submerged cable, may be considered a biologically and ecologically relevant for sessile organisms and for coastal environments more generally. This value exerted statistically significant effects on membranes, DNA integrity, kinetic parameters and mitochondrial activity of sperm cells. Moreover, a significant reduction in fertilization rate was observed in sperm exposed to the same magnetic induction level (1 mT) for 3 h, compared to controls. Regarding early larval stages, 48-h exposure did not affect the correct development. Our results represent a starting point for a future focus of research on magnetic field effects on early life stages of aquatic invertebrates, using model species as representative for reef-forming/encrusting organisms and ecological indicators of soft sediment quality.

https://pubmed.ncbi.nlm.nih.gov/37085101/

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Power lines and birds: An overlooked threat in South America

Rebolo-Ifrán N, Plaza P, Pérez-García JM, Gamarra-Toledo V, Santander F, Lambertucci SA. Power lines and birds: An overlooked threat in South America. Perspectives in Ecology and Conservation. 21(1):71-84. 2023. doi:10.1016/j.pecon.2022.10.005.

Abstract

Power lines endanger birds around the world, as a large number of them are killed every year through electrocutions and collisions. This problem can have severe consequences at population level, particularly for threatened species. While this threat has been widely studied in different parts of the world, information from South America is scarce. Here, we review information from scientific and grey literature on the collision and electrocution of birds on power lines from this sub-continent. We complement this information with novel data provided by a citizen science project, electrical companies and field monitoring records. Our results show that although in South America scientific and anecdotal information on this topic is scarce, data suggests that this threat is present in many areas of this sub-continent and affects several species, some of which are seriously

threatened. However, information on the most affected species, the number of individuals impacted, the most dangerous geographical areas and the effectiveness of mitigation action is scarce and mainly anecdotal. This is worrying, because South America is a hot spot of biodiversity with many threatened and endemic bird species. We urge conservationists to evaluate this problem in more detail, define areas where it is important to avoid power line installation and establish priority areas for implementation of effective mitigation actions. Scientific evidence shows that dangerous power lines require retrofitting, but this knowledge should also be applied to the new energy facilities and the establishment of national regulations, which would undoubtedly reduce the impact of this infrastructure on wildlife.

https://www.sciencedirect.com/science/article/pii/S2530064422000736

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[Electromagnetic fields (EMF) in electric cars]

My note: I would be interested in seeing an English translation of this report. The exposures reported in the following English-language summary are alarming since the ICNIRP exposure limits are too lax and inadequate to protect our health.

Eberhard J, Fröhlich J, Zahner M. [Electromagnetic fields (EMF) in electric cars] Elektromagnetische Felder (EMF) in Elektrofahrzeugen. Swiss Federal Office of Energy (SFOE). 2023.

Summary

More and more battery-powered electric vehicles (e-vehicles) are being put into operation to facilitate the decarbonisation of mobility. Electric, magnetic and electromagnetic fields (EMF) are generated in and around vehicles by the electrical components of the drive, through battery charging and from other diverse electronic systems used in modern vehicles. In principle, it can be stated from a technical point of view that all vehicles generate immissions of electromagnetic fields, regardless of the type of drive. In addition to the electrical parameters of the components, the design and the materials used are significant. A feature of exposure in vehicles is that passengers may be simultaneously exposed to a large number of sources of various frequencies in a very confined space for hours at a time. One is also in a volume that is (partially) shielded by the car body and window panes coated with vapour-deposited metal.

The aim of this project was to assess, through measurements on a selection of e-vehicles, whether the additional EMF immissions from the electric drive and associated components are to be judged critically as a health risk and whether further, more in-depth clarifications are necessary.

For this purpose, extensive measurements of the occurring low-frequency and high-frequency EMFs extant under real operating conditions, including the charging process, were carried out on a small selection of series-production passenger vehicles (5 e-vehicles purely electric and battery-powered, 1 diesel-motorised vehicle for comparison) from the stock vehicle market in order to be able to assess the immissions on passengers and persons staying in the vicinity of the vehicle. Since there are currently no specific regulations for EMF in e-vehicles, the field strengths of the measured EMF were classified against internationally established limit

recommendations (ICNIRP). The total exhaustions of the limit values thus determined from all sources were rather low, on average in the range of up to 5% for low-frequency magnetic fields and up to approx. 10% for high-frequency EMF. Occasionally, higher peak readings of low-frequency magnetic fields up to approx. 50% of the limit values were found. In general, as is common with magnetic fields in general, these high values are often very localised. Moreover, due to the dynamic and complex situation in vehicles, they often occur only sporadically and, as far as they could be identified, are hardly directly related to the electric drive. The measurement results of the present study are consistent with other previous studies. Wireless power transfer (charging) was not investigated in this project.

As far as the results of this study can be generalised, the electric drive with energy drawn from a battery appears to be unproblematic with regard to additional EMF.

Regardless of the type of drive, attention must be paid to further technological development, especially with regard to the trend toward increasing networking and digitisation. One outstanding issue remains the insufficient EMF regulation for vehicle interiors.

Open access report in German: https://www.aramis.admin.ch/Default?DocumentID=70257&Load=true

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Wireless technologies, non-ionizing electromagnetic fields and children: Identifying and reducing health risks

Davis D, Birnbaum L, Ben-Ishai P, Taylor H, Sears M, Butler T, Scarato T. Wireless technologies, non-ionizing electromagnetic fields and children: Identifying and reducing health risks. Curr Probl Pediatr Adolesc Health Care. 2023. doi: 10.1016/j.cppeds.2023.101374.

Abstract

Children today are conceived and live in a sea of wireless radiation that did not exist when their parents were born. The launch of the digital age continues to transform the capacity to respond to emergencies and extend global communications. At the same time that this increasingly ubiquitous technology continues to alter the nature of commerce, medicine, transport and modern life overall, its varied and changing forms have not been evaluated for their biological or environmental impacts. Standards for evaluating radiation from numerous wireless devices were first set in 1996 to avoid heating tissue and remain unchanged since then in the U.S. and many other nations. A wide range of evidence indicates that there are numerous non-thermal effects from wireless radiation on reproduction, development, and chronic illness. Many widely used devices such as phones and tablets function as two-way microwave radios, sending and receiving various frequencies of information-carrying microwave radiation on multiple simultaneously operating antennas. Expert groups advising governments on this matter do not agree on the best approaches to be taken. The American Academy of Pediatrics recommends limited screen time for children under the age of two, but more than half of all toddlers regularly have contact with screens, often without parental engagement. Young children of parents who frequently use devices as a form of childcare can experience delays in speech acquisition and bonding, while older children report feelings of disappointment due to 'technoference'—parental distraction due to technology. Children who begin using devices early in life can become socially, psychologically and physically

addicted to the technology and experience withdrawal upon cessation. We review relevant experimental, epidemiological and clinical evidence on biological and other impacts of currently used wireless technology, including advice to include key questions at pediatric wellness checkups from infancy to young adulthood. We conclude that consistent with advice in pediatric radiology, an approach that recommends that microwave radiation exposures be As Low As Reasonably Achievable (ALARA) seems sensible and prudent, and that an independently-funded training, research and monitoring program should be carried out on the long term physical and psychological impacts of rapidly changing technological milieu, including ways to mitigate impacts through modifications in hardware and software. Current knowledge of electrohypersensitivity indicates the importance of reducing wireless exposures especially in schools and health care settings.

49 journal pages including 38 pages in the body of the paper plus 286 references.

https://pubmed.ncbi.nlm.nih.gov/36935315/

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ICNIRP Guidelines' Exposure Assessment Method for 5G Millimetre Wave Radiation May Trigger Adverse Effects

Redmayne M, Maisch DR. ICNIRP Guidelines' Exposure Assessment Method for 5G Millimetre Wave Radiation May Trigger Adverse Effects. *Int. J. Environ. Res. Public Health* **2023**, *20*, 5267. doi: 10.3390/ijerph20075267.

Abstract

The current global roll-out of 5G infrastructure is designed to utilise millimetre wave frequencies (30–300 GHz range) at data transmission rates in the order of gigabits per second (Gbps). This frequency band will be transmitted using beamforming, a new introduction in near-field exposures. The International Commission on Non-Ionising Radiation Protection (ICNIRP) has recently updated their guidelines. We briefly examine whether the new approach of the ICNIRP is satisfactory to prevent heat damage and other adverse bio-effects once millimetre wave 5G is included, and we challenge the use of surface-only exposure assessment for local exposures greater than 6 GHz in part due to possible Brillouin precursor pulse formation. However, this is relevant whether or not Brillouin precursors occur from absorption of either 5G or future G transmissions. Many significant sources conclude there is insufficient research to assure safety even from the heat perspective. To date, there has been no published in vivo, in vitro or epidemiological research using exposures to 5G New Radio beam-formed signals.

Conclusions

Surface radiofrequency exposure assessments including mmW radiation are insufficient to ensure safety; there are several reasons assessment of SA_{ab} is also needed.

A real danger of the 'expert' assurances of a lack of risk is that they discourage the necessary research to evaluate risk properly. They may also discourage review of apparently outmoded/questionable approaches being taken in RF exposure standards.

Once the 5G mmW band is internationally operational, a significant proportion of the world's population will be exposed to new hazards. The intensity and complexity of near-field exposure, such as when carrying a phone in a pocket or using it next to the head, will be different for 5G, and this is the first time mmW have been used for public telecommunications and the first time beamforming has been deliberately introduced for near-field use. Without research on the impact of near-field 5G, this global step is an experiment at the population level. Bearing this in mind, there is a vital and urgent need for targeted research and for a re-evaluation of the scientific relevance of the current RF human exposure standards' basic approach and assumptions.

Open access paper: https://www.mdpi.com/1660-4601/20/7/5267

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Relationship between radiofrequency radiation from cell phones and brain tumor incidence trends in South Korea

Moon J. The relationship between radiofrequency-electromagnetic radiation from cell phones and brain tumor: The brain tumor incidence trends in South Korea.
Environmental Research (2023). doi: 10.1016/j.envres.2023.115657.

Highlights

• Positive correlation for malignant neoplasm of cerebrum, except lobes and ventricles/the frontal lobe/the temporal lobe.

• Positive correlation for benign neoplasm of meninges/brain and other parts of the central nervous system/supratentorial brain.

• The highest correlation coefficient: malignant neoplasm of the frontal lobe/the temporal lobe.

• Cell phones: RF-EMR exposure through the frontotemporal side of the brain.

• Four reasons for statistically insignificant results of recent studies.

Abstract

Introduction The aim of this study is to investigate the relationship between the nationwide cell phone subscription rate and the nationwide incidence of brain tumors in South Korea. The nationwide cell phone subscription rate was used as a proxy for the RF-EMR exposure assessment.

Methods The data for cell phone subscriptions per 100 persons from 1985 to 2019 were found in the Statistics, International Telecom Union (ITU). The brain tumor incidence data from 1999 to 2018 provided by the South Korea Central Cancer Registry operated by the National Cancer Center were used.

Results In South Korea, the subscription rate increased from 0 per 100 persons in 1991 to 57 per 100 persons in 2000. The subscription rate became 97 per 100 persons in 2009 and 135 per 100 persons in 2019. For the correlation coefficient between cell phone subscription rate before 10 years and ASIR [Age-Standardized Incidence Rate] per 100,000, a positive correlation coefficient with a statistical significance was reported in 3

benign brain tumors (International Classification of Diseases, ICD-10 code, D32, D33, and D32.0) and in 3 malignant brain tumors (ICD-10 code, C71.0, C71.1, and C71.2). Positive correlation coefficients with a statistical significance in malignant brain tumors ranged from 0.75 (95% CI 0.46–0.90) for C71.0 to 0.85 (95% CI 0.63–0.93) for C71.1.

Discussion In consideration of the fact that the main route for RF-EMR exposure has been through the frontotemporal side of the brain (the location of both ears), the positive correlation coefficient with a statistical significance in the frontal lobe (C71.1) and temporal lobe (C71.2) can be understood. Statistically insignificant results from recent cohort and large population international studies and contrasting results from many previous case-control studies could indicate a difficulty in identifying a factor as a determinant of a disease in ecological study design.

https://pubmed.ncbi.nlm.nih.gov/36906274/

Excerpts

Numerous systematic reviews and meta-analyses on the association between Radiofrequency-Electromagnetic Radiation (RF-EMR) exposure from cell phones and the incidence of brain tumors have been published until the present time (Belpomme et al., 2018; Elwood, 2003; Morgan et al., 2015; Myung et al., 2009; Wang et al., 2018). The conclusion of each study varied depending on the magnitude of exposure, the location of brain tumors, the histologic type of brain tumors, and a number of confounding factors such as research team and funding source (Belpomme et al., 2018; Hardell et al., 2008a; Morgan et al., 2015; Wang et al., 2018)....

C70 Malignant neoplasm of meninges
C71 Malignant neoplasm of brain
C72 Malignant neoplasm of the spinal cord, cranial nerves, and other parts of the central nervous system
C70.0 Malignant neoplasm of cerebral meninges
C70.9 Malignant neoplasm of meninges, unspecified
C71.0 Malignant neoplasm of cerebrum, except lobes and ventricles
C71.1 Malignant neoplasm of the frontal lobe
C71.2 Malignant neoplasm of the temporal lobe
C71.9 Malignant neoplasm of brain, unspecified
C72.0 Malignant neoplasm of spinal cord
D32 Benign neoplasm of meninges
D33 Benign neoplasm of brain and other parts of the central nervous system
D32.0 Benign neoplasm of brain

The AAPC [Average Annual Percentage Change] for C72, C71.0, C71.1, C71.2, C72.0, D32, D33, and D32.0 was positive with statistical significance.... The AAPC for C70, C70.0, and C71.9 was negative with statistical significance.

For the correlation coefficient between cell phone subscription rate before 10 years and ASIR per 100,000, a positive correlation coefficient with a statistical significance was reported in 3 benign brain tumors (D32, D33, and D32.0) and in 3 malignant brain tumors (C71.0, C71.1 and C71.2). A negative correlation coefficient with

statistical significance was reported in 3 malignant brain tumors: C70, C70.0, and C71.9 [i.e., malignant meninges, cerebral meninges, and brain, unspecified].

Conclusion

In South Korea, for the correlation coefficient between cell phone subscription rate before 10 years and ASIR per 100,000, a positive correlation coefficient with a statistical significance was reported in 3 malignant brain tumors (C71.0, C71.1, and C71.2) [i.e., cerebrum except lobes and ventricles, frontal lobe and temporal lobe] and 3 benign brain tumors (D32, D33, and D32.0) [i.e. nonmalignant meninges, brain and other CNS, and brain, supratentorial]. Among these results, that for malignant brain tumors in the frontal lobe (C71.1) and in the temporal lobe (C71.2) is suspicious of the association with RF-EMR emitted from cellular phones. The other 4 possible hypotheses do not fit well with the observed phenomena.

Statistically insignificant results from recent cohort or large population international studies and contrasting results from many previous case-control studies might come from several issues. A statistically significant increased risk can be found if (ⅰ) a more accurate exposure assessment such as site-specific, time-integral of SAR for each individual is applied or (ⅱ) massive populations over 100,000 are studied.

https://www.sciencedirect.com/science/article/pii/S0013935123004498

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Editorial: Experts' opinions in radiation and health: Emerging issues in the field

Leszczynski D (2023) Editorial: Experts' opinions in radiation and health: Emerging issues in the field. *Front. Public Health* 11:1168971. doi: 10.3389/fpubh.2023.1168971.

No abstract

Open access paper: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1168971/full

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Theta band brainwaves in human resting EEG modulated by mobile phone radiofrequency

Wallace J, Shang W, Gitton C, Hugueville L, Yahia-Cherif L, Selmaoui B. Theta band brainwaves in human resting EEG modulated by mobile phone radiofrequency. Int J Radiat Biol. 2023 Mar 9:1-9. doi: 10.1080/09553002.2023.2187477.

Abstract

Purpose: Wireless communication has become an integral part of our lives. The growing number of antennas in our environment and the expanding use of mobile phones (MPs) are increasing the population's exposure to electromagnetic fields. The present study aimed to examine the potential impact of MPs radiofrequency electromagnetic fields (RF-EMF) exposure on the brainwaves of the resting electroencephalogram (EEG) in humans.

Materials and methods: Twenty-one healthy volunteers were exposed to Global System for Mobile communications (GSM) signal at 900 MHz MP RF-EMF. The maximum specific absorption rate (SAR) of the MP averaged on 10 g tissue and 1 g tissue were measured at 0.49 W/kg, 0.70 W/kg, respectively.

Results: Results showed that while delta and beta rhythms of resting EEG were not affected, theta brainwaves were significantly modulated during exposure to RF-EMF related to MPs. For the first time, it was shown that this modulation is dependent on the eye condition, i.e. closed or open.

Conclusions: This study strongly suggests that acute exposure to RF-EMF alters the EEG theta rhythm at rest. Long-term exposure studies are required to explore the effect of this disruption in high-risk or sensitive populations.

https://pubmed.ncbi.nlm.nih.gov/36867417

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A Data-Science Approach for Creation of a Comprehensive Model to Assess the Impact of Mobile Technologies on Humans

Garvanova M, Garvanov I, Jotsov V, Razaque A, Alotaibi B, Alotaibi M, Borissova D. A Data-Science Approach for Creation of a Comprehensive Model to Assess the Impact of Mobile Technologies on Humans. *Applied Sciences*. 2023; 13(6):3600. https://doi.org/10.3390/app13063600.

Abstract

Mobile technologies are an essential part of people's everyday lives since they are utilized for a variety of purposes, such as communication, entertainment, commerce, and education. However, when these gadgets are misused, the human body is exposed to continuous radiation from the electromagnetic field created by them. The communication services available are improving as mobile technologies advance; however, the problem is becoming more severe as the frequency range of mobile devices expands. To solve this complex case, it is necessary to propose a comprehensive approach that combines and processes data obtained from different types of research and sources of information, such as thermal imaging, electroencephalograms, computer models, and surveys. In the present article, a complex model for the processing and analysis of heterogeneous data is proposed based on mathematical and statistical methods in order to study the problem of electromagnetic radiation from mobile devices in-depth. Data science selection/preprocessing is one of the most important aspects of data and knowledge processing aiming at successful and effective analysis and data fusion from many sources. Special types of logic-based binding and pointing constraints are considered for data/knowledge selection applications. The proposed logic-based statistical modeling method provides both algorithmic as well as data-driven realizations that can be evolutionary. As a result, non-anticipated and collateral data/features can be processed if their role in the selected/constrained area is significant. In this research, the data-driven part does not use artificial neural networks; however, this combination was successfully applied in the past. It is an independent subsystem maintaining control of both the statistical and machine-learning parts. The proposed modeling applies to a wide range of reasoning/smart systems.

Conclusions

We developed a novel data-science technique to identify the detrimental impacts of electromagnetic radiation from mobile devices on the human body. The proposed method for analyzing heterogeneous data is based on mathematical and statistical methodologies (thermal imaging and electroencephalograms). The proposed solution combines the ANOVA statistical method with deep modeling and rapid preprocessing approaches, such as binding/pointing/crossword constraints. Several tests were conducted utilizing the Pwelch function of MATLAB software, both with and without a mobile device. Each experiment was 30 min long.

The resulting signals were filtered and classified into four frequency ranges: delta (1–4 Hz), theta (4–8 Hz), alpha (8–13 Hz), and beta (13–32 Hz). The accuracy was determined for each frequency range with and without a mobile device based on the collected signals. The findings demonstrate that the emission of electromagnetic radiation from mobile devices has an effect on the signal frequency range accuracy. The presence of irradiation leads to an increase in the amplitude of brain signals in different frequency ranges. Furthermore, the results show that improved accuracy was reached without the use of a mobile device for each frequency band.

The proposed approach has limitations because it increases the computational complexity due to obtaining heterogeneous data. However, this issue can be resolved using a data-mining approach. In the future, different Quality-of-Service parameters (e.g., energy consumption, time complexity, and reliability) will be examined in the future. Furthermore, the proposed approach will also be compared to state-of-the-art approaches: IoT based mobile monitoring framework for hyper-local PM2 [1], and cognitive emotion pre-occupation method [38].

Open access paper: https://www.mdpi.com/2076-3417/13/6/3600/htm

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Effect of Electromagnetic Radiation from Mobile Phones on Auditory Brainstem Response

Varshney S, Angral S, Aggarwal P *et al.* Effect of Electromagnetic Radiation from Mobile Phones on Auditory Brainstem Response. *Indian J Otolaryngol Head Neck Surg* (2023). doi-org: 10.1007/s12070-022-03384-8.

Abstract

Mobile phones are being used by around 70% of the global population. A simple non-invasive procedure to detect early impairment of the acoustic nerve and auditory pathway is by auditory brainstem response (ABR). It's a response to the sound stimulus generated from the brainstem in the form of electrical impulses. To determine the effect of long-term usage of mobile phones on auditory brainstem responses (ABRs). This Epidemiological, cross-sectional study was undertaken at a tertiary care hospital and includes 865 individuals aged between 18 to 45 years using mobile phone for > 2 years. Users were categorized into various groups according to the minutes of mobile usage per day, years of mobile usage and total duration of mobile phone use in dominant (mobile using) and non-Dominant (non-mobile using) ears. The changes in ABR were studied in each ear to ascertain the effect of EMF exposure due to chronic mobile phone use. Mean age of subjects was 27.01 years. (M: F = 1.57:1.0). Range of mobile phone usage was from 4 to 900 min/day, with mean as 85.94 min/day. No significant differences were seen between dominant and non-dominant ears in regard to amplitudes of wave I, III and V, latencies of wave I and V and Inter peak latency (IPL) of wave I–III, III–V and I–V.

No statistically significant difference for I–III, III–V and I–V IPL were found b/w two groups/ears except for usage of mobile phone for > 180 min/day in wave I–V, usage for 0–4 years in wave I–III and I–V and net hours usage for > 1500 h in wave I–V. The mean IPL in all the waves increases with the increase in years of mobile usage and is maximum in all waves in > 12 years mobile users. The long-term exposure to EMF does induce measurable changes in ABRs. Amplitude and IPLs of ABR were found comparable between the dominant and non-dominant ears using mobile phones, except for those using mobile usage for > 180 min/day and with increasing years of usage of mobile phone. Therefore, prudent use of mobile phone should be encouraged for a shorter period of time and for essential purpose only.

Conclusion

Amplitude and inter wave latencies of ABR were found comparable between the dominant and non-dominant ears using mobile phones, except for maximum prolongation in IPL Wave I–III (m sec) and significant increase latencies in both ears on mobile usage of > 180 min and with increasing years of usage of mobile phone. The results of the present study may appear comforting in terms of the effects of mobile telephones on auditory pathway, this does not mean that the use of mobile phone should be encouraged. Individuals who use mobiles for longer duration (both daily and cumulative) are more prone for earlier otological disturbances as they are exposed to the EMRs to the maximum

https://link.springer.com/article/10.1007/s12070-022-03384-8

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Exposures to radio-frequency electromagnetic fields and their impacts on children's health – What the science knows?

Lim H, Choi J, Joo H, Ha M. Exposures to radio-frequency electromagnetic fields and their impacts on children's health – What the science knows? Current Opinion in Environmental Science & Health. Volume 32, 2023, 100456. doi: 10.1016/j.coesh.2023.100456.

Highlights

• We mainly reviewed epidemiological studies of the health effects of radiofrequency electromagnetic radiation on children.

• We could not find a consistent health effect of children in association with the exposure.

• The qualities of the epidemiological studies are mostly low to moderate levels in the risk-of-bias assessment.

• The current studies do not provide sufficient evidence to determine the adverse effects.

• Improved exposure assessment, causal study design and analytical models are needed for high-quality scientific evidence.

Abstract

The possible health effects of radiofrequency electromagnetic radiation on children have become a public concern due to biological vulnerability of developing children. To evaluate the evidence for possible adverse health effects on children, we systematically reviewed epidemiological studies, and briefly reviewed the experimental animal or mechanistic studies. Using a search strategy and risk-of-bias assessment, we summarized the existing data on cancer, birth outcome, neurocognitive development, and behavioral problems. There was no sufficient evidence to determine the adverse effects. Recent large-scale animal studies have shown carcinogenic findings, but the biological mechanism has not yet been elucidated. A well-designed future study is needed to produce high-quality scientific evidence of the possible harmful effects of radiofrequency electromagnetic radiation exposure in children.

<snip>

Discussion

We systematically reviewed 49 epidemiological studies and briefly reviewed an additional 5 epidemiological and 15 animal and mechanistic studies. There was less evidence for the prenatal exposure effects on neurocognitive development while more evidence was reported on behavioral problems. Postnatal exposure than prenatal showed more evidence for effects both on neurocognition or behavior. Fetal exposure did not show a definite effect on birth outcomes. Far- or near-field exposure to RF showed no evidence for carcinogenic effect on children.

However, the effect of postnatal exposure on the neurocognition and behavior of children should be cautiously interpreted due to the possibility of reverse causality. Behavioral characteristics may associate with the usage of mobile phones or any other IT devices. Furthermore, sleep deprivation and depressive moods by mobile phone usage in children may be another pathway to resulting behavioral problems.

Of several birth outcomes, shortened pregnancy duration was significantly associated with increased maternal mobile phone use. However, this finding should be interpreted with caution owing to the difficulties in disentangling the effects of RF-EMF exposure and maternal physical activity/behavioral factors, such as child-raising characteristics, caused by mobile phone usage. The same caution also should be applied to the results indicating an effect of prenatal exposure on the neurocognitive development and behavior of children. We did not find clear evidence to determine whether RF-EMF exposure affects children's health outcomes. The quality of the epidemiological studies is mostly low to moderate, and the direction and size of effect estimates are inconsistent.

We found that few studies have been assessed as high quality (low RoB) (Table 1). This is mostly due to the exposure assessment (Table S4). RF-EMF exposure has been assessed using proxy exposure variables for the use of electronic devices, mainly mobile phone use, or distance from mobile communication base stations. This type of exposure assessment may cause a nondifferential misclassification which leads the association toward the null.

Despite the remaining ambiguity of the biological mechanism, recent animal studies showing consistent

carcinogenic findings have driven more epidemiological studies, repetition of animal studies, and mechanistic studies, with higher levels of quality.

Conclusions

The current studies examining the possible association between RF-EMF exposure and children's health do not provide conclusive evidence. The results should be interpreted with caution due to the possibility of reverse causality, confounding or mediation of behavioral/environmental factors, and exposure misclassification.

Above all, in the epidemiological research, the accuracy of personal RF-EMF exposure assessment needs to be improved. A recent systematic review on the health effects of RF-EMFexposure in children and adolescents also recommended high-quality research [76]. Furthermore, advanced study design or analysis method that mimic a counter-factual model or randomization and strengthen causal inference, such as instrumental variable analysis, difference-in-differences analysis, and causal mediation analysis, are warranted.

Moreover, we suggest designing a census-based cohort that incorporates data from telecommunication operators. This would be relatively free from the recall and measurement biases of exposure, and exposure history can be profiled in detail. A sufficient statistical power with a large sample size would reveal the relatively small effect of RF-EMF from other competing risk factors, and be effective in the modeling to control confounding or modifying factors, such as restriction or stratified analysis. With the ongoing development of next-generation mobile communication, RF-EMF exposure is expected to increase in the general population. A well-designed future study is needed to produce high-quality scientific evidence of the possible harmful effects of RF-EMF exposure in children.

https://www.sciencedirect.com/science/article/pii/S2468584423000168

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Relationship between parental exposure to RF EMF and hematopoietic neoplasms (lymphoma, leukemia) and tumors in the central nervous system in children: a systematic review

Morales-Suárez-Varela M, Llopis-Morales A, Doccioli C, Donzelli G. Relationship between parental exposure to radiofrequency electromagnetic fields and primarily hematopoietic neoplasms (lymphoma, leukemia) and tumors in the central nervous system in children: a systematic review. Rev Environ Health. 2023 Mar 22. doi: 10.1515/reveh-2022-0248.

Abstract

Low-frequency electromagnetic fields have grown exponentially in recent years due to technological development and modernization. The World Health Organization (WHO)/International Agency for Research on Cancer (IARC) has classified radiofrequency electromagnetic fields (RF-EMFs) as possibly carcinogenic to humans (Group 2B), and recent studies have investigated the association between exposure to electromagnetic fields in parents and possible health effects in children, especially the development of tumours of the central nervous system (CNS). The objective of this systematic review was to collate all evidence on the relationship between parental occupational exposure to electromagnetic fields and the development of CNS cancer in children and to

evaluate this association. This review was prepared according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. PubMed, Embase, and Web of Science were searched from January 1990 to April 2021. The search was conducted using the following search string: "occupational" AND "child" AND "electromagnetic" AND "cancer". Seventeen articles met our inclusion criteria: 13 case-control studies, two cohort studies, and 2 meta-analyses. Most of the studies showed several methodological weaknesses that limited their results. Due to a lack of consistency regarding the outcome as well as the heterogeneity in the reviewed studies, the body of evidence for the effects of parental exposure to electromagnetic fields is not clear. Methodological heterogeneity in the way that studies were conducted could be responsible for the lack of consistency in the findings. Overall, the body of evidence allows no conclusion on the question of whether parental exposure to electromagnetic.

https://pubmed.ncbi.nlm.nih.gov/36944196/

As a result of this review, we should highlight that we could not obtain a conclusive result that identifies a positive or negative association between parental occupational exposure to electromagnetic fields and the occurrence of CNS tumors in children. A total of 17 studies, published between January 1990 and April 2021, that related parental occupational expo-sure to electromagnetic fields with the development of childhood CNS cancers were identified. We observed methodological heterogeneity in all the studies, independently from the identification of positive or negative associations. When stratifying by type of cancer under study, no evidence was identified to justify the different results obtained. In summary, this study did not find evidence of an association between electromagnetic fields exposure from parents' working environment and incidence of CNS tumors in the offspring.

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Critical window for the association between early electronic screen exposure and hyperactive behaviors in preschool children

Cai JY, Strodl E, Yang WK, Yin XN, Wen GM, Sun DL, Xian DX, Zhao YF, Chen WQ. Critical window for the association between early electronic screen exposure and hyperactive behaviors in preschool children. Psychol Health Med. 2023 Mar 16:1-13. doi: 10.1080/13548506.2023.2192039.

Abstract

Electronic screens have become an integral part of modern life, accompanied with growing concerns for children's neuropsychological development. This study aimed to evaluate the associations between measures of early life screen exposure and hyperactive behaviors among preschool children. The study also aimed to investigate their cumulative effects and the critical window for these associations. A cross-sectional survey was conducted among 52 625 mother-child dyads at preschools in LongHua District of Shenzhen, China. A self-administered structured questionnaire was used to assess socio-demographic characteristics, duration of children's electronic screen exposure in each of the first 3 years following birth and the presence of current hyperactive behaviors. A series of logistic regression models were used to examine the relationship between previous screen time and current hyperactive behaviors. A crossover analysis was used to explore the critical window for a significant relationship between screen time and hyperactive behaviors. We found that exposure

to electronic screens in the first 3 years of life was associated with hyperactive behaviors in preschool children. A cumulative effect was shown in children with an average daily screen time less than 60 min, with adjusted ORs increasing from 1.262 to 1.989 as screen exposure years increased from 1 to 3 years. A critical window was identified in that children in the first 2 years after birth were vulnerable to electronic screen exposure. Exposure to televisions, mobile phones, and computers were all related to elevated risks for hyperactive behaviors. In conclusion, early screen exposure appears to increase the risk for hyperactive behaviors in preschool children with the presence of a cumulative effect, a critical window and different electronic screens having similar effects.

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Electromagnetic fields as a health risk factor

Jakusova V, Sladicekova KH. Electromagnetic fields as a health risk factor. Clin Soc Work Health Interv 2022; 13 (6): 49-57. doi: 10.22359/cswhi_13_6_10

Abstract

This study is a collection of findings of published articles from the Department of Medical Biophysics and Department of Pub- lic Health at the Jessenius Faculty of Medicine in Martin, Comenius University Bratislava (JFM CU) with the topic on epidemiology of electromagnetic fields. During 14 years, 13 principal publications were created, of which 11 studies deal with radio frequency signals from mobile phones (mainly GSM900 and GSM1800 standard); one study describes the construction of a new exposure system and the other deals with the effects of low frequency electromagnetic fields. The results showed that the electromagnetic fields can affect heart rate variability both in humans and animals; increasing the activity of the parasympathetic or sympathetic nerve systems depending on place of body exposure (head or thorax, respectively); may cause disorders of heart rhythm; loss of concentration; headaches; and/or burning sensations in the ear area. Parameters of exposition were compared with the values issued by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). They had not exceeded the permitted limits. However, compared to data of the BioInitiative Report, in some cases, our measured values exceeded their limits.

Open access paper: https://clinicalsocialwork.eu/wp-content/uploads/2022/11/cswhi_06_2022_10_jakusova.pdf

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Assessment and Categorization of Biological Effects and Atypical Symptoms Owing to Exposure to RF Fields from Wireless Energy Devices

Razek A. Assessment and Categorization of Biological Effects and Atypical Symptoms Owing to Exposure to RF Fields from Wireless Energy Devices. *Applied Sciences*. 2023; 13(3):1265. doi: 10.3390/app13031265.

Abstract

Nowadays, environmental electromagnetic fields exist everywhere and the whole population is exposed. The most widespread technologies engendering exposure to electromagnetic fields for the public and workers are radiofrequency wireless communication systems. Such exposure can have direct effects on living tissue involving biological problems or personal symptoms, as well as indirect effects restricting healthcare appliances. This assessment aims to analyze, examine and categorize the consequences of non-ionizing electromagnetic fields emitted by radiofrequency devices. This concerns biological effects in living tissues and atypical personal symptoms for short and long-term exposures. The evaluation methodology in this field of investigation is also discussed. In the article, these consequences as well as their evaluation techniques, in the case of wireless digital communication tools, are analyzed and reviewed. The categorization of exposure sources, the corresponding effects and their assessment methodologies are analyzed. The concept of systematic reviews and meta-analyses and their applications in various assessments of these effects and symptoms are reviewed and discussed.

Open access paper: https://www.mdpi.com/2076-3417/13/3/1265

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Large-area mobile measurement of outdoor exposure to radio frequencies

Paniagua-Sánchez JM, García-Cobos FJ, Rufo-Pérez M, Jiménez-Barco A. Large-area mobile measurement of outdoor exposure to radio frequencies. Sci Total Environ. 2023 Mar 15;877:162852. doi: 10.1016/j.scitotenv.2023.162852.

Highlights

- Fast car-mounted RF measurements in large urban outdoor areas.
- The car alters personal exposimeter measurements in a quantifiable way.
- Exposure quotients for thermal effects calculated in a multi-frequency environment.
- Fusion of RF exposure maps with aerial photographs.

Abstract

A rapid outdoor sampling technique was tested to measure human exposure to radio frequencies in a city of 96,000 inhabitants. The technique consisted of taking measurements with a personal exposure meter inside a moving vehicle. Tests were carried out to quantify the alteration produced by the vehicle's structure and obtain correction factors in order to minimize this alteration. Data were collected at 3065 points where signals in the FM radio and mobile phone wavebands were detected. The coefficients of exposure to sources with multiple frequencies due to thermal effects were calculated from the measured values of the electric field. Kriging was used to generate maps of these coefficients, and these maps were then merged with aerial photographs of the city to readily identify the areas with greater or lesser exposure. The results indicated that the vehicle increased the FM broadcasting radiation readings by a factor of 1.66, but attenuated those of mobile telephony by factors of 0.54–0.66. The mean electric field levels detected throughout the city were 0.231, 0.057, 0.140, 0.124, and 0.110 V/m for the frequency bands FM, LTE 800 (DL), GSM + UMTS 900(DL), GSM 1800(DL), and UMTS 2100(DL), respectively. The mean coefficient of exposure to sources with multiple frequencies was 2.05 × 10−4, and the maximum was 9.81 × 10−3. It can be concluded from the study that it is possible to assess radio frequency

exposure using this method, and that the technique is scalable to different sized cities. It also allows measurement at different times so as to analyse the temporal variation of radio frequency levels.

Excerpts

This study has some drawbacks. Measurements were carried out homogeneously throughout the city, without focusing on any specific microenvironment or comparing exposure levels between different microenvironments, as is done in other studies (Urbinello et al., 2014; Sagar et al., 2018). This does not allow us to accurately assess human exposure to radio-frequencies since people spend most of their time outdoors in a city in specific places, such as parks, school playgrounds, shopping areas or residential yards. Future research might focus on the evaluation of exposure in these places taking the data provided in this study as a starting point.

A characteristic of this study and of other similar ones cited in the bibliography is that the measurement instrumentation captures radiation in limited ranges. In the case of PEMs such as ours, the frequency range is 87–5850 MHz, which includes the services addressed in Table 1. Although most of the electromagnetic radiation that affects people lies within this range, radiation from other important radio frequencies such as AM radio is not covered. The exposure coefficients for thermal effects of these radiations can be of the same order of magnitude as those found in the present work, and for electrical effects two orders of magnitude greater (Paniagua et al., 2009; Paniagua et al., 2010; Rufo et al., 2018). Although this type of study does not offer a complete vision of radio frequency exposure, it does allow exploration of a major part of the radio spectrum to which the population is exposed. It also allows one to analyse the temporal evolution of exposure to mobile telephony radiation, which changes more in the short and medium term due to the introduction of new generations, such as 5G, and the opening of new frequency bands.

Open access paper: https://www.sciencedirect.com/science/article/pii/S0048969723014687

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RF-EMF Exposure near 5G NR Small Cells

Aerts S, Deprez K, Verloock L, Olsen RG, Martens L, Tran PK, Joseph W. RF-EMF Exposure near 5G NR Small Cells.*Sensors* **2023**, *23*(6), 3145; doi: 10.3390/s23063145

Abstract

Of particular interest within fifth generation (5G) cellular networks are the typical levels of radiofrequency (RF) electromagnetic fields (EMFs) emitted by ‘small cells’, low-power base stations, which are installed such that both workers and members of the general public can come in close proximity with them. In this study, RF-EMF measurements were performed near two 5G New Radio (NR) base stations, one with an Advanced Antenna System (AAS) capable of beamforming and the other a traditional microcell. At various positions near the base stations, with distances ranging between 0.5 m and 100 m, both the worst-case and time-averaged field levels under maximized downlink traffic load were assessed. Moreover, from these measurements, estimates were made of the typical exposures for various cases involving users and non-users. Comparison to the maximum

permissible exposure limits issued by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) resulted in maximum exposure ratios of 0.15 (occupational, at 0.5 m) and 0.68 (general public, at 1.3 m). The exposure of non-users was potentially much lower, depending on the activity of other users serviced by the base station and its beamforming capabilities: 5 to 30 times lower in the case of an AAS base station compared to barely lower to 30 times lower for a traditional antenna.

This research was funded by the Electric Power Research Institute (EPRI), grant agreement 10013613.

Open access paper: https://www.mdpi.com/1424-8220/23/6/3145

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A Simple and Low-Cost Technique for 5G Conservative Human Exposure Assessment

Schettino F, Chirico G, D'Elia C, Lucido M, Pinchera D, Migliore MD. A Simple and Low-Cost Technique for 5G Conservative Human Exposure Assessment. *Applied Sciences*. 2023; 13(6):3524. doi: 10.3390/app13063524.

Abstract

The purpose of this paper is to introduce a simple, low-cost methodology for estimating a conservative value of the maximum field level that can be radiated by a 5G base station useful for human exposure assessment. The method is based on a Maximum Power Extrapolation (MPE) approach and requires the measurement of a reference quantity associated with the SS-PBCH, such as Primary Synchronization Signal (PSS), Secondary Synchronization Signal (SSS), Physical Broadcast CHannel (PBCH), or PBCH Demodulation Reference Signal (PBCH-DMRS). This step requires a simple spectrum analyzer and allows one to obtain the Resource Element (RE) power of a signal transmitted through broadcast beams. In the second phase, the RE power of the signal transmitted through the traffic beam is estimated using the Cumulative Distribution Function (CDF) of the antenna boost factor obtained from the broadcast and the traffic envelope radiation patterns made available by the base station vendor. The use of the CDF allows us to mitigate the problems related to the exact estimation of the direction of the measurement point with respect to the beam of the 5G antenna. The method is applied to a real 5G communication system, and the result is compared with the value given by other MPE methods proposed in the literature.

Conclusions

A method to estimate a conservative value of the maximum field level that can be radiated by a 5G base station has been introduced and experimentally validated.

The method is conceived to be simple and low-cost. It requires the broadcast and the traffic Envelop Radiation Patterns and the measurement of a reference value transmitted through the broadcast beams.

In the experimental example, a standard and relatively low-cost scalar spectrum analyzer was used. It is understood that other solutions can be adopted, for example, directly accessing reference signals, but such solutions would require more expensive devices.

With reference to the technology currently used in 5G systems, the main limitation of the proposed procedure is that it gives only a conservative value of the field level. If the limit of the standard is exceeded, it is, therefore, necessary to use other procedures that allow a more precise estimation of the field level.

As noted in the introduction, this paper is closely linked to the two papers [24,26], with which it shares the experimental set-up. The three papers together cover a large number of possible solutions for 5G MPE, giving at the same time a clear idea of the sheer complexity of MPE in 5G. This great complexity is due to the high flexibility of 5G and the limited information on the system status from the UE side, in particular with reference to the AAS configuration during the measurement session.

The enormous difficulties encountered in defining robust MPE 5G extrapolation techniques are a lesson that should be considered in setting the standard for the sixth generation of cellular communications systems.

Open access paper: https://www.mdpi.com/2076-3417/13/6/3524/htm

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Dominance of Smartphone Exposure in 5G Mobile Networks

Chiaraviglio L, Lodovisi C, Bartoletti S, Elzanaty A, Alouini MS. Dominance of Smartphone Exposure in 5G Mobile Networks. *IEEE Transactions on Mobile Computing*, doi: 10.1109/TMC.2023.3252662.

Abstract

The deployment of 5G networks is sometimes questioned due to the impact of ElectroMagnetic Field (EMF) generated by Radio Base Station (RBS) on users. The goal of this work is to analyze such issue from a novel perspective, by comparing RBS EMF against exposure generated by 5G smartphones in commercial deployments. The measurement of exposure from 5G is hampered by several implementation aspects, such as dual connectivity between 4G and 5G, spectrum fragmentation, and carrier aggregation. To face such issues, we deploy a novel framework, called 5G-EA, tailored to the assessment of smartphone and RBS exposure through an innovative measurement algorithm, able to remotely control a programmable spectrum analyzer. Results, obtained in both outdoor and indoor locations, reveal that smartphone exposure (upon generation of uplink traffic) dominates over the RBS one. Moreover, Line-of-Sight locations experience a reduction of around one order of magnitude on the overall exposure compared to Non-Line-of-Sight ones. In addition, 5G exposure always represents a small share (up to 38%) compared to the total one radiated by the smartphone.

Excerpt

We have then performed an extensive set of assessments in both outdoor and indoor locations. Interestingly, our results demonstrate that the smartphone contribution largely dominates over the other exposure components, particularly when UL traffic is injected. However, the largest contribution is due to pre-5G technologies, while 5G always constitute a small share (up to 38%) out of the total one that is radiated by the smartphone. In addition, the total exposure dramatically decreases when outdoor LOS conditions are experienced, and in general when the exposure from the RBS becomes detectable by the SAN. Moreover, we have designed and evaluated an exposure estimator based on the maximum UL traffic that is achieved by iPerf

in the measurement location. Eventually, the exposure tends to increase in indoor locations when passing from LOS to NLOS condition, for a given level of UL traffic that is set towards the smartphone. Finally, we have demonstrated that the measured exposure levels are influenced by key parameters, like DL vs. UL direction, smartphone orientation and relative distance of the smartphone w.r.t. the measurement antenna.

We believe that our work paves the way for future research in the field. First, the application of 5G-EA in other deployments (e.g., subject to different exposure regulations and/or different radio configurations) is an interesting step. Second, the evaluation of exposure should be extended by considering multiple UE models/types, locations in balconies/terraces in close proximity to the serving RBS, and additional sources like WiFi. Third, the assessment of exposure in 5G deployments including mm-Wave frequencies is another line of research. Fourth, we plan to perform extensive assessment by running commonly used smartphone applications (social media, video streaming, online conference, etc.). Fifth, the decrease of exposure observed in LOS locations suggest that deploying a dense 5G network, in which most of territory is in LOS w.r.t. the serving RBS, is the best solution to reduce the exposure from the terminals. This goal could be alternatively achieved by installing intelligent surfaces (active or passive), to improve the signal coverage over the territory. The evaluation of exposure in such innovative deployments is therefore a future activity.

Open access paper: https://ieeexplore.ieee.org/document/10059235

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Uncertainty quantification in the assessment of human exposure to pulsed or multi-frequency fields

Giaccone L. Uncertainty quantification in the assessment of human exposure to pulsed or multi-frequency fields. Phys Med Biol. 2023 Mar 30. doi: 10.1088/1361-6560/acc924.

Abstract

Objective: pulsed fields or waveforms with multi-frequency content have to be assessed with suitable methods. This paper deals with the uncertainty quantification associated to these methods.

Approach: among all possible approaches, the weighted peak method is widely employed in standards and guidelines, therefore, in this paper, we consider its implementation both in time domain and frequency domain. For the uncertainty quantification the polynomial chaos expansion theory is used. By means of a sensitivity analysis, for several standard waveforms, the parameters with more influence on the exposure index are identified and their sensitivity indices are quantified. The output of the sensitivity analysis is used to set up a parametric analysis with the aim of evaluating the uncertainty propagation of the analyzed methods and, finally, also several measured waveforms generated by a welding gun are tested.

Main findings: it is shown that the time domain implementation of the weighted peak method provides results in agreement with the basilar mechanisms of electromagnetic induction and electrostimulation. On the opposite, the WPM in frequency domain is found to be too sensitive to parameters that should not influence the

exposure index because its weight function includes sharp variations of the phase centered on real zeros and poles. To overcome this issue, a new definition for the phase of the weight function in frequency domain is proposed.

Significance: it is shown that the time domain implementation of the weighted peak method is the more accurate and precise. The standard WPM in frequency domain has some issues that can be avoided with the proposed modification of the phase definition of the weight function. Finally, all the codes used in this paper are hosted on a GitHub and can be freely accessed at https://github.com/giaccone/wpm_uncertainty.

https://pubmed.ncbi.nlm.nih.gov/36996847/

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Radiation Effect Analysis on Human Head Caused by Different Frequencies of Mobile Phone Antenna

Zhang X, Zhou W. Radiation Effect Analysis on Human Head Caused by Different Frequencies of Mobile Phone Antenna. *2022 International Applied Computational Electromagnetics Society Symposium (ACES-China)*, Xuzhou, China, 2022, pp. 1-3, doi: 10.1109/ACES-China56081.2022.10065276.

Abstract

This article discusses the bio-electromagnetic effects of the human head who exposure to the different operation frequency of three kinds of mobile phones. Three kinds of exposure sources with microwave and millimeter-wave bands respectively, which include the dual-band PIFA antenna operating at 900 MHz and 1860 MHz, the patch antenna operating at 3.5 GHz and the dual-band millimeter-wave antenna operating at 27 GHz and 40 GHz. We take a three-layer ball head model as the human head, and use the COMSOL Multiphysics software to simulate the specific absorption rate (SAR) and the absorbed power density (Sab) and temperature rise performance in the human head. The maximum SAR in human head is 1.41 W/kg and 4.4 W/kg, when it exposed to the microwave antenna and millimeter-wave antenna respectively. The results show that the millimeter-wave antennas have higher radiation energy than the microwave antennas for the human head model. The radiation dose absorbed in the human tissues are all below the limit restriction.

https://doi.org/10.1109/ACES-China56081.2022.10065276

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Effect of Radiofrequency Radiation Emitted by Modern Cellphones on Sperm Motility and Viability: An In Vitro Study

Chu KY, Khodamoradi K, Blachman-Braun R, Dullea A, Bidhan J, Campbell K, Zizzo J, Israeli J, Kim M, Petrella F, Ibrahim E, Ramasamy R. Effect of Radiofrequency Electromagnetic Radiation Emitted by Modern Cellphones on Sperm Motility and Viability: An In Vitro Study. Eur Urol Focus. 2023 Jan;9(1):69-74. doi: 10.1016/j.euf.2022.11.004.

Abstract

Background: Cellphones emit radiofrequency electromagnetic radiation (RF-EMR) for transmission of data for social media communication, web browsing, and music/podcast streaming. Use of Bluetooth earbuds has probably prolonged the time during which cellphones reside in the trouser pockets of men. It has been postulated that RF-EMR increases oxidative stress and induces free radical formation.

Objective: To investigate the effect of wireless-spectrum (4G, 5G, and WiFi) RF-EMR emitted by modern smartphones on sperm motility and viability and explore whether these effects can be mitigated using a physical barrier or distance.

Design, setting, and participants: Semen samples were obtained from fertile normozoospermic men aged 25-35 yr. A current-generation smartphone in talk mode was used as the RF-EMR source. A WhatsApp voice call was made using either 4G, 5G, or WiFi wireless connectivity. We determined if exposure effects were mitigated by either a cellphone case or greater distance from the semen sample.

Outcome measurements and statistical analysis: The semen samples were analyzed according to 2010 World Health Organization laboratory guidelines. Statistical analysis was performed using SPSS v.28.

Results and limitations: We observed decreases in sperm motility and viability with WiFi exposure but not with exposure to 4G or 5G RF-EMR. With large variability among smartphones, continued research on exposure effects is needed.

Conclusions: Our exploratory study revealed that sperm motility and viability are negatively impacted by smartphones that use the WiFi spectrum for data transmission.

Patient summary: We looked at the effect of cellphone use on sperm motility and viability. We found that cellphones using WiFi connectivity for data usage have harmful effects on semen quality in men.

Excerpts

Our study is not without limitations. First, our small sample size of 18 introduces potential sources of bias. We did not collect demographic data for these patients in order to maintain privacy, so the results may be subject to confounding bias. As the first of its kind at our institution, this small trial was a pilot study to validate our experimental model and procedures. We hope that further studies on the effects of RF-EMR on semen parameters can be performed on larger samples to validate our initial results. Second, we recognize that other potential variables, including temperature and radiation strength, could play a role in inducing changes in semen parameters. For this preliminary study, we were only interested in a single variable (radiation); future work should investigate the impact of temperature and radiation strength on changes in semen. This was an exploratory in vitro study, and further in vivo studies in animal models should be performed to further evaluate the impact of radiation on semen parameters.

Conclusions

Our study revealed that 4G/5G RF-EMR emitted by a contemporary cellphone did not have negative effects on sperm motility and viability. By contrast, WiFi exposure did have negative effects. During data use, there may be an increase in heat dissipated by a cellphone, depending on the power required to connect to the source. Interestingly, we observed varying effects of WiFi on sperm parameters, depending on the environment. We posit that a greater distance from the wireless router results in a need for more cellphone power, which may lead to greater heat production and result in negative effects on sperm motility and viability. Mitigation measures such as use of a cellphone case and increasing the distance between the cellphone and the sperm sample lessened the effects. Further studies need to be performed to better understand the effects of RF-EMR on sperm parameters.

https://pubmed.ncbi.nlm.nih.gov/36379868/

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Protective role of hispolon and its derivatives against apoptosis in cortical neurons induced by electromagnetic radiation from 4G mobile phone

Saka VP, V C, Narayanasamy D. Protective role of hispolon and its derivatives against apoptosis in cortical neurons induced by electromagnetic radiation from 4G mobile phone. J Biochem Mol Toxicol. 2023 Mar 30:e23351. doi: 10.1002/jbt.23351.

Abstract

Electromagnetic radiation (EMR) from wireless devices, particularly mobile phones, is a potentially growing public health concern. In this study, the neuronal effects of EMR on primary cortical neurons (PCNs) from neonatal rat cerebral cortex and the protective role of hispolon (HIS) and its derivatives were investigated as a measure of cranial exposure during mobile phone use. PCNs were isolated and cultured from day-old neonatal rats, then exposed for 2 h to EMR emitted by a mobile phone operating at a frequency of 2100 MHz with 1.6 W/Kg specific absorption rate (SAR) in call-answered mode treated with HIS and its derivatives. The induction of apoptosis through modulation of pro and anti-apoptotic genes via mitochondrial pathway and the protection by the test compounds was assessed. Pyrazole derivatives decreased apoptosis by modulating the levels of pro and anti-apoptotic genes by reducing the levels of reactive oxygen species (ROS) via mitochondrial damage, which was observed in the EMR exposed PCNs. The pyrazole compounds were found to have antioxidative and anti-apoptotic properties. Thus, the neuroprotective mechanisms of the pyrazole derivatives can be investigated further, which may make them appropriate as lead compounds in developing neuroprotective formulations.

https://pubmed.ncbi.nlm.nih.gov/36994543/

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Analysis of global DNA methylation changes in human keratinocytes immediately following exposure to a 900 MHz radiofrequency field

Cantu JC, Butterworth JW, Peralta XG, Payne JA, Echchgadda I. Analysis of global DNA methylation changes in human keratinocytes immediately following exposure to a 900 MHz radiofrequency field. Bioelectromagnetics. 2023 Mar 31. doi: 10.1002/bem.22439.

Abstract

The increasing use of nonionizing radiofrequency electromagnetic fields (RF-EMFs) in a wide range of technologies necessitates studies to further understanding of biological effects from exposures to such forms of electromagnetic fields. While previous studies have described mechanisms for cellular changes occurring following exposure to low-intensity RF-EMFs, the role of molecular epigenetics has not been thoroughly investigated. Specifically unresolved is the effect of RF-EMFs on deoxyribonucleic acid (DNA) methylation, which is a powerful epigenetic process, used by cells to regulate gene expression. DNA methylation is dynamic and can be rapidly triggered in response to external stimuli such as exposure to RF-EMFs. In the present study, we performed a global analysis of DNA methylation patterns in human keratinocytes exposed to 900 MHz RF-EMFs for 1 h at a low dose rate (estimated mean specific absorption rate (SAR) < 10 mW/kg). We used a custom system to allow stable exposure of cell cultures to RF-EMFs under biologically relevant conditions (37 °C, 5% CO_2 , 95% humidity). We performed whole genome bisulfite sequencing directly following RF-EMF exposure to examine the immediate changes in DNA methylation patterns and identify early differentially methylated genes in RF-EMF-exposed keratinocytes. By correlating global gene expression to whole genome bisulfite sequencing, we identified six common targets that were both differentially methylated and differentially expressed in response to RF-EMF exposure. The results highlight a potential epigenetic role in the cellular response to RF-EMFs. Particularly, the six identified targets may potentially be developed as epigenetic biomarkers for immediate responses to RF-EMF exposure.

https://pubmed.ncbi.nlm.nih.gov/36999566/

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ZIP9-centered pathway compensates for radiofrequency radiation-mediated reduction in resistance to H_2O_2 damage in Sertoli cells of rats

Yu G, Zhu Y, Song C, Chen L, Tang Z, Wu T. The ZIP9-centered androgen pathway compensates for the 2605 MHz radiofrequency electromagnetic radiation-mediated reduction in resistance to H_2O_2 damage in Sertoli cells of adult rats. Ecotoxicol Environ Saf. 2023 Mar 6;254:114733. doi: 10.1016/j.ecoenv.2023.114733

Highlights

• RF-EMR suppress ability of sertoli cells to resist external insults.

• Testosterone reversed reduction of resistence ability of sertoli cells exposed to RF-EMR.

• Testosterone exerted its compensatory effect via ZIP9 in sertoli cells.

• Unfolding protein response involved in testosterone-ZIP9 mediated compensatory effects.

• Testosterone-ZIP9 mediated effect might gradually weared off with exposure time prolonged.

Abstract

The direct biological effects of radiofrequency electromagnetic radiation (RF-EMR) from wireless communication equipment on the testes are still unclear. Our previous study proved that long-term exposure to 2605 MHz RF-EMR gradually damage spermatogenesis and resulted in time-dependent reproductive toxicity by directly disrupting blood-testis barrier circulation. Although short-term exposure did not cause readily observable damage to fertility, whether it caused specific biological effects and how these effects contributed to the time-dependent reproductive toxicity of RF-EMR were currently unknown. Studies on this issue are important for elucidating the time-dependent reproductive toxicity of RF-EMR. The present study established a 2605 MHz RF-EMR (SAR=1.05 W/Kg) scrotal exposure model with rats and extracted primary Sertoli cells for exposure to investigate the direct biological effects of short-term RF-EMR exposure on the testis. The results showed that short-term RF-EMR exposure did not decrease sperm quality and spermatogenesis, but it increased the levels of testicular testosterone (T) and zinc transporter 9 (ZIP9) in Sertoli cells of rats. In vitro, 2605 MHz RF-EMR exposure did not increase the apoptosis rate of Sertoli cells, but it increased the apoptosis rate and MDA of Sertoli cells exposed to H_2O_2. T reversed these changes and increased ZIP9 level in Sertoli cells, whereas inhibiting ZIP9 expression significantly suppressed these T-mediated protective effects. Moreover, T increased the levels of phosphorylated inositol-requiring enzyme 1 (P-IRE1), phosphorylated protein kinase R (PKR)-like endoplasmic reticulum kinase (P-PERK), phosphorylated eukaryotic initiation factor 2a (P-eIF2a) and phosphorylated activating transcription factor 6 (P-ATF6) in Sertoli cells, and these effects were reversed by ZIP9 inhibition. With prolonged exposure time, testicular ZIP9 was gradually downregulated, and testicular MDA increased. ZIP9 level was negatively correlated with MDA level in the testes of exposed rats. Thus, although short-term exposure to 2605 MHz RF-EMR (SAR=1.05 W/kg) did not significantly disturb spermatogenesis, it suppressed the ability of Sertoli cells to resist external insults, which was rescued by enhancing the ZIP9-centered androgen pathway in the short term. Increasing the unfolded protein response might be an important downstream mechanism involved. These results promote a better understanding of the time-dependent reproductive toxicity of 2605 MHz RF-EMR.

https://pubmed.ncbi.nlm.nih.gov/36889209/

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Pre and postnatal exposure to 900 MHz electromagnetic fields induce inflammation and oxidative stress, and alter renin-angiotensin system components

Kilic A, Ustunova S, Bulut H, Meral I. Pre and postnatal exposure to 900 MHz electromagnetic fields induce inflammation and oxidative stress, and alter renin-angiotensin system components differently in male and female offsprings. Life Sci. 2023 Mar 28:121627. doi: 10.1016/j.lfs.2023.121627.

Abstract

Aims: This study was designed to investigate inflammation, oxidative stress and renin-angiotensin system components in brain and kidney tissues of female and male rats prenatally and/or postnatally exposed to 900 MHz electromagnetic field (EMF). It is aimed to evaluate the biological effects of 900 MHz EMF exposure due to the increase in mobile phone use and especially the more widespread use of the GSM 900 system.

Main methods: Male and female Wistar albino offsprings were divided into four groups of control, prenatal,

postnatal, and prenatal+postnatal exposed to 900 MHz EMF for 1 h/day (23 days during pregnancy for prenatal period, 40 days for postnatal period). The brain and kidney tissues were collected when they reached puberty.

Key findings: It was found that the total oxidant status, IL-2, IL-6, and TNF-α levels increased ($p < 0.001$) and the total antioxidant status levels decreased ($p < 0.001$) in all three EMF groups comparing to controls in both male and female brain and kidney tissues. The renin- angiotensin system components such as angiotensinogen, renin, angiotensin type 1 and type 2 receptors, and MAS1-like G protein-coupled receptor expression were higher ($p < 0.001$) in all three EMF exposure groups comparing to controls in both male and female brain and kidney tissues. Although there are some differences of the levels of proinflammatory markers, ROS components and RAS components in brain and kidney tissues between males and females, the common result of all groups was increase in oxidative stress, inflammation markers and angiotensin system components with exposure to 900 MHz EMF.

Significance: In conclusion, our study suggested that the 900 MHz EMF can activate brain and kidney renin-angiotensin system, and this activation is maybe related to inflammation and oxidative stress in both male and female offsprings.

https://pubmed.ncbi.nlm.nih.gov/36997060/

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Physiological and Psychological Stress of Microwave Radiation-Induced Cardiac Injury in Rats

Li D, Xu X, Yin Y, Yao B, Dong J, Zhao L, Wang H, Wang H, Zhang J, Peng R. Physiological and Psychological Stress of Microwave Radiation-Induced Cardiac Injury in Rats. *International Journal of Molecular Sciences*. 2023; 24(7):6237. doi: 10.3390/ijms24076237.

Abstract

Electromagnetic waves are widely used in both military and civilian fields, which could cause long-term and high-power exposure to certain populations and may pose a health hazard. The aim of this study was to simulate the long-term and high-power working environment of workers using special electromagnetic radiation occupations to clarify the radiation-induced stress response and cardiac damage and thus gain insights into the mechanisms of injuries caused by electromagnetic radiation. In this study, the combination of microwave and stress was an innovative point, aiming to broaden the research direction with regard to the effect and mechanism of cardiac injury caused by radiation. The myocardial structure was observed by optical and transmission electron microscope, mitochondrial function was detected by flow cytometry, oxidative-stress markers were detected by microplate reader, serum stress hormone was detected by radioimmunoassay, and heart rate variability (HRV) was analyzed by multichannel-physiological recorder. The rats were weighed and subjected to an open field experiment. Western blot (WB) and immunofluorescence (IF) were used to detect the expressions and distributions of JNK (c-Jun N-terminal kinase), p-JNK (phosphorylated c-Jun N-terminal kinase), HSF1 (heat shock factor), and NFATc4 (nuclear factor of activated T-cell 4). This study found that radiation could lead to the disorganization, fragmentation, and dissolution of myocardial fibers, severe mitochondrial cavitation, mitochondrial dysfunction, oxidative-stress injury in myocardium, increase to stress hormone in serum,

significant changes in HRV, and a slow gain in weight. The open field experiment indicated that the rats experienced anxiety and depression and had decreased exercise capacity after radiation. The expressions of JNK, p-JNK, HSF1, and NFATc4 in myocardial tissue were all increased. The above results suggested that 30 mW/cm^2 of S-band microwave radiation for 35 min could cause both physiological and psychological stress damage in rats; the damage was related to the activation of the JNK pathway, which provided new ideas for research on protection from radiation.

Excerpt

The radiation cassette was made of acrylic in the shape of a disc with thirty individual compartmentalized spaces of the same volume, each with a separate lid. Twenty-eight rats were placed in the twenty-eight compartments of the radiation box with the lid closed, the radiation box was positioned on a radiation table below the radiation source, and the radiation table was rotated to eliminate position effects. The rats in the Group R were radiated with a microwave frequency of 2.856 GHz at 30 mW/cm2 for 35 min (peak power density: 200 W/cm2, pulse width: 500 ns, repetition rate: 300 Hz), and the rats in Group C were subjected to the same conditions except that they did not receive radiation, as shown in Figure 19 [15].

Open access paper: https://www.mdpi.com/1422-0067/24/7/6237

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Monte-Carlo based Numerical Dosimetry in Reverberation Chamber Exposure Systems Employed for In-Vivo Rodent Bioassays

De Santis V, Di Fracesco A, Foster KR, Bit-Babik G, Faraone A. Monte-Carlo based Numerical Dosimetry in Reverberation Chamber Exposure Systems Employed for In-Vivo Rodent Bioassays. *IEEE Access*, doi: 10.1109/ACCESS.2023.3251889.

Abstract

A Monte-Carlo based computational approach for the statistical characterization of the whole-body specific absorption rate (wbSAR) variability in large cohorts of rodents exposed to radio-frequency (RF) energy in reverberation chambers (RCs) is applied to adult male rat exposures illustrative of those in a US National Toxicology Program (NTP) cancer bioassay. A large number of 3D electromagnetic field realizations fulfilling Rayleigh fading properties were generated within an electrically-large volume representative of an ideal RC, yielding granular wbSAR distributions for an ensemble of 96 homogeneous rodent models with random mass distribution, postures, positions and orientations. Two case studies were addressed: a “momentary exposure” with each rat fixed in posture, position and orientation, and a “day-long exposure” in which the position, orientation and posture were varied randomly for each subsequent Rayleigh field realization. Over 500 and 2500 field realizations or “snapshots”, respectively, the rats’ instantaneous wbSARs, as well as their individual time-averaged wbSARs, were found to be well fit by lognormal distributions. The large variability in instantaneous wbSARs in the cohort was due in part to the inherent Rayleigh field variability in RCs (70-80%) and in part to weight, posture and position variations (20-30%), while the effect of cage location was found to be small over day-long exposures. Averaging the exposure over field realizations substantially reduces the range of wbSARs in

the cohort. Hence, when RF-induced thermal effects are studied, the relevant exposure metric (wbSAR averaged over appropriate times) features a narrower range than instantaneous wbSAR, which is the relevant metric in studies dealing with non-thermal effects. Compared to previous studies, the present approach was found to be computationally more efficient enabling thus a Monte-Carlo analysis by varying concurrently the incident field and the animals posture, position, and orientation. In practice, it can inform the choice of wbSAR targets in rodent bioassay, allowing to identify possible dose-effect trends while avoiding undue thermal stress.

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=10057396&isnumber=6514899

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Impacts of Radio-Frequency Electromagnetic Field on Lettuce: Evidence for Interference with Plant Stress Responses

Tran NT, Jokic L, Keller J, Geier JU, Kaldenhoff R. Impacts of Radio-Frequency Electromagnetic Field (RF-EMF) on Lettuce (*Lactuca sativa*)-Evidence for RF-EMF Interference with Plant Stress Responses. Plants (Basel). 2023 Feb 28;12(5):1082. doi: 10.3390/plants12051082.

Abstract

The increased use of wireless technology causes a significant exposure increase for all living organisms to radio frequency electromagnetic fields (RF-EMF). This comprises bacteria, animals, and also plants. Unfortunately, our understanding of how RF-EMF influences plants and plant physiology remains inadequate. In this study, we examined the effects of RF-EMF radiation on lettuce plants (*Lactuca sativa*) in both indoor and outdoor environments using the frequency ranges of 1890-1900 MHz (DECT) at 2.4 GHz and 5 GHz (Wi-Fi). Under greenhouse conditions, RF-EMF exposure had only a minor impact on fast chlorophyll fluorescence kinetics and no effect on plant flowering time. In contrast, lettuce plants exposed to RF-EMF in the field showed a significant and systemic decrease in photosynthetic efficiency and accelerated flowering time compared to the control groups. Gene expression analysis revealed significant down-regulation of two stress-related genes in RF-EMF-exposed plants: violaxanthin de-epoxidase (VDE) and zeaxanthin epoxidase (ZEP). RF-EMF-exposed plants had lower Photosystem II's maximal photochemical quantum yield (F_V/F_M) and non-photochemical quenching (NPQ) than control plants under light stress conditions. In summary, our results imply that RF-EMF might interfere with plant stress responses and reduced plant stress tolerance.

Excerpt

Our findings highlight the need for scientific studies on the effects of RF-EMF in plants under realistic scenarios. Significant RF-EMF effects could only be detected under outdoor settings. If we had conducted our experiments exclusively in the greenhouse, these effects would have gone unnoticed. Furthermore, the potential interaction between RF-EMF and other stressors requires further, more thorough investigation. Such connections, if verified, would have major consequences. We could expect in the near future both, the massively increased applications of wireless devices as well as a significant upsurge in weather extremes and insect outbreaks because of climate change. These two factors and their interconnections might have significant impacts for plants and endanger both our food security and the stability of our ecosystems.

Open access paper: https://www.mdpi.com/2223-7747/12/5/1082

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Safety evaluation of smart scales, smart watches, and smart rings with bioimpedance technology shows evidence of potential interference in cardiac implantable electronic devices

Ha GB, Steinberg BA, Freedman R, Bayés-Genís A, Sanchez B. Safety evaluation of smart scales, smart watches, and smart rings with bioimpedance technology shows evidence of potential interference in cardiac implantable electronic devices. Heart Rhythm. 2023 Apr;20(4):561-571. doi: 10.1016/j.hrthm.2022.11.026.

Abstract

Background: Smart scales, smart watches, and smart rings with bioimpedance technology may create interference in patients with cardiac implantable electronic devices (CIEDs).

Objectives: The purpose of this study was to determine interference at CIEDs with simulations and benchtop testing, and to compare the results with maximum values defined in the ISO 14117 electromagnetic interference standard for these devices.

Methods: The interference at pacing electrodes was determined by simulations on a male and a female computable model. A benchtop evaluation of representative CIEDs from 3 different manufacturers as specified in the ISO 14117 standard also was performed.

Results: Simulations showed evidence of interference with voltage values exceeding threshold values defined in the ISO 14117 standard. The level of interference varied with the frequency and amplitude of the bioimpedance signal, and between male and female models. The level of interference generated with smart scale and smart rings simulations was lower than with smart watches. Across device manufacturers, generators demonstrated susceptibility to oversensing and pacing inhibition at different signal amplitudes and frequencies.

Conclusions: This study evaluated the safety of smart scales, smart watches, and smart rings with bioimpedance technology via simulation and testing. Our results indicate that these consumer electronic devices could interfere in patients with CIEDs. The present findings do not recommend the use of these devices in this population due to potential interference.

https://pubmed.ncbi.nlm.nih.gov/36997272/

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Evaluation of Exposure to Radiofrequency Electromagnetic Fields from Smart Utility Meters operating at 868 MHz

Addison D, Calderon C, Peyman A. Evaluation of Exposure to Radiofrequency Electromagnetic Fields from Smart Utility Meters operating at 868 MHz. Bioelectromagnetics. 2023 Mar 31. doi: 10.1002/bem.22440.

Abstract

Power density and duty factor values were measured around smart utility meters operating at 868 MHz under laboratory-controlled conditions. The maximum 6-min averaged exposure recorded was 0.1 mWm^{-2} , which is less than 0.0024% of the corresponding 1998 ICNIRP general public reference level. Duty factors measured were less than 2.8%. This study found that the exposure contribution from Zigbee smart meter devices operating at 868 MHz is generally lower than, if not similar to, those operating at 2.4 GHz.

https://pubmed.ncbi.nlm.nih.gov/37002551/

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Can extremely low frequency magnetic field affect human sperm parameters and male fertility?

Muti ND, Salvio G, Ciarloni A, Perrone M, Tossetta G, Lazzarini R, Bracci M, Balercia G. Can extremely low frequency magnetic field affect human sperm parameters and male fertility? Tissue Cell. 2023 Feb 18;82:102045. doi: 10.1016/j.tice.2023.102045.

Highlights

• Exposure to ELF-MF at the frequency of 50 Hz (1 mT) for 2 h alters reproductive function of human spermatozoa.

• ELF-MF decreased spermatozoa progressive motility.

• Exposure to ELF-MF decreased non-progressive spermatozoa motility.

• ELF-MF decreased the spermatozoa with typical morphology.

• Exposure to ELF-MF did not alter sperm concentration.

Abstract

Exposure to extremely low frequency magnetic fields (ELF-MF) may have different effects on spermatozoa depending on the waveform, magnetic flux density, frequency of ELF-MF, and duration of exposure. In this study, we investigated the possible role of ELF-MF (50 Hz; 1 mT) exposure in altering sperm parameters. In this study we found that exposure to ELF-MF at the frequency of 50 Hz (1 mT) for two hours induces statistically significant alterations in progressive motility, morphology and reactive oxygen species (ROS) production of human spermatozoa, suggesting a role of ELF-MF in altering reproductive function of spermatozoa. Our results represent an important discovery in the field since occupational exposure to the sine waveform 1 mT 50 Hz ELF-MF used in our study is possible in workplace. Moreover, these electromagnetic fields are product by many electronic devices and household appliances. Thus, alterations of progressive motility and morphology of spermatozoa would be important consequences of human exposures to ELF-MF.

https://pubmed.ncbi.nlm.nih.gov/36870312/

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Extremely low frequency magnetic fields emitted by cell phones

Misek J, Jakus J, Hamza Sladicekova K, Zastko L, Veternik M, Jakusova V, Belyaev I. Extremely low frequency magnetic fields emitted by cell phones. Front. Phys. Volume 11, 2023. doi: 10.3389/fphy.2023.1094921

Cell phones expose significant parts of the human brain and head to extremely low frequency (ELF) magnetic fields (MF) classified by the IARC as a 2B carcinogen. ELF MF was measured on the front and back sides of 15 cell phones in standby, speaking, and listening modes for 2G and 3G standards in two frequency bands, LF1: 5 Hz–200 Hz and LF2: 120 Hz—10 kHz. The highest MF value was 70.03 µT (RMS) in LF1 (2G, listening mode, front side) and 12.67 µT (RMS) in LF2 (2G, speaking mode, front side). The 3G cell phones consistently emitted a lower ELF MF compared to the 2G ones. The exposure to ELF MF was also simulated at various locations (head, thorax, pelvis) using the CST Studio Suite. The simulations revealed 8.45 µT, 7.5 µT, and 6.09 µT in the middle of the head (midbrain), 3.89 µT, 3.98 µT, and 2.83 µT for the middle of the thorax (heart), and 2.03 µT, 1.96 µT, and 1.56 µT in the middle of the pelvis (scrotum) for 10 Hz, 50 Hz, and 200 Hz, respectively. These values are comparable to those reported to induce biological and health effects, including those related to carcinogenesis. The results can be used in future studies concerning the ELF exposure or the combined effects of electromagnetic fields of radiofrequency and ELF.

Open access paper: https://www.frontiersin.org/articles/10.3389/fphy.2023.1094921/full

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Relationship between low-frequency electromagnetic field and computer vision syndrome

Kösek O, Mete B, Öcal I, Yar K, Demirhindi H, Tokuş M. Relationship between low-frequency electromagnetic field and computer vision syndrome. Eur Rev Med Pharmacol Sci. 2023 Mar;27(5):1801-1807. doi: 10.26355/eurrev_202303_31541.

Abstract

Objective: This study aimed to determine the prevalence of computer vision syndrome (CVS) among secretaries working in different departments of a university hospital in Turkey and its relationship with low-frequency electromagnetic field (LF-EMF) exposure.

Subjects and methods: This cross-sectional study included 143 secretaries working in different departments of the hospital. Besides eye examinations, CVS Syndrome Questionnaire (CVS-Q) Scale and Ocular Surface Disease Index Scale (OSDI) were applied to the participants. LF-EMF of the work environment were measured with a 6010 Gauss/Teslameter device and the light intensity with an LX-1102 Device.

Results: The mean age of participants was 39.6 years, with a male-to-female ratio of 25.2% to 74.8%. CVS-Q scale revealed 83.9% of computer vision syndrome among participants. A weak positive correlation was found between CVS-Q and LF-EMF, while a moderately strong, negative correlation was found between LF-EMF and Schirmer test of both eyes. The work environment LF-EMF values were significantly higher among the

participants diagnosed with CVS ($p<0.05$). The risk of CVS was found to increase 3.27 times when the ambient LF-EMF was >1,725 μT and an increase of 0.004 units in the CVS-Q score was calculated for each one-unit increase in the LF-EMF of the environment.

Conclusions: A relationship between CVS, dry eye and EMF was observed among people exposed to LF-EMF. Regular measurement of EMF in work environments, and developing protective behaviours (work-break intervals, 20-20-20 rule, etc.) can be recommended.

Open access paper: https://www.europeanreview.org/article/31541

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Effect of prenatal stress and extremely low-frequency electromagnetic fields on anxiety-like behavior in female rats: With an emphasis on prefrontal cortex and hippocampus

Hosseini E, Kianifard D. Effect of prenatal stress and extremely low-frequency electromagnetic fields on anxiety-like behavior in female rats: With an emphasis on prefrontal cortex and hippocampus. Brain Behav. 2023 Mar 21:e2949. doi: 10.1002/brb3.2949.

Abstract

Objective: Prenatal stress (PS) is a problematic situation resulting in psychological implications such as social anxiety. Ubiquitous extremely low-frequency electromagnetic fields (ELF-EMF) have been confirmed as a potential physiological stressor; however, useful neuroregenerative effect of these types of electromagnetic fields has also frequently been reported. The aim of the present study was to survey the interaction of PS and ELF-EMF on anxiety-like behavior.

Method: A total of 24 female rats 40 days of age were distributed into four groups of 6 rats each: control, stress (their mothers were exposed to stress), EMF (their mothers underwent to ELF-EMF), and EMF/stress (their mothers concurrently underwent to stress and ELF-EMF). The rats were assayed using elevated plus-maze and open field tests.

Results: Expressions of the hippocampus GAP-43, BDNF, and caspase-3 (cas-3) were detected by immunohistochemistry in Cornu Ammonis 1 (CA1) and dentate gyrus (DG) of the hippocampus and prefrontal cortex (PFC). Anxiety-like behavior increased in all treatment groups. Rats in the EMF/stress group presented more serious anxiety-like behavior. In all treatment groups, upregulated expression of cas-3 was seen in PFC, DG, and CA1 and downregulated expression of BDNF and GAP-43 was seen in PFC and DG and the CA1. Histomorphological study showed vast neurodegenerative changes in the hippocampus and PFC.

Conclusion: The results showed female rats that underwent PS or/and EMF exhibited critical anxiety-like behavior and this process may be attributed to neurodegeneration in PFC and DG of the hippocampus and possibly decreased synaptic plasticity so-called areas.

Open access paper: https://onlinelibrary.wiley.com/doi/full/10.1002/brb3.2949

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Liver tissues oxidative status, epigenetic and molecular characteristics in rats administered magnetic and microwave treated water

Elmoslemany AM, Ghamry HI, Awad AA, El-Kholy RI, Almami ISM, Alyamani NM, Zedan AMG. Liver tissues oxidative status, epigenetic and molecular characteristics in rats administered magnetic and microwave treated water. Sci Rep. 2023 Mar 16;13(1):4406. doi: 10.1038/s41598-023-31168-9.

Abstract

Physical and chemical changes in the natural of water may affect biological organisms. In this study, we highlight the effect of magnetized-water and microwave-water on rats' liver tissues. Three groups of albino rats were separated. The first, rats were administered tap-water. The second, rats were administered magnetized-water. The third, rats were administered microwave-water. After two months, the results revealed a significant increase in liver functioning enzymes' levels and bilirubin in rats administered microwave-water, compared to tap- and magnetic-water. In relation to oxidative stress, there was a significant increase and decrease in oxidative and antioxidant parameters respectively in liver tissues of rat's administrated microwave-water. At the molecular level, there was a significant down-regulation in Metallothionein, CYP genes in magnetic-water compared to tap-water. Rats administered microwave-water have shown a significant down-regulation in GST, Metallothionein and CYP genes' expression, however, Amylase and HDAC3 genes were significantly up-regulated, compared to the other groups. The intake of microwave-water resulted in notable histopathological changes in liver tissues. Rats administered magnetic-water showed no clear changes in their liver tissues. In summary, microwave-water induced stress and epigenetic effects compared with magnetic-water and tap-water. Also, magnetic-water produced from the higher magnetic power had no side effect on liver tissues.

Open access paper: https://www.nature.com/articles/s41598-023-31168-9

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Effects of a 50 Hz Electric Field on Brain Tissue and Blood Tissue

Şenol N, Kaya E, Coşkun Ö, Aslankoç R, Çömlekçi S. Evaluation of the Effects of a 50 Hz Electric Field on Brain Tissue by Immunohistochemical Method, and on Blood Tissue by Biochemical, Physiological and Comet Method. *Applied Sciences*. 2023; 13(5):3276. doi: 10.3390/app13053276

Abstract

The aim of this study was to evaluate the possible effects of a 50 Hz electric field on brain tissue and the positive effects of juglone (5-hydroxy-1,4-naphthoquinone) antioxidant activity, using the immunohistochemical technique on male Wistar-Albino rats. The effects on blood tissue were also examined using biochemical, physiological and comet methods. Animals were randomly divided into three groups (eight in each group): group I: control, group II: electric field, group III: 50 Hz electric field + juglone (5-hydroxy-1,4-naphthoquinone)/300

ppm. Juglone was applied per day by gavage over 30 days. At the end of the experimental procedure, animals were sacrificed and brain tissue was subjected to routine histologic and immunohistochemical processes. As a result of histopathological examination, the brain tissue of rats with 50 Hz electric field exposure showed severe histopathological changes. The differences between groups were statistically significant according to total comet score ($p = 0.001$). For the antioxidant parameters on the blood, SOD activity in the electric field group was significantly higher among the other groups, although we did not find significant differences in MDA, CAT activity level.

Open access paper: https://www.mdpi.com/2076-3417/13/5/3276

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Statistical Amplification of the Effects of Weak Magnetic Fields in Cellular Translation

Binhi VN. Statistical Amplification of the Effects of Weak Magnetic Fields in Cellular Translation. Cells. 2023 Feb 24;12(5):724. doi: 10.3390/cells12050724.

Abstract

We assume that the enzymatic processes of recognition of amino acids and their addition to the synthesized molecule in cellular translation include the formation of intermediate pairs of radicals with spin-correlated electrons. The mathematical model presented describes the changes in the probability of incorrectly synthesized molecules in response to a change in the external weak magnetic field. A relatively high chance of errors has been shown to arise from the statistical enhancement of the low probability of local incorporation errors. This statistical mechanism does not require a long thermal relaxation time of electron spins of about 1 μs-a conjecture often used to match theoretical models of magnetoreception with experiments. The statistical mechanism allows for experimental verification by testing the usual Radical Pair Mechanism properties. In addition, this mechanism localizes the site where magnetic effects originate, the ribosome, which makes it possible to verify it by biochemical methods. This mechanism predicts a random nature of the nonspecific effects caused by weak and hypomagnetic fields and agrees with the diversity of biological responses to a weak magnetic field.

https://pubmed.ncbi.nlm.nih.gov/36899858/

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Effects of Intermediate Frequency (150 kHz) Electromagnetic Radiation on the Vital Organs of Female Sprague Dawley Rats

Sundaram V, Mohammed S, Cockburn BN, Srinivasan MR, Venkata CRA, Johnson J, Gilkes L, Jones KR, Zyuzikov N. Effects of Intermediate Frequency (150 kHz) Electromagnetic Radiation on the Vital Organs of Female Sprague Dawley Rats. Biology (Basel). 2023 Feb 14;12(2):310. doi: 10.3390/biology12020310.

Abstract

Exposure to electromagnetic radiation (EMR) from intermediate frequency sources has increased exponentially in recent years. The consequences of this exposure on biological systems are prompting scientists to study the effects on human health. This current study aimed to determine the effects of intermediate frequency (150 kHz) EMR exposure on the vital organs of female Sprague Dawley rats. The EMR group (*n* = 10 animals) was exposed to a frequency of 150 kHz with an intensity of 65 ± 15 μW/cm^2 for two months. The control group (*n* = 10 animals) was exposed to an intensity of 35 ± 15 nW/cm^2. Haematological, histochemical, gross, and histopathological profiles of all major organs of all animals were then performed using standard procedures. All major organs generally showed no significant detectable effects in either the control or EMR groups. However, gross and histopathological examinations revealed the effects of EMR on the liver and lungs, which showed inflammatory changes without significant biochemical/haematological manifestations. In addition, a significant increase in serum sodium level and a decrease in serum urea level were also observed in the EMR group. It can be concluded that the current frequency and duration of exposure trigger the changes in the liver and lungs but are not sufficient to cause clinical and functional manifestations. Therefore, a long-term exposure study might be helpful to determine the effects of 150 kHz IF EMR on these organs.

Open access paper: https://www.mdpi.com/2079-7737/12/2/310

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Problems in evaluating the health impacts of radio frequency radiation

Ishai PB, Davis D, Taylor H, Birnbaum L. Problems in evaluating the health impacts of radio frequency radiation. *Environmental Research*. 2023. doi: 10.1016/j.envres.2022.115038.

Abstract

In an effort to clarify the nature of causal evidence regarding the potential impacts of RFR [radio frequency radiation] on biological systems, this paper relies on a well-established framework for considering causation expanded from that of Bradford Hill, that combines experimental and epidemiological evidence on carcinogenesis of RFR. The Precautionary Principle, while not perfect, has been the effective lodestone for establishing public policy to guard the safety of the general public from potentially harmful materials, practices or technologies. Yet, when considering the exposure of the public to anthropogenic electromagnetic fields, especially those arising from mobile communications and their infrastructure, it seems to be ignored. The current exposure standards recommended by the Federal Communications Commission (FCC) and International Commission on Non-Ionizing Radiation Protection (ICNIRP) consider only thermal effects (tissue heating) as potentially harmful. However, there is mounting evidence of non-thermal effects of exposure to electromagnetic radiation in biological systems and human populations. We review the latest literature on *in vitro* and *in vivo* studies, on clinical studies on electromagnetic hypersensitivity, as well as the epidemiological evidence for cancer due to the action of mobile-based radiation exposure. We question whether the current regulatory atmosphere truly serves the public good when considered in terms of the Precautionary Principle and the principles for deducing causation established by Bradford Hill. We conclude that there is substantial scientific evidence that RFR causes cancer, endocrinological, neurological and other adverse health effects. In light of this evidence the primary mission of public bodies, such as the FCC to protect public health has not been

fulfilled. Rather, we find that industry convenience is being prioritized and thereby subjecting the public to avoidable risks.

Excerpts

The perennial question of the biological impacts of Radio Frequency Radiation (RFR) constitutes an especially challenging matter that has come to the fore recently, in part driven by public concerns over the introduction of 5G mobile communications. 5G Small Cell base stations are permitted to be sited as close as 3 m [meters] from the ground in proximity to homes, schools and offices in many locales in the US. In the U.S. alone, the industry estimates that up to one million new antennas will be required. 5G ranges broadly from 800 MHz to 100 GHz ...

It is important to note that such dismissive studies presume that the sole biological impact of RFR is a consequence of heating. This presumption ignores a substantial body of independent studies finding that RFR induces numerous adverse biochemical changes affecting the formation of free radicals, the rates of cell growth and death, and cellular membrane transport. These changes are widely reported in organisms as diverse as plants, animals, and humans. Furthermore, the Directorate-General for Parliamentary Research Services (Belpoggi, 2021) of the European Union, and an independent Swiss government scientific advisory group (BERENIS) reaches similar conclusions, adding that "EMF (Electromagnetic Fields) are probably carcinogenic for humans, in particular related to gliomas and acoustic neuromas." In addition, they add that "… … 450–6000 MHz: these frequencies clearly affect male fertility and possibly female fertility too. They may have adverse effects on the development of embryos, fetuses and newborns". This indicates that EMF/RF functions like a classic endocrine disruptor impairing both male and female reproductive functions....

... Recent experimental and epidemiological studies have added considerably to the record and have led Miller et al., 2018 to conclude that on the basis of evidence amassed as of 2018 RFR constitutes a class one proven human carcinogen. Another more recent report concurred (Hardell and Carlberg, 2020), as do the recent publications by Lin (2022b) and the (International Commission on the Biological Effects of Electromagnetic Fields (ICBE-EMF), 2022). This paper builds further on those records and provides an update on the science applying the principles for deducing a causal relationship between RFR and cancer.

These conclusions regarding the carcinogenic and other potential adverse effects of RFR are not shared equally, with strong dissent provided by a vocal number of industry-affiliated scientists (Foster et al., 2000, 2022; Grimes, 2021; Repacholi, 2010). While some that have questioned the causal nature of the relationship may be well-meaning, a disproportionate number of those who discount the data are in the direct or indirect employ of the affected telecom industries. As a result, the ability to carry out independent analysis of the matter remains hampered, fueled in no small part by the genuine complexity of the topic and by a well-organized effort to 'manufacture doubt' (Alster, 2015; Weller et al., 2022).

Given the unprecedented and exponentially rising growth in worldwide exposures to this technology, the lack of a vibrant well-funded program of training and research constitutes a major problem. Since the 1990s, panels of government and other experts have repeatedly examined the scientific evidence, found it wanting and called for more research to be conducted. Although the call for further research constitutes the one matter on which all are agreed, funding for this work remains quite limited. Thus, the principal output of such inquiries is to recommend research but has not resulted in major ongoing funding for such research. By the end of the 1990s,

Motorola had closed its world class bioelectromagnetics laboratory. The U.S. government programs on the subject were defunded by Congress at the same time. Thus, on this matter the absence of evidence is not proof of safety. Rather it is an indication of the intense struggle that has led to a lack of funding with respect to critical research questions, the failure to monitor human and environmental health impacts, and the ongoing manufacturing of doubt that has been documented by a number of experts (Davis, 2010)....

To clarify the matter, this four-part review evaluates the epistemological foundations for concluding that RFR is carcinogenic in animals and humans. First, we explore possible mechanisms of action underlying biological impacts of non-ionizing RFR. Then we assess recent key experimental findings including detailed reports from the genetic toxicology component of the National Toxicology Program (NTP) study (M. Wyde et al., 2018). We also evaluate evidence from evaluations of exposed human populations obtained through case-control and population-based studies. Finally, we consider the weight of evidence that RFR constitutes a carcinogen and also promotes other negative health effects....

Conclusion

There is a plethora of both experimental and epidemiological evidence establishing a causal relationship between EMF and cancer and other adverse health effects including adverse effects on fetal development and the endocrine system. Increases in biochemical alterations such as DNA damage, increased production of free radicals and other signals found to be predictive of cancer and other degenerative diseases have been clearly demonstrated. While the evidence is not consistent, the reasons for that inconsistency merit independent review and assessment. A number of industry-affiliated scientists have offered criticisms that are subject to bias, as we have outlined here. If progress is to be made in improving the public understanding of this complicated issue, it is imperative to insist on a complete picture of the evidence that relies on independent science.

While we may disagree strongly with the conclusions some critics have provided, we concur wholeheartedly that there is a need for a serious concerted program of research. No such program exists with support from National governments in the United States and Canada. The job of the government is to ensure the protection of Public Health. We earnestly hope that as the situation evolves, those in positions to create the training and funding for major interdisciplinary research programs in engineering, medicine, toxicology, and bioelectromagnetics will do so. In the meantime, we add our voices to those of more than four hundred experts in the field calling for discussion of a moratorium on 5G. Without such a program we are effectively conducting an uncontrolled experiment on ourselves, our families, and our children.

Indeed, the subject of RFR and carcinogenicity remains truly complex. Studies have to simulate intricate exposures that are taking place every day to billions of people around the world. Given the ubiquity of the technology, as we move ahead it will not be possible to find an unexposed control group in the modern world. The inarguable intricacy of the technology can easily become a way of confusing rather than clarifying the matter. The subject of the impact of RFR on human health is one of the most important topics of our age. It is one in which the general public seeks clear answers to a collective, but poorly defined angst. It is the job of experts to present the state of knowledge in clear and concise language that the layman can understand. The numerous omissions and distortions in recent articles originating from the industry perspective do not meet this

criteria. The medical and public health communities deserve the whole story, no matter how complicated or unpalatable it may be. There is an abundance of evidence pointed towards deleterious effects of RFR exposure on human health. Further, the growing applications of low levels of RF in medicine through electroceuticals constitutes evidence per se of biological impacts (Mishra, 2017). Any agent that can be beneficial, whether aspirin or oncology drugs, can also have negative impacts. Consequently, it is imperative to insist on a complete picture of the evidence and not the whitewashed or distorted version currently promoted. The need to take into account the complete weight of the evidence in devising regulatory policies is widely ignored to our detriment. It is time that the Precautionary Principle be applied to RFR.

https://www.sciencedirect.com/science/article/pii/S0013935122023659

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Special issue editorial: In vivo experimental studies of prenatal and neonatal exposures to EMF provide grounds for epidemiological surveillance and precaution

Kaplan S, Davis DL, Steinbusch HWM. Special issue editorial: In vivo experimental studies of prenatal and neonatal exposures to EMF provide grounds for epidemiological surveillance and precaution. J Chem Neuroanat. 2023 Feb 1;129:102238. doi: 10.1016/j.jchemneu.2023.102238**.**

No abstract

Excerpt

The widespread use of wireless communication tools such as mobile phones and their effects on human health requires serious investigation. Since cell phones are employed in close proximity to the brain and body, the impact of exposure to different frequencies of EMF on the central nervous system also requires careful evaluation. This special issue provides an in-depth look at the effects of different frequencies of EMF emitted from mobile phones on the brain. The findings can be regarded as preliminary indications of a wide range of potential neurological problems that may be expected to increase in the near future, extending from behavioral issues to autism and other more serious neuronal disturbances.

We hope that this special issue, which covers the effects of EMF exposure on the nervous system and neurodevelopmental processes, will encourage researchers to conduct epidemiological studies on human subjects. In the meantime, we concur with those researchers that conclude that current experimental evidence provides grounds for reducing human exposures to wireless radiation, especially for the young, pregnant woman and men who wish to father healthy children.

https://pubmed.ncbi.nlm.nih.gov/36736746

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Development of the Microwave Syndrome in Two Men Shortly after Installation of 5G on the Roof above their Office

Nilsson M, Hardell L. Development of the Microwave Syndrome in Two Men Shortly after Installation of 5G on the Roof above their Office. Ann Clin Case Rep. 2023; 8: 2378.

Abstract

The 5th generation, 5G, for wireless communication is rolled out without previous studies on potential effects on human health and the environment. In this case study we describe two men, case 1 and case 2, working in three office rooms close to base stations. After the deployment of 5G, both men developed symptoms typical for the microwave syndrome, e.g., headache, tinnitus, dizziness, balance disorder, concentration and attention deficiency, and fatigue. Radiofrequency Radiation (RFR) after the 5G deployment was measured in the three offices. In office one maximum (peak) RFR during one minute varied from 463 to 1,180,000 µW/m2, in office two from 6,230 to 501,000 and in office three from 13,700 to 613,000 µW/m2. The symptoms disappeared in both men within a couple of weeks (case 1) or immediately (case 2) after leaving the office for other offices with much lower maximum peak RFR emissions, maximum for case 1 =16 and for case 2 =2,920 µW/m2. This case report may be regarded as a provocation study on health from 5G RFR. The clinical picture in both men was clearly related to the exposure, although the exposures were well below the guidelines recommended by ICNIRP that are claimed to protect against all health effects. We conclude that the guidelines for RFR exposure based only on tissue heating by ICNIRP are inadequate to protect human health and that 5G appears to provoke symptoms of microwave syndrome in previously healthy people.

Open access paper: https://www.anncaserep.com/abstract.php?aid=9589

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Overview of the Evaluation Methods for the Maximum EMF Exposure in 5G Networks

Fellan A, Schotten HD. Overview of the Evaluation Methods for the Maximum EMF Exposure in 5G Networks. 2022 IEEE Conference on Standards for Communications and Networking (CSCN), Thessaloniki, Greece, 2022, pp. 53-57, doi: 10.1109/CSCN57023.2022.10050915.

Abstract

Instantaneous measurements of the electromagnetic field (EMF) strength do not reflect the maximum exposure levels possible in a given location. An extrapolation factor needs to be applied to the measurements before comparing them against the local exposure guidelines or recommendations for compliance evaluation. For the fifth generation (5G) networks, a standardized approach for extrapolating EMF values is yet to be defined. This work provides an overview of the state-of-the-art research that focuses on estimating the maximum EMF exposure caused by radiation from 5G base stations. It also considers current efforts by national and international organizations to establish standardized methods for extrapolating the EMF measurements which is necessary in investigating conformance with the EMF guidelines and regulations.

Conclusions

In this work, we provided a short review of current research on the extrapolation of 5G NR EMF measurements to the maximum EMF exposure values; a necessary step to ensure the compliance of 5G NR BSs with the EMF exposure limits and guidelines, set by organizations such as the ICNIRP or the responsible national regulatory

authorities, that are intended to protect humans and the environment. We classified the research efforts based on the measurement method used in the two main categories of frequency-selective and code-selective methods. We also summarized some of the national and international standardization endeavours that aim to set a reference method for evaluating the human EMF exposure taking into consideration the recent 5G technology. We plan to use this overview as a foundation for choosing the appropriate measurement methodology and EMF extrapolation method to assess our recently deployed 5G campus network in Kaiser-slautern [9].

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Occupational Exposure to Nonionizing Radiation and Risk for Malignancy in Young Adults

Shapira S, Nitecki M, Tzur D, Schwartz N, Silverman BG, Zack O, Friedensohn-Zuck L. Occupational Exposure to Nonionizing Radiation and Risk for Malignancy in Young Adults. *Military Medicine*, 2023. doi: 10.1093/milmed/usad020.

Abstract

Introduction Nonionizing radiation (NIR) is considered “possibly carcinogenic to humans,” and therefore, exposure of young military personnel raises concerns regarding increased risk for cancer. The aim of our study was to compare the cancer incidence in exposed and nonexposed populations in order to gain better understanding of their risk.

Materials and Methods A longitudinal retrospective cohort study, between 2009 and 2018, was conducted. Israel Defense Forces (IDF) aerial defense units service members, with NIR exposure (range of 2-300 GHz, below the International Commission of Non-Ionizing Radiation Protection guidelines), were compared with a similar sociodemographic group of service members without NIR exposure. Both groups were followed for cancer incidence (all-cause and specific malignancies). Kaplan–Meier analysis of cancer-free survival and univariate and multivariable logistic regressions for possible confounders and risk factors were performed. This analysis was repeated on a matched 1:1 control group.

Results Exposure and comparison groups included 3,825 and 11,049 individuals, respectively. Forty-one cases diagnosed with cancer were identified during the follow-up time (mean 4.8 [±2.7] years), 13 (0.34%) of which were reported in the exposure group, and 28 (0.25%) were reported in the comparison group. The odds ratio (OR) for cancer incidence in the exposure vs. control groups was 1.34 (95%CI, 0.70-2.60), *P*-value = 0.3807. The results remained unchanged after adjustment for sex, age at enrollment, service length, socioeconomic status, and military occupation (adjOR = 1.38 [95%CI, 0.67-2.82], *P* = 0.3818).

Conclusions Our study did not find an increased short-term risk for cancer in young adults exposed to NIR radiation as compared with unexposed young adults.

Excerpts

A trend toward a higher rate of hematological and testicular malignancies was reported, albeit was statistically insignificant.

The main shortcoming of most epidemiological data, both in the military and in mobile communication risk assessment, is a lack of a personal exposure dose measurement.... Another limitation is the relatively short follow-up period (a median of 4.4 years in the exposed group), which may be insufficient to diagnose some types of malignancies, although following our population for over 17,710 person years. Considering the rarity of cancer diagnosis in young adults, this study might have been underpowered to detect the effect of NIR because of an overall small number of cases despite the large cohort.

In this study, occupational exposure to NIR radiation did not increase the risk for cancer in young adults during the 9-year follow-up, as compared with unexposed individuals. Constant regulation of exposures by the IDF Occupational Health Administration as well as epidemiological surveillance is important for monitoring and reassessing possible health effects of modern radar systems.

https://academic.oup.com/milmed/advance-article/doi/10.1093/milmed/usad020/7025337

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Effect of Mobile Phone use on Hearing in Young Adults: An Observational Study

Sharma D, Chauhan A, Thakur S. Effect of Mobile Phone use on Hearing in Young Adults: An Observational Study. Indian J Otolaryngol Head Neck Surg. 2022 Dec;74(Suppl 3):3754-3757. doi: 10.1007/s12070-021-02523-x.

Abstract

There are concerns regarding the health effects of electromagnetic fields (EMFs) generated by mobile phones. There are apprehensions regarding the effect of these radiations on auditory system. The objective of this study was to find the effect of mobile phone on hearing in young adults. We studied 75 medical students who were mobile phone users for >1 year. Initial hearing status of subjects was assessed by Pure Tone Audiometry (PTA), Otoacoustic emissions (OAE) and Brainstem evoked response audiometry (BERA) at the time of enrollment in the study and repeat audiological assessment was conducted at 6 months and again at one year and comparison was done. The mean age of the population was 20.13 + 1.33 years. Right, left and no particular preference for any ear was seen in 74.7%, 16% and 9.3%, respectively. Mean PTA at baseline in right ear at baseline, 6 months and 1 year was 12.71 ± 3.51 dB, 13.73 ± 3.69 dB and 14.07 ± 3.25 dB (*p* value=0.120), respectively and the same values for left ear were 13.28±3.57, 14.32±3.10 and 14.24±3.20 (*p* = 0.170) at baseline, 6 months and 1 year. No statistically significant difference in hearing thresholds was seen at baseline and at subsequent follow-ups and between dominant ear and non-dominant ear on BERA and OAE. We did not find any short term effect of mobile phones on the hearing in young adults, however, long term effect on hearing with progressing age cannot be ruled out.

https://pubmed.ncbi.nlm.nih.gov/36742690/

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Association of Autonomic Balance With Phone Call Duration in Healthy Individuals

Gangwar V, Gupta S, Verma M, Singh AK, John N, Jasrotia RB, Singh A. Association of Autonomic Balance With Phone Call Duration in Healthy Individuals. Cureus. 2023 Jan 9;15(1):e33566. doi: 10.7759/cureus.33566.

Abstract

Background This study aimed to estimate the association of autonomic balance with the duration of phone calls in healthy individuals.

Methodology A total of 30 subjects aged between 18 and 30 years without any established systemic disease and using mobile phones for more than five years with minimum daily usage of 30 minutes were included in this analytical study. Heart rate variability (HRV) was recorded using a three-channel physiograph (AD Instruments South Asia (India) Pvt. Ltd., New Delhi, India) with the software LabChart PROV8.1.8 with HRV Module version 2.0.3 for 10 minutes. Time domain parameters were recorded in terms of the standard deviation of normal to normal interval (SDNN), root mean square of successive differences between normal heartbeats (RMSSD), R-R intervals greater than 50 ms (pRR50), and mean heart rate (MHR), and frequency domain parameters were total power, low-frequency power (LF), high-frequency power (HF), and the ratio of low-frequency to high-frequency power (LF/HF). HRV was recorded three times in each subject that included baseline HRV, HRV during the use of a mobile phone, and HRV after the use of a mobile phone.

Results A total of 30 subjects (14 males and 16 females) participated in this study. The mean age of participants was 31.93 ± 8.59 years (32.07 ± 9.87 years for males, and 31.81 ± 7.64 years for females). There were no findings of significant arrhythmia in any of the participants. There was a significant difference in pRR50 on comparing all three phases ($p = 0.036$). However, there was no significant variation in other parameters such as very low frequency (VLF, ms^2), VLF (%), LF (ms^2), LF (%), HF (ms^2), HF (%), LF/HF, SDNN (ms), RMSSD (ms), Poincare plot standard deviation perpendicular to the line of identity (ms), Poincare plot standard deviation along the line of identity (ms), systolic blood pressure (mmHg), and diabolic blood pressure (mmHg) during, before, and after exposure to mobile phone calls. There was no significant difference in the value of all parameters between males and females ($p < 0.05$).

Conclusions Mobile phone calls may influence HRV and autonomic balance. This change may be affected by the electromagnetic field and by speaking as well.

Open access paper: https://www.cureus.com/articles/129516-association-of-autonomic-balance-with-phone-call-duration-in-healthy-individuals#!/

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Joint Uplink and Downlink EMF Exposure: Performance Analysis and Design Insights

Chen L, Elzanaty A, Kishk MA, Chiaraviglio L, Alouini M -S. Joint Uplink and Downlink EMF Exposure: Performance Analysis and Design Insights. IEEE Transactions on Wireless Communications. 2023. doi: 10.1109/TWC.2023.3244155.

Abstract

Installing more base stations (BSs) into the existing cellular infrastructure is an essential way to provide greater network capacity and higher data rates in the 5th-generation cellular networks (5G). However, a non-negligible amount of the population is concerned that such network densification will generate a notable increase in exposure to electric and magnetic fields (EMF) over the territory. In this paper, we analyze the downlink, uplink, and joint downlink&uplink exposure induced by the radiation from BSs and personal user equipment (UE), respectively, in terms of the received power density and exposure index. In our analysis, we consider the EMF restrictions set by the regulatory authorities such as the minimum distance between restricted areas (e.g., schools and hospitals) and BSs, and the maximum permitted exposure. Exploiting tools from stochastic geometry, mathematical expressions for the coverage probability and statistical EMF exposure are derived and validated. Tuning the system parameters such as the BS density and the minimum distance from a BS to restricted areas, we show a trade-off between reducing the population's exposure to EMF and enhancing the network coverage performance. Then, we formulate optimization problems to maximize the performance of the EMF-aware cellular network while ensuring that the EMF exposure complies with the standard regulation limits with high probability. For instance, the exposure from BSs is two orders of magnitude less than the maximum permissible level when the density of BSs is less than 20 BSs/km2.

Excerpt

In Fig. 16, when $R < 100$ m, the total exposure is mainly from the BSs in downlink but when $R \geq 100$ m, downlink exposure is gradually decreasing and uplink exposure becomes dominant. Namely, there exists an optimal value, e.g., $R* = 100$ m, that minimizes the total exposure for the network with $\lambda b = 10{-}4.5$ BSs/m2.

Conclusions

This paper integrated the EMF restrictions on the coverage performance and exposure analysis and formulated optimization problems on how to design the EMF-aware cellular networks. Particularly, the distribution of BSs was generated by a 13 PHP, accounting for the distance between BSs and restricted areas where the presence of BSs is prohibited. Using tools of stochastic geometry, we analyzed the radiation and coverage probability in terms of downlink and uplink. Furthermore, we investigated the effect of system parameters on the joint downlink&uplink radiation from both BSs and UE through EI. With the aid of numerical results, we showed that even the conservative evaluation of the 95-th percentile of EMF exposure level can still comply with the international guidelines, and the exposure in more typical settings is far below the maximum permissible level. It can also be seen that increasing the baseline density of BSs or decreasing the permitted distance around restricted areas can reduce the exposure from mobile equipment in uplink while exacerbating the exposure from BSs in downlink. Such opposite trend demonstrated the reasonability of taking joint downlink&uplink exposure into account when designing the system parameters for the EMF- aware cellular network. We found that there exists optimal values of the distance between restricted areas and BSs and the baseline density of BSs that minimizes the total exposure under a certain network configuration.

https://ieeexplore.ieee.org/document/10047969

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Investigation of Microwave Electromagnetic Fields in Open and Shielded Areas and Their Possible Effects on Biological Structure

Vaverka F, Smetana M, Gombarska D, Psenakova Z. Investigation of Microwave Electromagnetic Fields in Open and Shielded Areas and Their Possible Effects on Biological Structure. Sensors (Basel). 2023 Feb 20;23(4):2351. doi: 10.3390/s23042351.

Abstract

The article's subject is the investigation of electromagnetic fields (EMF) of the microwave frequency band in a typical human living environment, especially in shielded areas. The point of view of electromagnetic field presence in the environment with the rapid increase in the level of the electromagnetic background is currently an essential point concerning population protection against the potential adverse effects of such EMFs. The authors focus on actual measurements, especially in shielded spaces frequently used in everyday life, such as elevator cabins and cars. The goal is a quantitative evaluation of the distribution of specific vector quantities of the EM field and a comparison with the currently valid hygiene standards. Measured values in shielded spaces show elevated levels in contrast to the open space. However, the values do not exceed limits set by considering the thermal effect on living tissues.

Conclusions

This article dealt with the measurements of the EM field in the microwave frequency band in shielded areas. A dipole antenna was used to perform the experiments, while a discone antenna was also used to verify the measurement results and calibrate the instruments. The assessment of the degree of possible EMF influence in the microwave band was carried out given the current legislation in force in the EU. Hygienic limits set maximum permissible EMF values, converted to given tissue parameters, but they do not include situations where EMF sources are in a shielded environment (for example, underground parking garages, garages, cellars, personal elevators, etc.). This study showed that the values are significantly elevated in the premises in question. At the same time, under certain circumstances (for example, several people talking on the phone in an elevator simultaneously, etc.) it can potentially affect the proper function of various implantable electronic devices (pacemaker, insulin pump, etc.) [13,18,21].

Measurements in shielded spaces such as elevators and car cabins show the raised values of RF fields when using communication devices, even car-embedded hands-free. It is recommended to avoid using the phone in a shielded environment or vehicles. The effects of exposure to electromagnetic fields depend on the human health constitution and qualification.

The directives and standards limiting the exposure of EMF are electric field strength limits for the frequency range up to 1800 MHz for "Public" 58 V/m and "Occupational" 127 V/m and for the frequency range up to 2100 MHz for "Public" 61 V/m and "Occupational" 137 V/m. The electric field strength in shielded space is much lower in our measurements than in exposure limits. Nevertheless, it is advisable to approach the use of mobile devices, especially in shielded areas, with caution.

Open access paper: https://www.mdpi.com/1424-8220/23/4/2351

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Radiofrequency Exposure Levels in Greece

Tyrakis C, Theodorou K, Kiouvrekis Y, Alexias A, Kappas C. Radiofrequency Exposure Levels in Greece. Bioelectromagnetics. 2023 Feb 14. doi: 10.1002/bem.22434.

Abstract

Medical Physics Department (Medical School, University of Thessaly) participated in a Greek National EMF research program (EDBM34) with the scope to measure and evaluate radiofrequency (RF) exposure (27-3000 MHz) in areas of sensitive land use. A thousand (1000) measurements were carried out at two "metropolitan locations" (Athens and Thessaloniki: 624 points) and several rest urban/rural locations (376 points). SRM 3006 spectrum analyzer manufactured by Narda Safety Test Solutions was used. The broadband mean electric field in metropolitan areas was 0.41 V/m, while in the rest of Greece was 0.36 V/m. In metropolitan areas, the predominant RF source was the TV and Radio FM signals (36.2% mean contribution to the total RF exposure level). In the rest areas, the predominant source was the systems of the meteorological and military/defensive service (31.1%). The mobile sector contributed 14.9% in metropolitan areas versus 12.2% in the rest of Greece. The predominant mobile source was 900 MHz in both cases (4.5% in metropolitan areas vs. 3.3% in the rest of Greece). The total exposure from all RF sources complied with the International Commission on Non-Ionizing Radiation Protection (ICNIRP) 2020 safety guidelines [ICNIRP, 2020]. The maximum exposure level was 0.129% of the limit for the metropolitan areas vs. 0.110% for the rest of Greece. Nonremarkable differences between metropolitan areas' exposure and the rest of Greece. In most cases, new 5 G antennas will be added to the existing base stations. Thus, the total exposure may be increased, leading to higher safety distances.

https://pubmed.ncbi.nlm.nih.gov/36786436/

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Effects of generalization descriptions on risk perception

Freudenstein F, Boerner F, Croft RJ, Leung RWS, Loughran SP, Wiedemann PM. Effects of generalization descriptions on risk perception. Environ Res. 2023 Feb 2:115422. doi: 10.1016/j.envres.2023.115422.

Abstract

The study addresses the effects of generalization descriptions on risk perceptions. In a 1-factorial online experiment, 629 participants were randomly allocated to one of three groups. Group G1 received an excerpt of an original press release from the International Agency for Research on Cancer (IARC) regarding mobile phones and cancer, classifying RF EMF as possibly carcinogenic to humans. Group G2 received an additional explanatory text module, and Group G3 received a rewritten text, with both G2 and G3 highlighting that the possible cancer risk only refers to mobile phones. Risk perceptions regarding cell phones and related personal devices, base stations, and high voltage power lines were used as dependent variables measured before and after text

reading. Further, the degree to which participants generalized from cell phone-related to other RF EMF exposures was assessed to determine whether this was predictive of their post-text risk perceptions. Regarding risk perceptions, no differences between the three groups were observed after reading the presented texts. Instead, all three experimental groups indicated increased risk perceptions for all electromagnetic field sources. However, we found significant differences according to the prevailing risk generalization belief. Respondents expressing a strong risk generalization belief showed significantly higher risk perceptions for all tested EMF sources (except mobile phones) than subjects with a weak risk generalization belief.

Highlights

• The study investigated how different description formats regarding potential health effects influence risk perception.
• Further the role of respondents' risk generalization beliefs was investigated.
• The example of risk communication on electromagnetic fields (EMF) was used in an experimental setup.
• The study results indicate that all description formats elevated respondents' risk perception.
• It is also shown that a strong risk generalization belief leads to higher risk perceptions for all tested EMF sources.

Conclusion

Our findings point to the usefulness of Reyna's fuzzy trace theory for risk communication research (Reyna, 2021a, 2021b). This is because information does not equal knowledge. Studies analyzing effects of different information provision, such as in our study, cannot assume that the same information leads to the same knowledge and that different information leads to different knowledge. Therefore, it makes sense to consider manipulation checks that are common in psychological experiments from a theoretically perspective. Risk communication research would benefit from considering how information is interpreted and which mental representations are formed is essential when it comes to relevant risk communication.

The mental representation of given risk information, particularly the risk generalization belief, is critical for risk perception. These beliefs determine the risk perception of a group of associated exposure sources, in our case, mobile communication devices. Therefore, the risk generalization belief is a significant component of intuitive risk appraisal that should have a place in risk perception studies. Furthermore, we would like to underline that risk assessors should pay attention to indicate the scope of their risk evaluations, i.e., under which conditions and for which exposure sources they are valid. In addition, risk communicators should be aware of people's tendency towards risk generalization, and further research should explore how to correct generalization biases.

Open access paper: https://www.sciencedirect.com/science/article/pii/S0013935123002141?via%3Dihub

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Genotoxic Risks to Male Reproductive Health from Radiofrequency Radiation (Review)

Kaur P, Rai U, Singh R. Genotoxic Risks to Male Reproductive Health from Radiofrequency Radiation. *Cells*. 2023; 12(4):594. doi: 10.3390/cells12040594.

Abstract

During modern era, mobile phones, televisions, microwaves, radio, and wireless devices, etc., have become an integral part of our daily lifestyle. All these technologies employ radiofrequency (RF) waves and everyone is exposed to them, since they are widespread in the environment. The increasing risk of male infertility is a growing concern to the human population. Excessive and long-term exposure to non-ionizing radiation may cause genetic health effects on the male reproductive system which could be a primitive factor to induce cancer risk. With respect to the concerned aspect, many possible RFR induced genotoxic studies have been reported; however, reports are very contradictory and showed the possible effect on humans and animals. Thus, the present review is focusing on the genomic impact of the radiofrequency electromagnetic field (RF-EMF) underlying the male infertility issue. In this review, both in vitro and in vivo studies have been incorporated explaining the role of RFR on the male reproductive system. It includes RFR induced-DNA damage, micronuclei formation, chromosomal aberrations, SCE generation, etc. In addition, attention has also been paid to the ROS generation after radiofrequency radiation exposure showing a rise in oxidative stress, base adduct formation, sperm head DNA damage, or cross-linking problems between DNA & protein.

Conclusions

The present review reveals a better understanding of the genotoxic effects of radiofrequency radiation on male reproductive health emitted from mobile phones, laptops, microwaves, wireless networks, etc. The study focused on different endpoints such as DNA damage, micronuclei formation and genomic instability, SCE & chromosomal aberrations covering both in vitro and in vivo parameters. The available information following in vitro and in vivo exposure shows that all the yielded data has both positive and negative results. In this review, studies reported DNA fragmentation, apoptosis, and elevated protein expression in both human and animal spermatozoa, concluding a decrease in viability, mitochondrial genomic destruction and DNA strand breaks. Further micronuclei formation, SCE and chromosomal aberrations are also found to cause abnormalities, leading to the accumulation of mutations and hence causing cancer risk. While controversial investigation, on the other hand, supported with no effect on cellular apoptosis or DNA integrity. Our present study reviewed that RFR has insufficient energy production to generate genomic damage. Yet, such effects were probably found to be responsible for male infertility due to the indirect mechanism of oxidative stress via ROS generation in the exposed system. Few studies also suggested that the damage due to the cumulative effect of repeated exposure varies with physical parameters such as distance from the radiation source, short-term or long-term exposure duration, penetration depth, and frequency of exposure. Therefore, considering all data together, the present review supports the capability of radiofrequency radiation to induce genotoxicity underlying male infertility keeping some limitations in mind, since the report is a conclusion of narrative study and limited literature were found explaining the actual mechanism of micronuclei formation, sister chromatid exchange, chromosomal aberration and genomic instability. Hence, more studies are needed to elucidate the DNA damage mechanism with more robust study designs favoring potential genotoxic effects of RFR on male reproductive health.

Open access paper: https://www.mdpi.com/2073-4409/12/4/594

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Exposure to Low Levels of Radiofrequency Electromagnetic Fields Emitted from Cell-phones as a Promising Treatment of Alzheimer's Disease: A Scoping Review Study

Shirbandi K, Khalafi M, J Bevelacqua J, Sadeghian N, Adiban S, Bahaeddini Zarandi F, Mortazavi SA, Mortazavi SH, Mortazavi SMJ, S Welsh J. Exposure to Low Levels of Radiofrequency Electromagnetic Fields Emitted from Cell-phones as a Promising Treatment of Alzheimer's Disease: A Scoping Review Study. J Biomed Phys Eng. 2023 Feb 1;13(1):3-16. doi: 10.31661/jbpe.v0i0.2109-1398.

Abstract

Background: Alzheimer's disease (AD) is one of the most significant public health concerns and tremendous economic challenges. Studies conducted over the past decades show that exposure to radiofrequency electromagnetic fields (RF-EMFs) may relieve AD symptoms.

Objective: To determine if exposure to RF-EMFs emitted by cellphones affect the risk of AD.

Material and methods: In this review, all relevant published articles reporting an association of cell phone use with AD were studied. We systematically searched international datasets to identify relevant studies. Finally, 33 studies were included in the review. Our review discusses the effects of RF-EMFs on the amyloid β (Aβ), oxidative stress, apoptosis, reactive oxygen species (ROS), neuronal death, and astrocyte responses. Moreover, the role of exposure parameters, including the type of exposure, its duration, and specific absorption rate (SAR), are discussed.

Results: Progressive factors of AD such as Aβ, myelin basic protein (MBP), nicotinamide adenine dinucleotide phosphate (NADPH) oxidase, and neurofilament light polypeptide (NFL) were decreased. While tau protein showed no change, factors affecting brain activity such as glial fibrillary acidic protein (GFAP), mitogen-activated protein kinases (MAPKs), cerebral blood flow (CBF), brain temperature, and neuronal activity were increased.

Conclusion: Exposure to low levels of RF-EMFs can reduce the risk of AD by increasing MAPK and GFAP and decreasing MBP. Considering the role of apoptosis in AD and the effect of RF-EMF on the progression of the process, this review indicates the positive effect of these exposures.

Conclusion

Studies included in this review show that exposure to RF-EMFs act as a double-edged sword. While the findings of some studies indicate a reduced incidence of AD, other studies show an acceleration of the course of the disease. We believe that parameters such as the level of exposure (e.g., specific absorption rate, exposure duration, cumulative exposure, etc.) can determine if the response to RF-EMFs will prove beneficial or detrimental. A future research effort should be conducted to determine if there is an optimum range of SAR values or radio frequency ranges that affect AD either positively or negatively. Moreover, it is crucial to determine how the animal data can be translated into human effects. Therefore, further studies in this field are clearly warranted.

Open access paper: https://jbpe.sums.ac.ir/article_48598.html

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Neuroendocrine System Adaptation during Consecutive Extrinsic Stimuli: A Pilot Dynamic Study

Geronikolou SA, Vasdekis V, Mantzou A, Davos C, Cokkinos DV, Chrousos GP. Neuroendocrine System Adaptation during Consecutive Extrinsic Stimuli: A Pilot Dynamic Study. Children (Basel). 2023 Jan 30;10(2):248. doi: 10.3390/children10020248.

Abstract

This pilot repeated measures study aims to evaluate the dynamics of the autonomic nervous system (ANS), the hypothalamic–pituitary–adrenal (HPA) axis, and/or their interplay with low-level inflammation in healthy schoolchildren during consecutive extrinsic stimuli. Twenty healthy schoolchildren and adolescents aged 11–14 years (12.5 ± 1.5) were consecutively exposed to an oral task (#2) and an arithmetic task (#3) (Trier Social Stress Test for Children (TSST-C)), lasting 5 min each, and a three-minute cellular phone call (#4). Salivary cortisol (SC) was sampled at baseline (#1) and immediately after each exposure (#2, 3, and 4). Baseline serum high-sensitivity C-reactive protein (hsCRP) and cortisol levels were also assessed. ANS dynamics and complexity were measured using Sample Entropy (SampEn) at each experimental time period (#1–4). Baseline serum hCRP and cortisol correlated negatively to each other, while the ANS and HPA axis acute reactions to the three consecutive stimuli differed over time. The ANS adaptation to these stimuli included complexity modulation, which was not dependent on baseline hsCRP or cortisol, and weakened during the third stimulation. However, baseline hsCRP and cortisol had a weakening and an increasing effect on the HPA axis over time, respectively. We conclude that low-level inflammation and baseline morning cortisol level have no effect on ANS dynamics but influence the HPA axis response to consecutive external stimuli.

Open access paper: https://www.mdpi.com/2227-9067/10/2/248

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The Importance of Subcellular Structures to the Modeling of Biological Cells in the Context of Computational Bioelectromagnetics Simulations

Jerbic K, Svejda JT, Sievert B, Rennings A, Fröhlich J, Erni D. The Importance of Subcellular Structures to the Modeling of Biological Cells in the Context of Computational Bioelectromagnetics Simulations. Bioelectromagnetics. 2023;10.1002/bem.22436. doi:10.1002/bem.22436

Abstract

Numerical investigation of the interaction of electromagnetic fields with eukaryotic cells requires specifically adapted computer models. Virtual microdosimetry, used to investigate exposure, requires volumetric cell models, which are numerically challenging. For this reason, a method is presented here to determine the current and volumetric loss densities occurring in single cells and their distinct compartments in a spatially accurate manner as a first step toward multicellular models within the microstructure of tissue layers. To achieve this, 3D models of the electromagnetic exposure of generic eukaryotic cells of different shape (i.e. spherical and ellipsoidal) and internal complexity (i.e. different organelles) are performed in a virtual, finite element method-based capacitor experiment in the frequency range from 10 Hz to 100 GHz. In this context, the spectral response

of the current and loss distribution within the cell compartments is investigated and any effects that occur are attributed either to the dispersive material properties of these compartments or to the geometric characteristics of the cell model investigated in each case. In these investigations, the cell is represented as an anisotropic body with an internal distributed membrane system of low conductivity that mimics the endoplasmic reticulum in a simplified manner. This will be used to determine which details of the cell interior need to be modeled, how the electric field and the current density will be distributed in this region, and where the electromagnetic energy is absorbed in the microstructure regarding electromagnetic microdosimetry. Results show that for 5 G frequencies, membranes make a significant contribution to the absorption losses.

Open access paper: https://onlinelibrary.wiley.com/doi/10.1002/bem.22436

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Changes in cognitive function, synaptic structure and protein expression after long-term exposure to 2.856 and 9.375 GHz microwaves

Wang H, Liu Y, Sun Y, Dong J, Xu X, Wang H, Zhao X, Zhang J, Yao B, Zhao L, Liu S, Peng R. Changes in cognitive function, synaptic structure and protein expression after long-term exposure to 2.856 and 9.375 GHz microwaves. Cell Commun Signal. 2023 Feb 13;21(1):34. doi: 10.1186/s12964-022-01011-1.

Abstract

Health hazards from long-term exposure to microwaves, especially the potential for changes in cognitive function, are attracting increasing attention. The purpose of this study was to explore changes in spatial learning and memory and synaptic structure and to identify differentially expressed proteins in hippocampal and serum exosomes after long-term exposure to 2.856 and 9.375 GHz microwaves. The spatial reference learning and memory abilities and the structure of the DG area were impaired after long-term exposure to 2.856 and 9.375 GHz microwaves. We also found a decrease in SNARE-associated protein Snapin and an increase in charged multivesicular body protein 3 in the hippocampus, indicating that synaptic vesicle recycling was inhibited and consistent with the large increase in presynaptic vesicles. Moreover, we investigated changes in serum exosomes after 2.856 and 9.375 GHz microwave exposure. The results showed that long-term 2.856 GHz microwave exposure could induce a decrease in calcineurin subunit B type 1 and cytochrome b-245 heavy chain in serum exosomes. While the 9.375 GHz long-term microwave exposure induced a decrease in proteins (synaptophysin-like 1, ankyrin repeat and rabankyrin-5, protein phosphatase 3 catalytic subunit alpha and sodium-dependent phosphate transporter 1) in serum exosomes. In summary, long-term microwave exposure could lead to different degrees of spatial learning and memory impairment, EEG disturbance, structural damage to the hippocampus, and differential expression of hippocampal tissue and serum exosomes.

Excerpts

... There were no significant increases in rectal temperature ($p = 0.1000$, $p = 0.128$, $p = 0.104$) between the time points before and immediately after microwave exposure in any group, indicating that the effects of microwave radiation on the mice in this experiment were mainly nonthermal effects (Fig. 1C)....

The radiation duration in this study was based on the ICNIRP guidelines for Limiting Exposure to Electromagnetic Fields (2020 version), which established a standard time interval of 6 min for head health threats. Therefore,

6 min was used as a daily exposure time to explore the effects. Moreover, to determine whether the thermal effect played a role in the exposure period, a core temperature detection method was used in our study according to the previous literature [30]. The experimental results indicated that nonthermal effects were mainly involved in our study....

In summary, long-term microwave exposure (2.856 and 9.375 GHz, 6 min/d, 5 d/w, 6 w) led to different degrees of spatial learning and memory impairment, EEG disturbance, damage to hippocampal structure and differential expression of hippocampal tissue and serum exosomes. The SNARE-associated protein Snapin and charged multivesicular body protein 3 in the hippocampus could be used as sensitive markers of microwave exposure, and synaptic vesicle recycling was inhibited by long-term microwave exposure. Different proteins in serum exosomes were found after exposure to different frequency microwaves.

Open access paper: https://biosignaling.biomedcentral.com/articles/10.1186/s12964-022-01011-1

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Effects of Nonthermal Radiofrequency Stimulation on Neuronal Activity and Neural Circuit in Mice

Hao Y, Liu W, Liu Y, Liu Y, Xu Z, Ye Y, Zhou H, Deng H, Zuo H, Yang H, Li Y. Effects of Nonthermal Radiofrequency Stimulation on Neuronal Activity and Neural Circuit in Mice. Adv Sci (Weinh). 2023 Feb 8:e2205988. doi: 10.1002/advs.202205988.

Abstract

Whether the nonthermal effects of radiofrequency radiation (RFR) exist and how nonthermal RFR acts on the nervous system are unknown. An animal model of spatial memory impairment is established by exposing mice to 2856-MHz RFR in the range of thermal noise (≤1 °C). Glutamate release in the dorsal hippocampus (dHPC) CA1 region is not significantly changed after radiofrequency exposure, whereas dopamine release is reduced. Importantly, RFR enhances glutamatergic CA1 pyramidal neuron calcium activity by nonthermal mechanisms, which recover to the basal level with RFR termination. Furthermore, suppressed dHPC dopamine release induced by radiofrequency exposure is due to decreased density of dopaminergic projections from the locus coeruleus to dHPC, and artificial activation of dopamine axon terminals or D1 receptors in dHPC CA1 improve memory damage in mice exposed to RFR. These findings indicate that nonthermal radiofrequency stimulation modulates ongoing neuronal activity and affects nervous system function at the neural circuit level.

https://pubmed.ncbi.nlm.nih.gov/36755196/

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Pilot Study of the Long-Term Effects of Radiofrequency Electromagnetic Radiation Exposure on the Mouse Brain

Spandole-Dinu S, Catrina A-M, Voinea OC, Andone A, Radu S, Haidoiu C, Călborean O, Popescu DM, Suhăianu V, Baltag O, Tuță L, Roșu G. Pilot Study of the Long-Term Effects of Radiofrequency Electromagnetic Radiation Exposure on the Mouse Brain. *International Journal of Environmental Research and Public Health*. 2023; 20(4):3025. doi: 10.3390/ijerph20043025.

Abstract

The increasing radiofrequency (RF) electromagnetic radiation pollution resulting from the development and use of technologies utilizing RF has sparked debate about the possible biological effects of said radiation. Of particular concern is the potential impact on the brain, due to the close proximity of communication devices to the head. The main aim of this study was to examine the effects of long-term exposure to RF on the brains of mice in a real-life scenario simulation compared to a laboratory setting. The animals were exposed continuously for 16 weeks to RF using a household Wi-Fi router and a laboratory device with a frequency of 2.45 GHz, and were compared to a sham-exposed group. Before and after exposure, the mice underwent behavioral tests (open-field test and Y-maze); at the end of the exposure period, the brain was harvested for histopathological analysis and assessment of DNA methylation levels. Long-term exposure of mice to 2.45 GHz RF radiation increased their locomotor activity, yet did not cause significant structural or morphological changes in their brains. Global DNA methylation was lower in exposed mice compared to sham mice. Further research is needed to understand the mechanisms behind these effects and to understand the potential effects of RF radiation on brain function.

Open access paper: https://www.mdpi.com/1660-4601/20/4/3025

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Adverse effects of 900, 1800 and 2100 MHz radiofrequency radiation emitted from mobile phones on bone and skeletal muscle

Bektas H, Nalbant A, Akdag MB, Demir C, Kavak S, Dasdag S. Adverse effects of 900, 1800 and 2100 MHz radiofrequency radiation emitted from mobile phones on bone and skeletal muscle. Electromagn Biol Med. 2023 Feb 16:1-9. doi: 10.1080/15368378.2023.2179065

Abstract

The goal of this study was to biomechanically and morphologically research both the impact of mobile phone like radiofrequency radiations (RFR) on the tibia and the effects on skeletal muscle through oxidative stress parameters. Fifty-six rats (200-250 g) were put into groups: healthy sham (n = 7), healthy RFR (900, 1800, 2100 MHz) (n = 21), diabetic sham (n = 7) and diabetic RFR (900, 1800, 2100 MHz) (n = 21). Over a month, each group spent two hours/day in a Plexiglas carousel. The rats in the experimental group were exposed to RFR, but the sham groups were not. At the end of the experiment, the right tibia bones and skeletal muscle tissue were removed. The three-point bending test and radiological evaluations were performed on the bones, and CAT, GSH, MDA, and IMA in muscles were measured. There were differences in biomechanics properties and radiological evaluations between the groups ($p < .05$). In the measurements in the muscle tissues, significant differences were statistically found ($p < .05$). The average whole-body SAR values for GSM 900, 1800 and 2100 MHz were 0.026, 0.164, and 0.173 W/kg. RFRs emitted from mobile phone may cause adverse effects on tibia and skeletal muscle health, though further studies are needed.

https://pubmed.ncbi.nlm.nih.gov/36794487/

Conclusion

The results of this study show that mobile phone-derived RFRs (900, 1800 and 2100 MHz) may cause adverse effects on tibia bone and skeletal muscle health, according to bone biomechanics and morphological analysis evaluations and determined skeletal muscle oxidative stress parameters. It was observed that some of these adverse effects intensify with the increase in the frequency of the exposed RFR. In addition, these results suggest that the effects of mobile phone-derived RFRs on bone and muscle tissue should be investigated further through both molecular and histological analyses.

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Swimming exercise reduces oxidative stress and liver damage indices of male rats exposed to electromagnetic radiation

Amiri H, Shabkhiz F, Pournemati P, Saffar Kohneh Quchan AH, Zeighami Fard R. Swimming exercise reduces oxidative stress and liver damage indices of male rats exposed to electromagnetic radiation. Life Sci. 2023 Jan 30;317:121461. doi: 10.1016/j.lfs.2023.121461.

Abstract

Objectives: Hepatic damage caused by oxidative stress is one of the problems associated with the emission of electromagnetic radiation (EMR). In this study, the effects of swimming exercise (SE) on oxidative stress and liver cell damage caused by EMR emission in rats were investigated.

Methods: Thirty-two rats (8 weeks old) were randomly divided into four groups, including control (C), EMR, SE, and EMR + SE. During four weeks, the animals engaged in SE (30 min/session, 5session/week) and were also exposed to EMR (4 h/day, seven days/week) emission from a Wi-Fi 2.45GHZ router. The liver and blood samples were collected at 48 h after completing four weeks of SE to assess histopathological damage, oxidative stress, and liver enzymes.

Key findings: Tissue sections showed severe liver damage in the EMR group compared to the C group, while the SE attenuated the liver damage. In the EMR group, compared to the C, SE and EMR + SE groups, the activity of superoxide dismutase (SOD) and catalase (CAT) decreased significantly, and the concentration of malondialdehyde (MDA) and liver enzymes (AST, ALT, and ALP) increased significantly ($P < 0.05$). Swimming exercise in the SE and EMR + SE groups compared to EMR led to a significant increase in the activity of SOD and CAT and a significant decrease in the concentration of MDA and liver enzymes ($P < 0.05$).

Conclusion: The study findings showed that the SE is beneficial in attenuating the harmful effects of RF-EMR emitted from the Wi-Fi on the liver.

https://pubmed.ncbi.nlm.nih.gov/36731647/

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Exercise ameliorates hippocampal damage induced by Wi-Fi radiation; a biochemical, histological, and immunohistochemical study

Mohamed AO, Hafez SMNA, Ibrahim RA, Rifaai RA. Exercise ameliorates hippocampal damage induced by Wi-Fi radiation; a biochemical, histological, and immunohistochemical study. J Chem Neuroanat. 2023 Feb 14:102252. doi: 10.1016/j.jchemneu.2023.102252.

Highlights

• The use of electromagnetic devices has now increased. Additionally, using the wireless devices has an impact on human health.
• Physical activity is a good non-pharmacological strategy that protect against the adverse effects of electromagnetic waves
• This study investigates the protective effect of exercise on the hippocampal damage induced by waves of the Wi-Fi devices
• It preserves hippocampal structure, enhances neurogenesis and reduces oxidative stress induced by waves of the Wi-Fi devices.
• This provides an insight on the importance of exercise in prevention of many health problems including mental health.

Abstract

Introduction: Nowadays, using electromagnetic devices (EMD) has been increased. However, the control of EMD hazards was poorly evaluated, especially those affected the hippocampus. Regular physical exercises are safe, easily, inexpensive and acceptable for long-term use. It is reported that exercise protects against many health problems.

Aim: is to investigate the hypothesis of the possible prophylactic effect of exercise on the hippocampal damage induced by electromagnetic waves of Wi-Fi.

Material and methods: Adult male albino rats were divided into four groups: group I (control), group II (exercise), group III (Wi-Fi), and group IV (exercise -Wi-Fi). Hippocampi were subjected to biochemical, histological, and immunohistochemical techniques.

Results: In group III, a significant increase in the oxidative enzymes as well as decrease in antioxidant enzymes were detected in rat hippocampus. Additionally, the hippocampus showed degenerated pyramidal and granular neurons. An evident decrease in both PCNA and ZO-1 immunoreactivity was also noticed. In group IV, physical exercise alleviates the effect of Wi-Fi on previously mentioned parameters.

Conclusion: Regular physical exercise performance significantly minimizes the hippocampal damage and protects against the hazarders of chronic Wi-Fi radiation exposure.

https://pubmed.ncbi.nlm.nih.gov/36796735/

Excerpts

Wi-Fi device (802–16e 2005- WiMAX- Indoor CPE -antenna, model number: WIXFMM-130, China) with a frequency of 2.45 -GHz. Duration of radiation was 2 h per day in a 30-cm distance from antenna to the cages (Mahmoudi et al., 2018).

Animals of the exposed groups were exposed to Wi-Fi radiation from the 2nd week of the experiment for 2 h per day per week for 6 weeks, while the control and exercised groups were isolated in a separate room away from any source of radiation....

Regular exercise has three potential pathways that can help to reduce the risk associated with Wi-Fi radiation exposure. It could lower ROS levels and increase the activity of antioxidant enzymes. It also could enhance neurogenesis in the dentate gyrus which could compensate the degenerated cells resulting from EMR exposure. More-over it plays an important role in neuronal communication and survival.

Taken together, it could be concluded that physical exercise attenuates the effect of EMF exposure on the hippocampus through different mechanisms. It reduces oxidative stress, preserves neuronal structure, maintains BBB and synaptic integrity and enhances neurogenesis.

Further investigations on the prophylactic effect of exercise against EMR on different organs and at different time point using different spectrum is recommended. Also, further research about using antioxidant agents with exercise to augment the protective effect against hazards of Wi-Fi radiation is also recommended.

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Effects of 2.45 GHz Non-Ionizing Radiation on Anxiety-Like Behavior, Gene Expression, and Corticosterone Level in Male Rats: Long-term Radiation Exposure Modifies Memory and Anxiety Behavior

Tarsaei M, Peyrovan ZS, Mahdavi SM, Modarresi Chahardehi A, Vafaie R, Haidari MH. (2022). Effects of 2.45 GHz Non-Ionizing Radiation on Anxiety-Like Behavior, Gene Expression, and Corticosterone Level in Male Rats: Long-term Radiation Exposure Modifies Memory and Anxiety Behavior in Rats. *Journal of Lasers in Medical Sciences*, *13*, e56.

Abstract

The effects of short-term and long-term exposures to 2.45 GHz radiofrequency electromagnetic radiation (RF-EMR) on anxiety-like behavior, corticosterone level, and gene expression were investigated. The animals have been classified into eight groups, sham groups and, exposed groups for short-term and long-term exposure to the same dose of RF-EMR for one hour daily. The Wi-Fi equipment in the sham control group was not turned on during the experiment. The goal of this study was to explore the effect of electromagnetic fields of 2.45 GHz on clinical signs such as bodyweight and anxiety-like behavior, including the elevated plus maze test and open-field test, and also on messenger RNA (mRNA) expression of *Bax* (Bcl2-associated x) and *Bcl-2* (B-cell lymphoma 2) genes on the cognitive memory functions in an animal model of rats. Both genes were further confirmed by reverse transcriptase-polymerase chain reaction (RT-PCR). The semi-quantitative PCR method of

electromagnetic fields in the 2.45 GHz range impacted the expression of *Bax* and *Bcl-2* genes in the rat's memory. The present study exhibited that short-term radiation could decrease the percentage of entry into the open arm and the percentage of time spent, while there were no substantial impacts on the long-term radiation effect. Our data support the hypothesis that short-term exposure worked as a systemic stressor, raising plasma corticosterone and changing glucocorticoid receptor expression in the hippocampus. Additional research on this specific frequency and amount of radiation is required to discover strategies for protecting the nervous system from the detrimental effects of RF-EMR radiation.

Open access paper: https://journals.sbmu.ac.ir/jlms/article/view/39761

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Evaluation of cognitive functions and EEG records in rats exposed to 2.45 GHz electromagnetic field

Yucel H, Dundar NO, Doguc DK, Uguz C, Celik O, Aksoy FT, Nazıroglu M, Comlekci S, Dundar B. Evaluation of cognitive functions and EEG records in rats exposed to 2.45 GHz electromagnetic field. Int J Radiat Res 2022, 20(4): 753-760.

Abstract

Background: Electromagnetic fields may primarily affect cognitive functions. It has not been elucidated how electromagnetic radiation affects the brain, particularly in the young age group. We aimed to examine the cognitive function, expression of N-methyl-D-aspartate receptors (NMDA), and EEG alterations in weaned rats exposed to a 2.45 GHz electromagnetic field.

Materials and Methods: Twenty-one weaned (21 days old) male Wistar Albino rats were divided into two groups as experimental group (n=12) and control group (n=9). Animals in the experimental group were exposed to a 2.45 GHz electromagnetic field for one hour a day for more than 28 days. At the end of this period, rats were subjected to training and learning test using Morris Water Maze. After obtaining EEG records, hippocampi were removed. 2A and 2B subunits of NMDA receptors were studied in hippocampal homogenates using the Western Blot method.

Results: There were no statistically significant differences between the two groups in measures of latency to target quadrant, time spent in the target quadrant, and average swim speed as compared in Morris water maze. However, the time to arrive at the visible platform was significantly longer in experimental animals. There were no statistically significant differences in expression of 2A and 2B subunits of NMDA receptors between the two groups. Evaluation of EEG records revealed that spike frequency was significantly higher and time to first spike was significantly shorter in the experimental group.

Conclusion: These results indicated that a 2.45 GHz electromagnetic field might negatively affect EEG, motivation, and attention, particularly in the young age group.

Open access paper: http://ijrr.com/article-1-4460-en.pdf

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Evaluating the Effect of Jammer Radiation on Learning and Memory in Male Rats

Yazdanpanahi M, Namazi A, Shojaeifard MB, Nematolahi S, Pourahmad S. Evaluating the Effect of Jammer Radiation on Learning and Memory in Male Rats. J Biomed Phys Eng. 2023 Feb 1;13(1):29-38. doi: 10.31661/jbpe.v0i0.2001-1049.

Abstract

Background: Previous studies shown that mobile phone can impairment of working memory in humans.

Objective: In this study, the effect of radiofrequency radiation emitted from common mobile jammers have been studied on the learning and memory of rats.

Material and methods: In this prospective study, 90 Sprague-Dawley rats, were divided into 9 groups (N=10): Control, Sham1st (exposed to a switched-off mobile jammer device at a distance of 50 or 100 cm/1 day, 2 hours), Sham2nd (similar to Sham1st, but for 14 days, 2 h/day), Experimental1st -50 cm/1 day &100 cm/1 day (exposed to a switched-on device at a distance of 50 or 100 cm for 2 hours), Experimental2nd (similar to experimental1st, but for 14 days, 2 h/day). The animals were tested for learning and memory the next day, by the shuttle box. The time that a rat took to enter the dark part was considered as memory.

Results: Mean short-term memory was shorter in the experimental- 50 cm/1 day than control and sham- 50 cm/1 day (P=0.034), long-term memory was similar. Mean short- and long-term memory were similar in the experimental- 100 cm/1 day, control and sham- 100 cm/1 day (P>0.05). Mean short-term memory was similar in experimental- 50 cm/14 days, control, and sham- 50 cm/14 days (P=0.087), but long-term learning memory was shorter in the radiated group (P=0.038). Mean short- and long-term were similar among experimental-100 cm/14 days, control or sham 100 cm/14 days (P>0.05).

Conclusion: Rats exposed to jammer device showed dysfunction in short- and long-term memory, which shown the unfavorable effect of jammer on memory and learning. Our results indicated that the distance from radiation source was more important than the duration.

Excerpt: The mobile jammer used in this study was an MB06-Mobile blocker, designed for 4-four different frequencies, including code division multiple access, digital cellular service, global system for mobile (GSM) communication, and third-generation which blocks the following frequencies: 850, 900, and 1800 MHz. The shielding radius was indicated to be 0-40 m on the jammer device.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9923240/

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Microwaves can kill malaria parasites non-thermally

Coronado LM, Stoute JA, Nadovich CT, Cheng J, Correa R, Chaw K, González G, Zambrano M, Gittens RA, Agrawal DK, Jemison WD, Donado Morcillo CA, Spadafora C. Microwaves can kill malaria parasites non-thermally. Front Cell Infect Microbiol. 2023 Feb 2;13:955134. doi: 10.3389/fcimb.2023.955134.

Abstract

Malaria, which infected more than 240 million people and killed around six hundred thousand only in 2021, has reclaimed territory after the SARS-CoV-2 pandemic. Together with parasite resistance and a not-yet-optimal vaccine, the need for new approaches has become critical. While earlier, limited, studies have suggested that malaria parasites are affected by electromagnetic energy, the outcomes of this affectation vary and there has not been a study that looks into the mechanism of action behind these responses. In this study, through development and implementation of custom applicators for *in vitro* experimentation, conditions were generated in which microwave energy (MW) killed more than 90% of the parasites, not by a thermal effect but via a MW energy-induced programmed cell death that does not seem to affect mammalian cell lines. Transmission electron microscopy points to the involvement of the haemozoin-containing food vacuole, which becomes destroyed; while several other experimental approaches demonstrate the involvement of calcium signaling pathways in the resulting effects of exposure to MW. Furthermore, parasites were protected from the effects of MW by calcium channel blockers calmodulin and phosphoinositol. The findings presented here offer a molecular insight into the elusive interactions of oscillating electromagnetic fields with *P. falciparum*, prove that they are not related to temperature, and present an alternative technology to combat this devastating disease.

Open access paper: https://www.frontiersin.org/articles/10.3389/fcimb.2023.955134/full

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Impacts of Radio-Frequency Electromagnetic Field (RF-EMF) on Lettuce (*Lactuca sativa*)—Evidence for RF-EMF Interference with Plant Stress Responses

Tran NT, Jokic L, Keller J, Geier JU, Kaldenhoff R. Impacts of Radio-Frequency Electromagnetic Field (RF-EMF) on Lettuce (*Lactuca sativa*)—Evidence for RF-EMF Interference with Plant Stress Responses. *Plants*. 2023; 12(5):1082. doi: 10.3390/plants12051082.

Abstract

The increased use of wireless technology causes a significant exposure increase for all living organisms to radio frequency electromagnetic fields (RF-EMF). This comprises bacteria, animals, and also plants. Unfortunately, our understanding of how RF-EMF influences plants and plant physiology remains inadequate. In this study, we examined the effects of RF-EMF radiation on lettuce plants (Lactuca sativa) in both indoor and outdoor environments using the frequency ranges of 1890–1900 MHz (DECT) at 2.4 GHz and 5 GHz (Wi-Fi). Under greenhouse conditions, RF-EMF exposure had only a minor impact on fast chlorophyll fluorescence kinetics and no effect on plant flowering time. In contrast, lettuce plants exposed to RF-EMF in the field showed a significant and systemic decrease in photosynthetic efficiency and accelerated flowering time compared to the control groups. Gene expression analysis revealed significant down-regulation of two stress-related genes in RF-EMF-exposed plants: violaxanthin de-epoxidase (VDE) and zeaxanthin epoxidase (ZEP). RF-EMF-exposed plants had

lower Photosystem II's maximal photochemical quantum yield (F_V/F_M) and non-photochemical quenching (NPQ) than control plants under light stress conditions. In summary, our results imply that RF-EMF might interfere with plant stress responses and reduced plant stress tolerance.

Open access paper: https://www.mdpi.com/2223-7747/12/5/1082

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Effects of extremely low-frequency magnetic fields on human MDA-MB-231 breast cancer cells: proteomic characterization

Lazzarini R, Eléxpuru-Zabaleta M, Piva F, Giulietti M, Fulgenzi G, Tartaglione MF, Zingaretti L, Tagliabracci A, Valentino M, Santarelli L, Bracci M. Effects of extremely low-frequency magnetic fields on human MDA-MB-231 breast cancer cells: proteomic characterization. Ecotoxicol Environ Saf. 2023 Feb 16;253:114650. doi: 10.1016/j.ecoenv.2023.114650.

Abstract

Extremely low-frequency electromagnetic fields (ELF-MF) can modify the cell viability and regulatory processes of some cell types, including breast cancer cells. Breast cancer is a multifactorial disease where a role for ELF-MF cannot be excluded. ELF-MF may influence the biological properties of breast cells through molecular mechanisms and signaling pathways that are still unclear. This study analyzed the changes in the cell viability, cellular morphology, oxidative stress response and alteration of proteomic profile in breast cancer cells (MDA-MB-231) exposed to ELF-MF (50 Hz, 1 mT for 4 h). Non-tumorigenic human breast cells (MCF-10A) were used as control cells. Exposed MDA-MB-231 breast cancer cells increased their viability and live cell number and showed a higher density and length of filopodia compared with the unexposed cells. In addition, ELF-MF induced an increase of the mitochondrial ROS levels and an alteration of mitochondrial morphology. Proteomic data analysis showed that ELF-MF altered the expression of 328 proteins in MDA-MB-231 cells and of 242 proteins in MCF-10A cells. Gene Ontology term enrichment analysis demonstrated that in both cell lines ELF-MF exposure up-regulated the genes enriched in "focal adhesion" and "mitochondrion". The ELF-MF exposure decreased the adhesive properties of MDA-MB-231 cells and increased the migration and invasion cell abilities. At the same time, proteomic analysis, confirmed by Real Time PCR, revealed that transcription factors associated with cellular reprogramming were upregulated in MDA-MB-231 cells and downregulated in MCF-10A cells after ELF-MF exposure. MDA-MB-231 breast cancer cells exposed to 1 mT 50 Hz ELF-MF showed modifications in proteomic profile together with changes in cell viability, cellular morphology, oxidative stress response, adhesion, migration and invasion cell abilities. The main signaling pathways involved were relative to focal adhesion, mitochondrion and cellular reprogramming.

https://pubmed.ncbi.nlm.nih.gov/36805133

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Effect of 50-Hz magnetic fields on the expression of activation-induced deaminase, B-cell lymphoma 6 and serum levels of interleukin-6, interleukin-21

Gholamian-Hamadan M, Behzad M, Molaei S, Zaerieghane Z, Talebi-Ghane E, Zamani A. Effect of 50-Hz magnetic fields on the expression of activation-induced deaminase, B-cell lymphoma 6 and serum levels of interleukin-6, interleukin-21. Int J Radiat Biol. 2023 Feb 6:1-18. doi: 10.1080/09553002.2023.2177767.

Abstract

Background: Investigations showed different effects of magnetic fields (MFs) on the immune system. During humoral immune responses, genes of activation-induced deaminase (AID) and B-cell lymphoma-6 (Bcl-6) are expressed and interleukin (IL)-6 and IL-21 are produced. These factors play significant roles in class switching, affinity maturation of antibodies and activations of B cells germinal centers (GCs). Therefore, this study investigated the effect of 50-Hz MFs exposure with different densities on these factors.

Materials and Methods: Eighty rats were divided into four exposures and a control groups. The treatment groups were exposed to magnetic flux densities of 1, 100, 500, and 2000 μT (50 Hz, 2h/day for 60 days). To activation of the immune system, all the animals were immunized with human serum albumin on days 31, 44, and 58 of exposure. Reverse transcription quantitative polymerase chain reaction was used to assay the expression levels of AID and Bcl-6 genes in the spleen. The serum levels of IL-6 and IL-21 were also detected by enzyme-linked immunosorbent assay at the pre- and post-immunization phases.

Results: AID expression was significantly declined at 1μT magnetic flux density, while no change was observed in the expression of Bcl-6. Serum IL-6 was increased only in 500 μT group at the post-immunization phase.

Conclusion: It seems exposure to 50-Hz MFs at 1μT density, suppresses AID and may cause decline in class switching and affinity maturation of Abs. On the other hand, exposure to 500μT, may activate them. These findings demonstrate the various potential effects of MFs on the humoral immune system.

https://pubmed.ncbi.nlm.nih.gov/36745859/

Conclusion

It appears two months exposure to 50-Hz MFs causes to change some aspect of humoral immunity, both in low and high flux densities. Reduction in AID expression at lower density may hypothesize a suppression role in humoral immunity, especially class switching and affinity maturation of Abs. In contrast, higher density could increase serum IL-6 and activate the differentiation of B cells to plasma cells and may enhances humoral responses. This finding indicated the complexities of these reactions which highlight the need for further studies.

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Assessing electric field strength inside a anatomical hand model caused by a magnetic deactivator device for Electronic Article Surveillance System labels

Schneeweiss P, Hirtl R, Schmid G. Assessing non-sinusoidal in situ electric field strength inside a detailed anatomical hand model caused by a magnetic deactivator device for EAS labels. J Radiol Prot. 2023 Feb 6. doi: 10.1088/1361-6498/acb955.

Abstract

To evaluate the localized magnetic field (MF) exposure of the cashier's hand due to a particular de-magnetization device (deactivator) for single-use labels of an acousto-magnetic (AM) electronic article surveillance (EAS) system, comprehensive measurements of MF near the surface of the deactivator and numerical computations of the induced electric field strength $E_i$were performed in high-resolution anatomical hand models of different postures and positions with respect to the deactivator. The measurement results for magnetic induction B were assessed with respect to the action levels (AL) for limb exposure, and the computational results for $E_i$were evaluated with respect to the exposure limit values (ELV) for health effects according to EU directive 2013/35/EU. For the ELV-based assessment, the maximum of the 2 x 2 x 2 mm^3averaged E_i ($maxE_{i,avg}$) and the respective 99.9^{th}, 99.5^{th}, and 99.0^{th} percentiles were used. As the MF impulse emitted by the deactivator for de-magnetization of the AM-EAS labels was highly non-sinusoidal, measurement results were assessed based on the weighted peak method in time domain (WPM-TD). A newly developed scaling technique was proposed to apply the WPM-TD also for the assessment of the (non-sinusoidal) $E_i$regarding the ELV. It was used to calculate the resulting WPM-TD based exposure index (EI) from frequency domain computations. The assessment regarding the AL for limbs yielded peak values of magnetic induction of up to 97 mT (measured with a 3 cm^2MF probe on top of the deactivator surface) corresponding to an EI of 443 %. However, this was considered an overestimation of the actual exposure in terms of $E_i$as the AL were defined conservatively by intention. A WPM-TD based assessment of $E_i$finally led to worst case EI up to 135 %, 93 %, 78 %, and 72 % when using the $maxE_{i,avg}$, 99.9^{th}, 99.5^{th}, and 99.0^{th}percentiles, respectively.

https://pubmed.ncbi.nlm.nih.gov/36745918/

... it can be hypothesized that the ICNIRP 2010 reference levels may not be conservative in the sense that even when meeting the reference levels, compliance with the basic restrictions is not guaranteed, although an additional reduction factor of 3 was introduced when deriving the reference levels from the basic restrictions, with the intention to account for numerical uncertainties. In particular, this has significant implications for workplace safety, as according to the definition in 2013/35/EU, a workplace can be assumed compliant if the AL are met without any further investigation with respect to the ELV. All in all, the investigated device must be considered at least borderline to non-compliance and precautionary measures are recommended, e.g., ensuring a distance of 50 mm to the deactivator surface to ensure compliance. **All in all, the investigated device must be considered at least borderline to non-compliance and precautionary measures are recommended, e.g., ensuring a distance of 50 mm to the deactivator surface to ensure compliance.**

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Aligning Exposure Limits for Contact Currents with Exposure Limits for Electric Fields

Kavet R, Tell RA. Aligning Exposure Limits for Contact Currents with Exposure Limits for Electric Fields. Health Phys. 2023 Feb 3. doi: 10.1097/HP.0000000000001659.

Abstract

The Institute for Electrical and Electronic Engineers (IEEE) and the International Commission on Non-ionizing Radiation Protection (ICNIRP) have established limits for exposures to electromagnetic fields across the 0-300 GHz (non-ionizing) spectrum, including limits on contact currents (CC) specified by IEEE for 0-110 MHz (ICNIRP issued a CC "guidance level"). Both sets of limits seek to protect against potentially adverse effects, including aversive electrostimulation at frequencies <100 kHz and excessive heating of tissue at frequencies >100 kHz. For the most part, CC is linked to electric field (E-field) exposures for an ungrounded person contacting a grounded object, with the short-circuit current (ISC) through the contact point (usually the hand) equivalent to the current through the grounded feet of a free-standing person exposed to a vertically polarized E-field. The physical linkage between these two quantities dictates that their respective exposure limits align with one another, which is presently not the case, especially with respect to frequencies from100 kHz to 110 MHz. Here we focus specifically on recommendations for revisions to the IEEE standard, IEEE Std C95.1™-2019 ("IEEE C95.1"), in which the E-field exposure limit (E-field exposure reference levels, ERLs) >100 kHz induces substantially greater currents than the CC ERLs currently prescribed. The most important scenario deserving of attention concerns finger contact through a 1-cm2 cross-sectional interface between the skin and a grounded conductor in which the rate of temperature rise in the presence of an E-field ERL can be rapid enough to cause a burn injury. This rate is highly dependent on the moistness/dryness of the skin at the contact point (i.e., its impedance)-a highly variable value-with temperature increasing more rapidly with increasing dryness (greater contact impedance). The two main remedies to alleviate the possibility of injury in this "touch" scenario are to (a) limit the time of finger contact to 1 s in all cases and (b) revise the E-field ERL between 100 kHz and 30 MHz from a "hockey-stick-shaped" curve vs. frequency to a "ramp" across this frequency range. These measures factored in with the real-world prevalence of potentially hazardous scenarios should afford greater protection against adverse outcomes than is presently the case. IEEE C95.1 also specifies limits for grasp contact (15 cm2 in the palm) and associated wrist heating, plus heating in the ankles from free-standing induction. However, these scenarios are more manageable compared to finger touch due mainly to the comparatively lower rates of tissue heating attributable to the wrist's and ankle's relatively greater cross-sectional area. Recommendations for grasp can thus be dealt with separately. Two identified but unaddressed issues in IEEE C95.1 deserving of further attention are first, the circumstance in which a grounded person contacts an ungrounded object situated in an electric field for which there are countless numbers of scenarios that are not amenable to a single ERL. Second, arcing between an extended limb and E-field-exposed object is perhaps the most hazardous of all scenarios. Both of these scenarios cannot be stereotyped and must be dealt with on a case-by-case basis. Future revisions of IEEE Std C95.1-2019 (and the ICNIRP guidelines) will benefit from improved insight into strategies of affording protection from potentially adverse effects in these circumstances.

https://pubmed.ncbi.nlm.nih.gov/36735538/

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High-Fidelity 3D Stray Magnetic Field Mapping of Smartphones to Address Safety Considerations with Active Implantable Electronic Medical Devices

Saha N, Millward JM, Herrmann CJJ, Rahimi F, Han H, Lacour P, Blaschke F, Niendorf T. High-Fidelity 3D Stray Magnetic Field Mapping of Smartphones to Address Safety Considerations with Active Implantable Electronic Medical Devices. Sensors (Basel). 2023 Jan 20;23(3):1209. doi: 10.3390/s23031209.

Abstract

Case reports indicate that magnets in smartphones could be a source of electromagnetic interference (EMI) for active implantable medical devices (AIMD), which could lead to device malfunction, compromising patient

safety. Recognizing this challenge, we implemented a high-fidelity 3D magnetic field mapping (spatial resolution 1 mm) setup using a three-axis Hall probe and teslameter, controlled by a robot (COSI Measure). With this setup, we examined the stray magnetic field of an iPhone 13 Pro, iPhone 12, and MagSafe charger to identify sources of magnetic fields for the accurate risk assessment of potential interferences with AIMDs. Our measurements revealed that the stray fields of the annular array of magnets, the wide-angle camera, and the speaker of the smartphones exceeded the 1 mT limit defined by ISO 14117:2019. Our data-driven safety recommendation is that an iPhone 13 Pro should be kept at least 25 mm away from an AIMD to protect it from unwanted EMI interactions. Our study addresses safety concerns due to potential device-device interactions between smartphones and AIMDs and will help to define data-driven safety guidelines. We encourage vendors of electronic consumer products (ECP) to provide information on the magnetic fields of their products and advocate for the inclusion of smartphones in the risk assessment of EMI with AIMDs.

Open access paper: https://www.mdpi.com/1424-8220/23/3/1209

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Evaluating 60 GHz FWA Deployments for Urban and Rural Environments in Belgium

Castellanos G, De Beelde B, Plets D, Martens L, Joseph W, Deruyck M. Evaluating 60 GHz FWA Deployments for Urban and Rural Environments in Belgium. Sensors (Basel). 2023 Jan 17;23(3):1056. doi: 10.3390/s23031056.

Abstract

Fixed wireless access (FWA) provides a solution to compete with fiber deployment while offering reduced costs by using the mmWave bands, including the unlicensed 60 GHz one. This paper evaluates the deployment of FWA networks in the 60 GHz band in realistic urban and rural environment in Belgium. We developed a network planning tool that includes novel backhaul based on the IEEE 802.11ay standard with multi-objective capabilities to maximise the user coverage, providing at least 1 Gbps of bit rate while minimising the required network infrastructure. We evaluate diverse serving node locations, called edge nodes (EN), and the impact of environmental factors such as rain and vegetation on the network design. Extensive simulation results show that defining a proper EN's location is essential to achieve viable user coverage higher than 95%, particularly in urban scenarios where street canyons affect propagation. Rural scenarios require nearly 75 ENs per km2 while urban scenarios require four times (300 ENs per km2) this infrastructure. Finally, vegetation can reduce the coverage by 3% or increment infrastructure up to 7%, while heavy rain can reduce coverage by 5% or increment infrastructure by 15%, depending on the node deployment strategy implemented.

Open access paper: https://www.mdpi.com/1424-8220/23/3/1056

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Essential elements of radical pair magnetosensitivity in Drosophila

Bradlaugh AA, Fedele G, Munro AL, Hansen CN, Hares JM, Patel S, Kyriacou CP, Jones AR, Rosato E, Baines RA. Essential elements of radical pair magnetosensitivity in Drosophila. Nature. 2023 Feb 22. doi: 10.1038/s41586-023-05735-z.

Abstract

Many animals use Earth's magnetic field (also known as the geomagnetic field) for navigation[1]. The favoured mechanism for magnetosensitivity involves a blue-light-activated electron-transfer reaction between flavin adenine dinucleotide (FAD) and a chain of tryptophan residues within the photoreceptor protein CRYPTOCHROME (CRY). The spin-state of the resultant radical pair, and therefore the concentration of CRY in its active state, is influenced by the geomagnetic field[2]. However, the canonical CRY-centric radical-pair mechanism does not explain many physiological and behavioural observations[2-8]. Here, using electrophysiology and behavioural analyses, we assay magnetic-field responses at the single-neuron and organismal levels. We show that the 52 C-terminal amino acid residues of Drosophila melanogaster CRY, lacking the canonical FAD-binding domain and tryptophan chain, are sufficient to facilitate magnetoreception. We also show that increasing intracellular FAD potentiates both blue-light-induced and magnetic-field-dependent effects on the activity mediated by the C terminus. High levels of FAD alone are sufficient to cause blue-light neuronal sensitivity and, notably, the potentiation of this response in the co-presence of a magnetic field. These results reveal the essential components of a primary magnetoreceptor in flies, providing strong evidence that non-canonical (that is, non-CRY-dependent) radical pairs can elicit magnetic-field responses in cells.

Open access paper: https://www.nature.com/articles/s41586-023-05735-z

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Extremely low-frequency electromagnetic field (ELF-EMF) induces alterations in epigenetic regulation in the myometrium - An in vitro study

Franczak A, Drzewiecka EM, Kozlowska W, Zmijewska A, Wydorski PJ. Extremely low-frequency electromagnetic field (ELF-EMF) induces alterations in epigenetic regulation in the myometrium - An in vitro study. Theriogenology. 2023 Feb 7;200:136-146. doi: 10.1016/j.theriogenology.2023.02.005.

Abstract

Previous research by the authors indicated that an extremely low-frequency electromagnetic field (ELF-EMF) evokes molecular alterations in the porcine myometrium. It was hypothesized that the ELF-EMF could induce alterations in the epigenetic regulation of gene expression in the myometrium. In the current study, slices of the porcine myometrium during the peri-implantation period (n = 4) were used for further in vitro exposition to ELF-EMF (50 Hz, 8 mT, 2 h treatment duration). The study tested whether the ELF-EMF may affect: 1/the expression of DNA (cytosine-5)-methyltransferase 1 (DNMT1) and DNA (cytosine-5)-methyltransferase 3a (DNMT3a), 2/the level of genomic DNA methylation, and 3/the level of amplification of methylated and unmethylated variants of promoter regions of selected genes with altered expression in response to ELF-EMF. It was found that ELF-EMF treatment increased DNMT1, decreased DNMT3a mRNA transcript and protein abundance, and increased the level of genomic DNA methylation. The direction of alterations in the level of amplification of methylated and unmethylated variants of the promoter region of selected genes with altered expression, i.e. prodynorphin (PDYN), interleukin 15 (IL15) signal transducer and activator of transcription 5A (STAT5A), tumor necrosis factor (TNF), and between down-regulated genes were early growth response 2 (EGR2), hyaluronan and proteoglycan

link protein 1 (HAPLN1), and uteroferrin associated basic protein-2 (UABP2), mostly involving the direction of changes in their transcriptional activity, which was evaluated in a previous study by the authors. Thus, ELF-EMF radiation disturbs epigenetic mechanisms, which may underlay ELF-EMF-related transcriptomic alterations in the myometrium.

https://pubmed.ncbi.nlm.nih.gov/36806924/

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Comparison of electromagnetic exposure for passengers at different positions on the subway platform

Li J, Lu M. Comparison of electromagnetic exposure for passengers at different positions on the subway platform. EMIE 2022; The 2nd International Conference on Electronic Materials and Information Engineering, Hangzhou, China, 2022, pp. 1-6.

Abstract

To evaluate the safety of electromagnetic exposure for passengers at different positions on the subway platform, the High Frequency Structure Simulator software is used to establish the exposure source, i.e., the leakage coaxial cable model and the adult and child passenger models. Three waiting positions (A, B and C) with an interval of 1.5 m are selected on the subway platform. The distribution of the specific absorption rate of the adult and child passengers at different waiting positions was calculated at 900 MHz. Results show that among the three locations, the maximum SAR values in the adult and child bodies appear at position A nearest to the exposure source, which are 1.5859×10(exp -7) and 1.0854×10(exp -7) W/kg, respectively. According to the comparison of the SAR distribution between the adult and the child at positions A and C, the SAR values in the child's brain tissue are 4.98 and 2.80 times higher than those of the adult, respectively. The simulation results are well below the International Commission on Non-Ionizing Radiation Protection limits for the general public, indicating that the adult and child passengers do not suffer health risks under the electromagnetic exposure emitted by the leaky coaxial cable on the subway platform.

https://ieeexplore.ieee.org/document/10048274

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The assumption of safety is being used to justify the rollout of 5G technologies

McCredden JE, Weller S, Leach V. The assumption of safety is being used to justify the rollout of 5G technologies. Frontiers in Public Health. 11. 2023. doi:10.3389/fpubh.2023.1058454.

No Abstract

Conclusions

The potential long-term health risks from global EMF continue to rise as exposures in the built environment increase in time and density. Mankind has chosen to base the justification for this rollout on shaky foundations, where there is minimal understanding of the impact of new radiofrequencies being introduced into the

environment on long-term human and planetary health.

The evidence presented above suggests that there are credible risks of biological interference effects for frequencies planned for 5G, occurring well-below ICNIRP reference limits. Given the ubiquitous and often non-consensual nature of man-made wireless radiation exposures, the presence of even a small number of significant bioeffects requires follow up with more focused research.

The communication of existing investigations has not been fully clear or transparent. It is the responsibility of government review panels, regulatory bodies, scientists, public advocates, industry and policy makers to clearly communicate the research and its implications, so as to ensure that no fallacious conclusions can be drawn. If these are allowed to continue, both those delivering the message and the unsuspecting billions using their new 5G devices may be led in a direction that places global public and environmental health at risk.

The mmWave evidence base that has been made visible in this article suggests that plausible health effects cannot be ruled out, and that urgent action is needed on two fronts:

1. Further sound scientific research, done carefully, using the best laboratory practices and sufficiently large samples to produce significant results, funded and overseen by trusted bodies with appropriate expertise (38).

2. Precautionary actions to be taken by policy makers via use of risk aversion strategies such as the actions recommended in an EU commissioned report [(47), p. 152–153]. Risk aversion constitutes good leadership.

The limitations of scientific knowledge imply moral courage in taking precautionary action in time to avert harm [(17), p. 687].

Open access paper: www.frontiersin.org/articles/10.3389/fpubh.2023.1058454

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Incongruities in recently revised radiofrequency exposure guidelines and standards

Lin JC. Incongruities in recently revised radiofrequency exposure guidelines and standards. Environmental Research. 222, 2023. doi: 10.1016/j.envres.2023.115369.

Abstract

The currently promulgated RF exposure guidelines and standards cover the entire range of RF radiation and apply predominantly to restrict RF-induced short-term heating and in guarding against raising tissue temperatures, including the 5G frequencies. There are substantial abnormalities in these putative health safety protection guidelines and standards. Some of the safety limits are irrelevant, debatable, and absent of scientific justification from the standpoint of safety and public health protection. Also, the cellular mobile 5G technology is hailed as a speedier and more secure wireless communication technology than its predecessor systems. The key supporting architecture uses millimeter-wave (mm-wave) and antenna array technology to achieve better

directivity, lower latency, and elevated data transmission rates. For radiation protection, it is not obvious whether the health effects of 5G mm-wave radiations would be analogous or not to radiations from previous generations (which was classified as possibly carcinogenic in humans by IARC). The interaction of mm-waves with the structure and function of pertinent cellular elements and cutaneous neuroreceptors in the skin are of special concern. The current scientific database is inadequate at mm wavelengths to render a trustworthy appraisal or to reach a judgment with confidence.

https://www.sciencedirect.com/science/article/pii/S0013935123001615

Excerpts

As mentioned, recently, both ICES and ICNIRP have published revisions of their recommendations for exposure limits (IEEE-ICES, 2019a, 2019b; ICNIRP, 2020). The revised limits are clearly tied to heating effects associated with measurable tissue temperature changes. They are based primarily on biological data from short-term (6 or 30 min) exposures to RF and microwave radiation and do little to placate the troubling questions on recommended limits for long-term, low-level exposures. The scenarios of a persistently expressed lack of confidence in these RF exposure guidelines are recurring in many parts of the world involving wireless and mobile telecommunication devices and installations (ICBE-EMF, 2022; Elkind, 2022; Investigate Europe, 2019; Koeppel, 2022).

Conclusion

The rapid proliferation of cellular mobile telecommunication devices and systems is raising public health concerns about the biological effects and safety of radiofrequency (RF) radiation exposure. There is also concern about the efficacy of promulgated health safety limits, rules, and recommendations for RF radiation used by these devices and systems. The recently revised RF exposure limits adjust only for heating with RF radiation. These limits are devised largely for restricting short-term heating by RF radiation to raise tissue temperatures. They disregarded decisions by scientific organizations such as IARC. Furthermore, the limits are based on obsolete information, circumvent important animal data, and even more so in the case of mm-wave radiation from 5G mobile communications for which there is a paucity of health effects studies in the published literature. They are flawed and are not applicable to long-term exposure at low levels. Instead of advances in science, they are predicated on misguided assumptions with outdated exposure metrics that do not adequately protect children, workers, and the public from exposure to the RF radiation or people with sensitivity to electromagnetic radiation from wireless devices and systems. Thus, many of the recommended limits are debatable and absent of scientific justification from the standpoint of safety and public health protection.

Cellphones and wireless mobile communication technologies have enriched human lives. It is difficult to imagine contemporary lives without them. The deployment of 5G mobile technology is well underway with it heralded mm-wave performances. It is not evident whether the health effects of 5G mm-wave radiations would be analogous or not to previous generations of cellphone and wireless communication technologies. Without dispute, cellphones have provided direct benefits to multiple arenas of human endeavor that includes helping to safeguard our personal security and safety. Nonetheless, for the judgment on the health and safety of billions of users who are subjected to repeated, unnecessary levels of RF radiation perhaps over their lifetimes, the verdict is still out. It is significant to note that current cellphones have SARs ranging from 0.2 to 0.5 W/kg (EMF Academy, 2022). Clearly, cellphones are operating at a fraction of the 2.0-W/kg SAR acceptable to ICNIRP and

IEEE-ICES. It is conceivable that forthcoming developments could enable cellphone functions including data and video operations at much lower exposure levels. The practice of ALARA — as low as reasonably achievable — should be followed for RF health and safety when confronted with such divergent assessments of wireless RF radiation.

https://www.sciencedirect.com/science/article/pii/S0013935123001615

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In Vivo Studies on Radiofrequency (100 kHz–300 GHz) Electromagnetic Field Exposure and Cancer: A Systematic Review

Pinto R, Ardoino L, Villani P, Marino C. In Vivo Studies on Radiofrequency (100 kHz–300 GHz) Electromagnetic Field Exposure and Cancer: A Systematic Review. *International Journal of Environmental Research and Public Health*. 2023; 20(3):2071. doi: 10.3390/ijerph20032071.

Abstract

The increasing exposure of the human population to radiofrequency electromagnetic fields has increased concern about its possible health effects. The aim of this systematic review is to provide an update of the state of the research on this topic, through a quantitative analysis, to assess the increased risk of tumor incidence in laboratory animals (rodents) without limitations of species, strain, sex or genotype. The review was conducted according to the PRISMA guideline and individual studies were assessed by referring to the OHAT Risk of Bias Rating Tool for Human and Animal Studies. A total of 27 studies were considered eligible for the evaluation of tumor incidence; a meta-analysis was carried out on 23 studies to assess the possible increased risk of both malignant and benign tumors onset at the systemic level or in different organs/tissues. A significant association between exposure to RF and the increased/decreased risk of cancer does not result from the meta-analysis in most of the considered tissues. A significant increased/decreased risk can be numerically observed only in heart, CNS/brain, and intestine for malignant tumors. Nevertheless, the assessment of the body of evidence attributes low or inadequate evidence for an association between RF exposure and the onset of neoplasm in all tissues.

Conclusions

This systematic review analyzed the experimental data extracted from 27 eligible articles regarding the onset of neoplasms in laboratory rodents exposed to EMF-RF; a quantitative analysis (meta-analysis) was conducted on 23 papers. Each study was ex amined for possible methodological limits and the RoB was evaluated.

A total of 25 organs/tumors were analyzed for malignant tumors and 16 for benign tumors to assess the confidence in the body of evidence of the carcinogenic effects. Starting from a “high quality” grade, a general feature for randomized in vivo studies [5], all items underwent a quality downgrade due to “serious” or “very serious” limitations in the experimental design, mainly caused by a low number of animals in sham groups.

A further downgrade was determined by the classification of all studies as “some con cerns” for bias, even

without taking into account the conflict of interest. The results obtained after subgrouping analysis by species (rats vs. mice) allowed an upgrade of the certainty of the evidence for many types of malignant and benign tumors. The lack of a dose–response relationship in all the analyzed samples did not allow for further upgrades.

Overall, these evaluations have determined a confidence rating from very low (heart sample for malignant tumors and CNS sample for benign ones) to moderate, resulting in 28 of 34 inadequate or insufficient health evidence for a definitive assessment of the association between EMF-RF exposure and carcinogenesis in vivo. This lack of certainty in the conclusions mainly derives from a very cautious GRADE approach, which does not appear entirely justified in this case given that the considered articles present a good homogeneity, both in the methods and in the results, providing adequate answers for the aims of this study. In this regard, it should be considered that, although in recent years the use of systematic reviews has been extended to experimental laboratory studies, the main guidelines [4,5] were developed considering the clinical tri- als. The different approach between clinical and laboratory works has highlighted some methodological difficulties for the application of grade procedures, which could be better analyzed in order to improve the guidelines for the future systematic reviews on animal studies. Furthermore, it should be considered that the inclusion of only English-language papers may have represented a limitation of this systematic review.

In conclusion, the inadequate/insufficient health evidence found does not allow this systematic review to give additional information for the integration of present regulatory frameworks. Otherwise, this review updates the state of the art of research on in vivo RF-EMF experiments related to carcinogenesis and, for future research in this field, it emphasizes the need of an appropriate experimental design that takes into account the animal number and the sample number used for the sham control groups.

Future work will be the update of this review as required in [4]; in fact, the question of this review is of continuing importance to decision makers and the availability of new data or new methods would have a meaningful impact on the review findings. Moreover, a review update provides an opportunity for the scope, eligibility criteria and methods used in the review to be revised.

Open access paper: https://www.mdpi.com/1660-4601/20/3/2071

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Non-ionizing radiation as possible carcinogen (Review)

Gupta S, Sharma RS, Singh R. Non-ionizing radiation as possible carcinogen. *Int J Environ Health Res*. 2022;32(4):916-940. doi:10.1080/09603123.2020.1806212**.**

Abstract

The advent of wireless technologies has revolutionized the way we communicate. The steady upsurge in the use of mobile phone all over the world in the last two decades, while triggered economic growth, has caused substantial damage to the environment, both directly and indirectly. The electromagnetic radiation generated from mobile phones, radio-based stations, and phone towers, high-voltage power lines have been reported which leads to the variety of health scares such as the risk of cancer in human beings and adverse effects in

animals, birds, etc. Though the usage of such radiation emitting from mobile phones has risen steeply, there is a lack of proper knowledge about the associated risks. The review provides the latest research evidence based both on *in vitro* studies, *in vivo* studies, and possible gaps in our knowledge. Moreover, the present review also summarizes available literature in this subject, reports and studies which will help to form guidelines for its exposure limits to the public.

https://pubmed.ncbi.nlm.nih.gov/32885667/

Conclusion

In conclusion, the results of the investigations were inconclusive, and in fact, indicated little or no association between the exposure to RFR with that of radiation and cancer. But NTP reported that RFR causes cancer in experimental animals. Nevertheless, it should also be pointed out in several epidemiological studies where weak association between carcinogenicity and RFR was observed. All the more reasons that the effects and the risk associated with the exposure to mobile phones were not consistent and didn't show any regular pattern. Studies on the exposure in children were also very limited. This discussion was intended to answer whether there's a health risk involved with the use of mobile phones, but at this stage, the review has not all the answers. The good thing is, several researchers are working on this field, and with more studies we'll surely get better clarity on the subject. Although there's little doubt of the risks involved with mobile phone usage, and therefore, this review indicates that precautions are needed while using mobile phones. Although the available evidences do not provide a link between the exposure to RFR and microwave radiation and its effect on human health, at this moment, it's not possible to state otherwise as well. In the case of cancer, only the studies that were conducted for more extended period of time able to indicate any association between the use of mobile phone and cancer, especially brain cancer. The above studies suggested that GSM operated mobile phones have significant effect in comparison to CDMA operated mobile phones. As mobile phones have become an integral part of our everyday life, and so, it's even more critical today to study their effects on the human body. To conclude, it's time for government agencies and concerned bodies to understand the potentially harmful effects of RFR and to consider preventive actions like use of good phone brands keeping health and safety at priorities, use of Bluetooth (hands-free devices) and mobile phones having minimum SAR value. Animal studies for longer period of time are needed to execute for the probable health effects. There are no useful data available regarding RF; thus only data suggest a health risk associated with RF so far and the research is still shapeless, about both the amount and quality of available data. Thus, it's not possible to draw any conclusions yet and we must wait for future results.

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Effect of Mobile Phone Radiation on Parotid and Submandibular Salivary Glands-An Ultrasonographic Study

Yendluru, MS. Rana P, Sekhar MC, Chakravarthi GD, Suresh D, Nagajyoki P, Meghana G, Solanke S. Effect of Mobile Phone Radiation on Parotid and Submandibular Salivary Glands-An Ultrasonographic Study. J Clinical Diagnostic Research. Oct 2022. 16 (10) , pp.ZC25-ZC30.

Introduction: In this era of digitalism, mobile phones have become a cultural accessory. Frequent smartphone usage results in possible adverse effects from low radiofrequency radiation and thermal effect emitted by these devices. One of the major concerns is salivary glands as the mobile phones are held against the side of face in close proximity to these glands.

Aim: To assess the effect of cell phone radiation on the volume, systolic velocity, salivary flow rate of parotid and submandibular gland between the dominant and non dominant side of mobile phone users.

Materials and Methods: A cross-sectional study was conducted in the Department of Oral Medicine and Radiology with the sample size of 100 (50 males and 50 females). Inclusion criteria were based on the frequency of mobile phone usage of more than two hours per day. Mobile phone usage was determined based on patient's answer to the questionnaire. Ultrasonography (USG) of both parotid and submandibular gland was done bilaterally to measure the volume of the glands and Colour Doppler of external background-color:inherit"carotid artery to measure systolic velocity. Modified Schirmer tear strips were used bilaterally to measure unstimulated salivary flow rate. The data was entered into MS excel and significance was calculated using independent sample t-test.

Results: In parotid gland, mean volume, mean systolic velocity and mean salivary flow rate were of higher value in the dominant side (14.22 +/- 2.17 mL; 15.14 +/- 3.74 cm/s; 0.37 +/- 0.26 mm/5 mins) compared to the non dominant side (13.76 +/- 2.14 mL; 14.53 +/- 3.39 cm/s; 0.24 +/- 0.2 mm/5 mins). In submandibular gland, mean volume, mean systolic velocity and mean salivary flow rate were of higher value in the dominant side (9.60 +/- 1.96 mL; 15.70 +/- 6.44 cm/s; 0.30 +/- 0.22 mm/5 mins) compared to the non dominant side (8.88 +/- 2.17 mL; 13.87 +/- 4.83 cm/s; 0.26 +/- 0.21 mm/5 mins).

Conclusion: The volume, systolic velocity of blood flow, the salivary flow rate, of the parotid gland and submandibular gland were significantly more on the dominant side than the non dominant side of mobile phone usage. The study emphasised that prolonged mobile phone usage causes biological changes in salivary glands and its flow rate.

Open access paper:
https://www.jcdr.net/articles/PDF/17035/56667_CE[Vi]_F[SH]_PF1(AB_SHU)redo_PFA(SS)_PB(AB_SS)_PN(SS).pdf

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Electromagnetic radiations on the functional potential of spermatozoa

Ranjitsingh AJA, Elizabeth MM, Dhasarathan P, Athinarayanan G. Electromagnetic radiations on the functional potential of spermatozoa. Res. J. Biotech. 17(10):12-17; 2022. doi: 10.25303/1710rjbt12017.

Abstract

The growing exposure to digital communication system and tools leads to radiation toxicity to the users. Unaware of the safety measures, even a kid at the age of one starts operating digital gadgets emitting radio frequency-electromagnetic radiations. Radiations from mobile phones, laptops, notepad, Wi-Fi or other devices are reported to be harmful beyond the permissible limit. So there is a growing concern for the overall health, reproductive and hormonal functions. Experimental studies were conducted by using a Wi-Fi network active laptop and live spermatozoa. The exposure of sperms to the source of EMF showed that the activity of the live sperms got reduced and mortality was observed depending on the exposure duration and the distance from

EMF sources.

After 5h of exposure to RF-EMF source, the semen quality changed when compared with control. The vitality of sperm in the control was 95±1.0 after 2 hr and it was reduced to 60±1.5 percent at a distance of 1cm and 55 ±2.2 percent at a distance of 10 cm. After 5 hour exposure, the vitality was reduced to 63±1.86 at 1 cm distance and 70± 1.42 at 10 cm distance. The reduction in vitality of sperm after exposure to RFEMF source for 2 hour was 35% at 1cm and 40% at 10cm distance.

Conclusion

The present study on the impact of radiations from a laptop upon the functional mechanism of spermatozoa confirmed that operating the digital devices without precautionary measures and distance interferes with fertilizable ability of the sperms that may end in infertile marriage. The present users of laptop or other digital devices must be cautious about the possible fertility problems from such devices.
Open access paper:
https://worldresearchersassociations.com/Archives/RJBT/Vol(17)2022/October%202022/Electromagnetic%20radiations%20on%20the%20functional%20potential%20of%20spermatozoa.aspx

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Does exposure to radiofrequency radiation (RFR) affect the circadian rhythm of rest-activity patterns and behavioral sleep variables in humans?

Singh MM, Chandel P, Pati A, Parganiha A. (2022) Does exposure to radiofrequency radiation (RFR) affect the circadian rhythm of rest-activity patterns and behavioral sleep variables in humans? Biological Rhythm Research, 53:9, 1414-1438, doi: 10.1080/09291016.2021.1945788.

Abstract

We evaluated the effects of the exposure to radio-frequency radiation emanating from the base transceiver station (BTS) on the characteristics of circadian rest-activity rhythm and behavioral sleep variables in humans. We performed this exploratory field study in a sample of 89 healthy subjects randomly chosen out of 1434 individuals surveyed for the purpose. We divided 89 subjects into five groups, including the control, as a function of distance from the BTS. The E-field strength was higher in the groups of the inter-tower region and between 0 and 150 m away from the BTS. The E-field (distance) did not significantly affect the circadian rhythm parameters and behavioral sleep variables, except a marginal delay in the peak timings of the rest-activity rhythm of subjects in the inter-tower and 300–500 m groups. Notable secondary effects of the factor gender were noticed on circadian amplitude, sleep efficiency, dichotomy index, and wake after sleep onset. We concluded that exposure to radiation from the BTS did not modulate actigraphy-based behavioral sleep variables of people residing around BTS installations. We recommend more extensive field-based studies with rigorous longitudinal designs to validate the effects of radiation from the BTS in humans.

https://www.tandfonline.com/doi/abs/10.1080/09291016.2021.1945788

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Association of Autonomic Balance With Phone Call Duration in Healthy Individuals

Gangwar V, Gupta S, Verma M, et al. (January 09, 2023) Association of Autonomic Balance With Phone Call Duration in Healthy Individuals. Cureus 15(1): e33566. doi:10.7759/cureus.33566

Abstract

Background This study aimed to estimate the association of autonomic balance with the duration of phone calls in healthy individuals.

Methodology A total of 30 subjects aged between 18 and 30 years without any established systemic disease and using mobile phones for more than five years with minimum daily usage of 30 minutes were included in this analytical study. Heart rate variability (HRV) was recorded using a three-channel physiograph (AD Instruments South Asia (India) Pvt. Ltd., New Delhi, India) with the software LabChart PROV8.1.8 with HRV Module version 2.0.3 for 10 minutes. Time domain parameters were recorded in terms of the standard deviation of normal to normal interval (SDNN), root mean square of successive differences between normal heartbeats (RMSSD), R-R intervals greater than 50 ms (pRR50), and mean heart rate (MHR), and frequency domain parameters were total power, low-frequency power (LF), high-frequency power (HF), and the ratio of low-frequency to high-frequency power (LF/HF). HRV was recorded three times in each subject that included baseline HRV, HRV during the use of a mobile phone, and HRV after the use of a mobile phone.

Results A total of 30 subjects (14 males and 16 females) participated in this study. The mean age of participants was 31.93 ± 8.59 years (32.07 ± 9.87 years for males, and 31.81 ± 7.64 years for females). There were no findings of significant arrhythmia in any of the participants. There was a significant difference in pRR50 on comparing all three phases ($p = 0.036$). However, there was no significant variation in other parameters such as very low frequency (VLF, ms2), VLF (%), LF (ms2), LF (%), HF (ms2), HF (%), LF/HF, SDNN (ms), RMSSD (ms), Poincare plot standard deviation perpendicular to the line of identity (ms), Poincare plot standard deviation along the line of identity (ms), systolic blood pressure (mmHg), and diabolic blood pressure (mmHg) during, before, and after exposure to mobile phone calls. There was no significant difference in the value of all parameters between males and females ($p < 0.05$).

Conclusions Mobile phone calls may influence HRV and autonomic balance. This change may be affected by the electromagnetic field and by speaking as well.

https://www.cureus.com/articles/129516-association-of-autonomic-balance-with-phone-call-duration-in-healthy-individuals

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Case Report: The Microwave Syndrome after Installation of 5G Emphasizes the Need for Protection from Radiofrequency Radiation

Hardell L, Nilsson M. (2023). Case Report: The Microwave Syndrome after Installation of 5G Emphasizes the Need for Protection from Radiofrequency Radiation. Ann Case Report. 8: 1112. doi: 10.29011/2574-7754.101112.

Abstract

In this case report two previously healthy persons, a man aged 63 years and a woman aged 62 years, developed symptoms of the microwave syndrome after installation of a 5G base station for wireless communication on the roof above their apartment. A base station for previous telecommunication generation technology (3G/4G) was present at the same spot since several years. Very high radiofrequency (RF) radiation with maximum (highest measured peak value) levels of 354 000, 1 690 000, and >2 500 000 µW/m2 were measured at three occasions in the bedroom located only 5 meters below the new 5G base station, compared to maximum (peak) 9 000 µW/m2 prior to the 5G deployment. The rapidly emerging symptoms after the 5G deployment were typical for the microwave syndrome with e.g., neurological symptoms, tinnitus, fatigue, insomnia, emotional distress, skin disorders, and blood pressure variability. The symptoms were more pronounced in the woman. Due to the severity of symptoms, the couple left their dwelling and moved to a small office room with maximum (peak) RF radiation 3 500 µW/m2. Within a couple of days, most of their symptoms alleviated or disappeared completely. This medical history can be regarded as a classic provocation test. The RF radiation levels in the apartment were well below the limit proposed to be "safe" below which no health effects would occur, recommended by the International Commission on Non-Ionizing Radiation (ICNIRP). These now presented symptoms of the microwave syndrome were caused by non-thermal effects from RF radiation and highlight that the ICNIRP guidelines used in most countries including Sweden do not protect human health. Guidelines based on all biological negative effects from RF radiation are urgently needed, as well as monitoring human health, not the least due to rapidly increasing levels of exposure.

Open access paper: https://www.gavinpublishers.com/article/view/case-report-the-microwave-syndrome-after-installation-of-5g-emphasizes-the-need-for-protection-from-radiofrequency-radiation

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Status of the Neuroendocrine System in Animals Chronically Exposed to Electromagnetic Fields of 5G Mobile Network Base Stations

Perov SY, Rubtsova NB, Belaya OV. Status of the Neuroendocrine System in Animals Chronically Exposed to Electromagnetic Fields of 5G Mobile Network Base Stations. Bull Exp Biol Med. 2023 Jan 4. doi: 10.1007/s10517-023-05689-2.

Abstract

We studied the biological effect of chronic exposure to multifrequency electromagnetic fields simulating the effects of 5G NR/IMT-2020 mobile communication systems. Male Wistar rats were exposed to 24-h radiation (250 µW/cm2) for 4 months. The exploratory activity of the animals and blood concentrations of ACTH and corticosterone were evaluated at the end of each month of exposure and 1 month after exposure. The results

suggest that exposure to multifrequency electromagnetic field simulating the effects of 5G systems affected functional activity of the hypothalamus-pituitary-adrenal axis and was stressful in nature.

Excerpts

The animals were divided into 5 experimental (exposure to EMF of 5G systems, power density (PD) 250 μW/cm2) and 5 control (sham exposure) groups (12 rats each). Exposure conditions: chronic experiment — exposure for 4 months (120 days; 24-h, 7 days per week) and 1-month (30 days) post exposure period (without irradiation). During exposure period, the animals of experimental groups were kept in radio transparent (plastic) cages. Exposure was carried out by 5G/IMT-2020 base stations with simultaneous use of radio channels with 3.6 GHz (n78 with 100 MHz channel bandwidth), 28 GHz (n257 with 100 MHz channel bandwidth) and 37 GHz (n260 with 400 MHz channel bandwidth) central frequencies....

The neuroendocrine system of rats responded to chronic 4-month EMF exposure by waveform changes of serum levels of ACTH and corticosterone. ACTH content had a tendency to increase after 3 months of the experiment (Fig. 1).

Changes in serum corticosterone content in exposed animals were more pronounced; significant differences from the control group were revealed after 1 and 2 months of exposure and the maximum increase was found 1 month after end of exposure (Fig. 2).

Chronic exposure induced changes in orientation and exploratory activity and emotional state of experimental animals. These changes were detected starting from 3rd month of exposure, but did not reach significance threshold, and 1 month after the end of irradiation, the excitation and inhibition processes in the CNS returned to normal.

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Effects of continuous prenatal and postnatal global system for mobile communications electromagnetic waves (GSM-EMW) exposure on the oxidative stress biomarkers in female rat liver

Salameh M, Zeitoun-Ghandour S, Sabra L, Ismail L, Daher A, Bazzi A, Khalil M, Joumaa WH. Effects of continuous prenatal and postnatal global system for mobile communications electromagnetic waves (GSM-EMW) exposure on the oxidative stress biomarkers in female rat liver. Heliyon. 2022 Dec 17;8(12):e12367. doi: 10.1016/j.heliyon.2022.e12367.

Abstract

In light of the increased use of communication technologies, the harm caused by continuous exposure to emitted radiation on pregnancy and developing newborns is among the public concerns. Using Sprague-Dawley rats, our study investigates the effects of 24 h/day prenatal and postnatal 900 MHz radiofrequency

electromagnetic radiation (RF-EMR) exposure of female rats on liver oxidative stress (OS) and other hepatic parameters at postnatal days (PND) 1, 9, and 21. Our results showed that RF-EMR exposure led to an increase in oxidative stress status as indicated by a significant elevation in MDA level at PND9 and PND21, a decrease in catalase (CAT) activity at all ages, a reduction (PND1 and PND9) in catalase amounts and mRNA expression, in addition to a decrease in GPx activity at PND21 in the exposed group. Current findings also showed a significant increase in cytoSOD at PND9 and 21 and a reduction in mitoSOD at PND21 in the exposed groups compared to the control groups. However, significant increases in glutathione peroxidase (GPx) level and mitoSOD activity were observed at all studied ages. Furthermore, cytoSOD activity showed a significant reduction in PND1, whereas in PND9 the value of this parameter increased compared to the non-exposed group. Moreover, while SOD1 mRNA expression increased at PND1, it decreased at PND9 and 21. However, GPx1 expression was shown to be always decreased in the exposed group. In addition, at PND1 and 9, exposed rats showed a similar response on Akt1, nuclear factor erythroïd 2-related factor 2 (Nrf-2), and intercellular adhesion molecule-1 (ICAM-1) expression. Therefore, an increased oxidative stress status produced from a continuous (24 h/day) GSM-modulated 900 MHz radiofrequency electromagnetic radiation (RF-EMR) exposure during the prenatal and postnatal periods may result in adverse health effects during future life stages.

Excerpt

Briefly, animals were exposed to radiation emitted by a device similar to the antennas of mobile phone stations with a frequency equal to 900 MegaHertz. This device generally consists of a radiofrequency signal (RF) generator (model RFS 900–64, RFPA, Artigues-près-Bordeaux, France) accompanied with RF-EMF antennas (local made) supported by a stand, and placed horizontally 100 cm above the cages containing rats (Figure 1). The generator's power was set to obtain a field intensity of 25 ± 0.4 V/m. A radiofrequency probe (PMM EP600, Narda Safety Test Solution, Hauppauge, NY, USA) monitored with computer software (Win EP 600, Narda Safety Test Solution) was used to check the level of RF-EMF exposure at 3 different periods (gestational day 1, PND1 and PND21). The liver-specific absorption rate (SAR) (0.783 W/kg) was calculated using the equation ....

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Interstitial space between cells in the left and right lobes of rat brains exposed to 900, 1800 and 2100 MHz radiofrequency radiation

Dasdag S, Akdag MZ, Er H, Akpolat V, Deveci E. (2023) Interstitial space between cells in the left and right lobes of rat brains exposed to 900, 1800 and 2100 MHz radiofrequency radiation. Biotechnology & Biotechnological Equipment, 37(1): 180-187. doi: 10.1080/13102818.2023.2170828

Abstract

The head is the body part that is most exposed to radiofrequency radiation (RFR) during a mobile phone conversation. Therefore, it can be expected that brain cells will be positively or negatively affected by this physical agent. The purpose of this study was to investigate the effects of 900, 1800 and 2100 MHz on the interstitial space between cells in the right and left lobes of the brain. The study was carried out on 28 Wistar

Albino rats, which were divided randomly into four groups (n: 7): sham control, 900 MHz, 1800 MHz and 2100 MHz exposure groups. The rats in the exposure groups were subjected to RFR for 3 h/day for one month. At the end of the last exposure, brains were immediately removed and prepared for electron microscopic examination. We determined the interstitial space (μm) between brain cells in the left and right lobes separately and compared them statistically. The results indicated that all three frequencies used in this study increased the interstitial space between cells in both brain lobes. The maximum effective frequencies were 1800 MHz for the right lobe and 2100 MHz for the left lobe. In conclusion, we observed that the RFR used in this study enhanced the interstitial space between cells in both lobes of the brain. Further studies are needed to confirm the results of this study, which we think will open different horizons.

Conclusions

In this study, we observed that exposure of rats to 900, 1800 and 2100 MHz frequency RFRs resulted in increased interstitial space in the right and left lobes of the brain. This result may contribute to the treatment of some brain-related diseases, but we should not forget the research results that show RFRs can cause brain tumors. Due to the limited number of studies on the subject, further and more detailed new studies are needed for risk assessment and clarification of the observed effects.

Open access paper: https://www.tandfonline.com/doi/full/10.1080/13102818.2023.2170828

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The HL-60 human promyelocytic cell line constitutes an effective in vitro model for evaluating toxicity, oxidative stress and necrosis/apoptosis after exposure to black carbon particles and 2.45 GHz radio frequency

Benavides RAS, Leiro-Vidal JM, Rodriguez-Gonzalez JA, Ares-Pena FJ, López-Martín E. The HL-60 human promyelocytic cell line constitutes an effective in vitro model for evaluating toxicity, oxidative stress and necrosis/apoptosis after exposure to black carbon particles and 2.45 GHz radio frequency. Sci Total Environ. 2023 Jan 9;867:161475. doi: 10.1016/j.scitotenv.2023.161475.

Highlights

• RF+ BC increase ROS production and have an oxidant-antioxidant effect on HL-60 cells.

• RF or BC exposure activates expression of the anti-apoptotic gene BCL2a in HL-60 cells.

• Cell necrosis due to BC was manifested at 24 h, while cell death (necrosis and/or apoptosis) due to irradiation and/or BC lasted up to 48 h.

• Interaction between RF and BC enhanced cell toxicity in the promyelocytic cell line

Abstract

The cellular and molecular mechanisms by which atmospheric pollution from particulate matter and/or electromagnetic fields (EMFs) may prove harmful to human health have not been extensively researched. We analyzed whether the combined action of EMFs and black carbon (BC) particles induced cell damage and a pro-

apoptotic response in the HL-60 promyelocytic cell line when exposed to 2.45 GHz radio frequency (RF) radiation in a gigahertz transverse electromagnetic (GTEM) chamber at sub-thermal specific absorption rate (SAR) levels. RF and BC induced moderately significant levels of cell damage in the first 8 or 24 h for all exposure times/doses and much greater damage after 48 h irradiation and the higher dose of BC. We observed a clear antiproliferative effect that increased with RF exposure time and BC dose. Oxidative stress or ROS production increased with time (24 or 48 h of radiation), BC dose and the combination of both. Significant differences between the proportion of damaged and healthy cells were observed in all groups. Both radiation and BC participated separately and jointly in triggering necrosis and apoptosis in a programmed way. Oxidative-antioxidant action activated mitochondrial anti-apoptotic BCL2a gene expression after 24 h irradiation and exposure to BC. After irradiation of the cells for 48 h, expression of FASR cell death receptors was activated, precipitating the onset of pro-apoptotic phenomena and expression and intracellular activity of caspase-3 in the mitochondrial pathways, all of which can lead to cell death. Our results indicate that the interaction between BC and RF modifies the immune response in the human promyelocytic cell line and that these cells had two fates mediated by different pathways: necrosis and mitochondria-caspase dependent apoptosis. The findings may be important in regard to antimicrobial, inflammatory and autoimmune responses in humans.

Conclusions

Combined exposure to 2.45 Ghz RF and to BC over a period of 48 h caused very high levels of toxicity in a HL-60 cell line and triggered an antiproliferative effect that was dependent on the BC dose and exposure time. Activation the expression of antioxidant BCL2a and initial expression of the FAS cell death receptors, with no apparent activation of caspase-8, indicated mitochondrial cell damage due to triggering of apoptosis through a caspase-dependent pathway (increased caspase-3). However, cell death did not seem to be mediated by apoptosis alone, at least not caspase-dependent apoptosis, in any of the groups. This leads us to consider that other forms of programmed cell death may be activated by one or both stressors (Barati et al., 2021). The cell damage induced in vitro by the combination of both RF and BC in promyelocytic cells indicate ineffective antimicrobial function and increased immune or autoimmune tolerance (Glencross et al., 2020).

https://pubmed.ncbi.nlm.nih.gov/36632900/

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Assessment of Inflammation in 3D Reconstructed Human Skin Exposed to Combined Exposure to Ultraviolet and Wi-Fi Radiation

Szilágyi Z, Németh Z, Bakos J, Kubinyi G, Necz PP, Szabó E, Thuróczy G, Pinto R, Selmaoui B. Assessment of Inflammation in 3D Reconstructed Human Skin Exposed to Combined Exposure to Ultraviolet and Wi-Fi Radiation. *International Journal of Molecular Sciences*. 2023; 24(3):2853. doi: 10.3390/ijms24032853.

Abstract

In the human environment, the increasing exposure to radiofrequency (RF) radiation, especially that emitted by wireless devices, could be absorbed in the body. Recently, mobile and emerging wireless technologies (UMTS, DECT, LTE, and Wi-Fi) have been using higher frequencies than 2G GSM systems (900/1800 MHz), which means

that most of the circulating RF currents are absorbed into the skin and the superficial soft tissue. The harmful genotoxic, cytotoxic, and mutagenic effects of solar ultraviolet (UV) radiation on the skin are well-known. This study aimed at investigating whether 2422 MHz (Wi-Fi) RF exposure combined with UV radiation in different sequences has any effect on the inflammation process in the skin. In vitro experiments examined the inflammation process by cytokines (IL-1α, IL-6, IL-8) and MMP-1 enzyme secretion in a 3D full-thickness human skin model. In the first study, UV exposure was immediately followed by RF exposure to measure the potential additive effects, while in the second study, the possible protective phenomenon (i.e., adaptive response) was investigated when adaptive RF exposure was challenged by UV radiation. Our results suggest that 2422 MHz Wi-Fi exposure slightly, not significantly increased cytokine concentrations of the prior UV exposure. We could not detect the adaptive response phenomenon.

Open access paper: https://www.mdpi.com/1422-0067/24/3/2853

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Modelling of daily radiofrequency electromagnetic field dose for a prospective adolescent cohort

Eeftens M, Shen C, Jana Sönksen J, Schmutz C, van Wel L, Liorni I, Vermeulen R, Cardis E, Wiart J, Toledano M, Röösli M. Modelling of daily radiofrequency electromagnetic field dose for a prospective adolescent cohort. Environment International. 2023. doi: 10.1016/j.envint.2023.107737.

Highlights

• First longitudinal study to estimate daily RF-EMF dose of 6152 U.K. adolescents at ages 12 and 14.

• At baseline (age 12), mean daily whole body RF-EMF dose was 170 mJ/kg/day.

• Two years later, whole body dose was similar, but brain dose increased (+32% for temporal lobe).

• The main contributor to the head and brain was own device use, in particular 2G mobile calls.

• Dose at baseline and follow-up were correlated between 0.25 and 0.36 for various tissues.

Abstract

Introduction Radiofrequency electromagnetic fields originate from a variety of wireless communication sources operating near and far from the body, making it challenging to quantify daily absorbed dose. In the framework of the prospective cohort SCAMP (Study of Cognition, Adolescents and Mobile Phones), we aimed to characterize RF-EMF dose over a 2-year period.

Methods The SCAMP cohort included 6605 children from greater London, UK at baseline (age 12.1 years; 2014-2016) and 5194 at follow-up (age 14.2; 2016-2018). We estimated the daily dose of RF-EMF to eight tissues including the whole body and whole brain, using dosimetric algorithms for the specific absorption rate transfer into the body. We considered RF-EMF dose from 12 common usage scenarios such as mobile phone calls or data transmission. We evaluated the association between sociodemographic factors (gender, ethnicity, phone

ownership and socio-economic status), and the dose change between baseline and follow-up.

Results Whole body dose was estimated at an average of 170 mJ/kg/day at baseline and 178 mJ/kg/day at follow-up. Among the eight tissues considered, the right temporal lobe received the highest daily dose (baseline 1150 mJ/kg/day, follow-up 1520 mJ/kg/day). Estimated daily dose [mJ/kg/day] increased between baseline and follow-up for head and brain related tissues, but remained stable for the whole body and heart. Doses estimated at baseline and follow-up showed low correlation among the 3384 children who completed both assessments. Asian ethnicity (compared to white) and owning a bar phone or no phone (as opposed to a smartphone) were associated with lower estimated whole-body and whole-brain RF-EMF dose, while black ethnicity, a moderate/low socio-economic status (compared to high), and increasing age (at baseline) were associated with higher estimated RF-EMF dose.

Conclusion This study describes the first longitudinal exposure assessment for children in a critical period of development. Dose estimations will be used in further epidemiological analyses for the SCAMP study.

Excerpts

A more critical issue for dose estimation is the type of mobile phone network. The RF-EMF dose model puts the output power of calling on a mobile phone on the 2G and 3G networks at 89.7 mW and 0.45 mW respectively, which is a large difference and explains the relative importance of the 2G calls for total dose. The model does not include a scenario for 4G, but we assumed the emitted radiation to be equal to that of 3G (Joshi, 2017). We did not have information on proportion of 2G/3G/4G use in the cohort (5G was still not relevant at the time of data collection), and assumed that 2G, 3G and 4G were each used approximately one third of the time for both baseline and follow-up, but this assumption could not be validated. Considering the importance of 2G in dose modelling, any change of this ratio within the two years would have noticeable impact on the dose estimate. Thus, we cannot rule out that decrease in 2G use over the study period may have overcompensated the increased usage, which would mean that the RF-EMF dose would have actually decreased over time....

Conclusion

This study in a large sample of adolescents confirms that mobile phone use is the main contributor to daily RF-EMF dose for the whole body and various brain regions. The correlation between individual dose estimates within two years was relatively low, likely reflecting both dynamic changes in mobile device usage in this age group, as well as uncertainty when estimating own wireless communication use. This calls for repeated exposure assessment in longitudinal studies on RF-EMF.

Open access paper: https://www.sciencedirect.com/science/article/pii/S0160412023000107

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Research on Electromagnetic Radiation Safety Assessment of Co-construction and Sharing 5G Network

Senwen L, Zhizhong W, Huagang W, Shaochuan C. Research on Electromagnetic Radiation Safety Assessment of Co-construction and Sharing 5G Network. 2022 6th International Conference on Communication and Information Systems (ICCIS), 2022, pp. 27-34, doi: 10.1109/ICCIS56375.2022.9998130.

Abstract

Electromagnetic radiation safety of 5G base stations has been widely concerned by society and the public due to the accelerated development. This paper analyzes the electromagnetic radiation propagation characteristics of 5G mMIMO beam-forming, and monitors the field radiation level of the low-frequency 5G(Sub 6G) base station which co-constructed and shared by China Telecom and China Unicom in-situ real time, also studies and assesses the electromagnetic radiation safety of 5G co-construction and sharing network according to the international and China's 5G electromagnetic radiation limit standards.

Excerpts

... Currently, the rated transmission power of commercial 5G macro station has specifications such as 160W, 200W, 240W and 320W, which is far more than the 40W to 60W transmission power of 4G macro stations.

At the same time, as 5G adopts a higher working frequency band and is affected by high-frequency attenuation, the coverage radius of 5G macro stations is about 300m to1500m, which is much smaller than the coverage radius of 4G macro stations of 1000m to 3500m, obviously, in order to ensure the same coverage quality, the number of 5G base stations is usually 3 to 5 times more than that of 4G....

As can be seen from Table I, for the 5G networks of these four operators in China, the maximum electromagnetic radiation limit (power density) of 5G(Sub 6G) base stations specified by China's national standard GB8702-2014 is between 40 μW/cm2 to 67 μW/cm2, and the maximum limit (power density) specified by HJ/T10.3-1996 in China's environmental protection industry is 8 μW/cm2 to 13.4 μW/cm2, but the maximum limit of electromagnetic radiation (power density) of 5G base stations specified by international standards ICNIRP2020 and IEEE C95.1-2019 can reach 1000 μW/cm2, obviously, the China's national standard of 5G base station radiation limit is 15 to 25 times harsher than that of other countries that mostly adopt international standard limits. If China's environmental protection industry standard HJ/10.3 is used, it is 75 to 125 times stricter than that of other countries that adopt international standards.

Conclusions

Although the beam-forming characteristic of the 5G mMIMO base station has strong beam directivity, and the electromagnetic radiation intensity of 5G base station also has a strong relationship with the user's download rate, however, in the most extreme application scenario of eMBB high-speed downlink lasting 6min without interruption, through frequency selection monitoring, the electromagnetic radiation level of 5G shared base stations with the maximum power of 320W and 200M working bandwidth in China's commercial network is far lower than China's national limit standard and international standard, which also shows that the high power, high frequency and high speed 5G network does not necessarily mean the safety problem of electromagnetic radiation. In fact, the electromagnetic environment quality of the sensitive area around the base station can still

meet the national standard.

In addition, considering that China's national standard limit requirements are 15-25 times stricter than international standards, most countries have adopted more relaxed limit requirements for public exposure to 5G electromagnetic radiation, therefore, combined with the in-situ monitoring results obtained under the extreme eMBB application scenarios, which are far lower than the requirements of the national limit standard GB8702-2014, as long as the operators can timely do the pre-assessment of radiation risk before the base station construction and routine monitoring during operation, the electromagnetic radiation risk in sensitive areas covered by 5G

https://ieeexplore-ieee-org/iel7/9998130

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The temporal imprint of mobile phone emission level when running various applications in 4G versus 5G networks

Miclaus S, Deaconescu DB, Vatamanu D, Buda AM. The temporal imprint of mobile phone emission level when running various applications in 4G versus 5G networks. 2022 International Symposium on Electronics and Telecommunications (ISETC), Timisoara, Romania, 2022, pp. 1-4, doi: 10.1109/ISETC56213.2022.10010000.

Abstract

Human exposure to electromagnetic fields emitted by mobile communications sources is dominated by the mobile phone radiation. Not only the dose of radiation is important, but also dose- or fluence-rate. In this regard, present research emphasizes the features of the dynamics of mobile terminal emission levels by means of statistics, nonlinear data analysis with recurrence quantification and time-frequency analyses. Time series of radiated electric field strengths were recorded and processed for a set of five mobile applications usage per communication standard. Both 4G-LTE emission channel of 20 MHz bandwidth and 5G-NR FR1 emission channel with a bandwidth of 40 MHz were studied. Differences between 4G and 5G emissions variabilities are presented, and application-specific features of the time imprint are highlighted.

Conclusions

An original approach was applied here for extracting the temporal imprint of mobile phone emissions when it was successively connected to 4G and 5G (sub-6GHz) networks. The same five types of mobile applications were investigated while running, from the point of view of statistics, recurrence quantification and time-frequency plots of normalized E-field strengths emitted during 24s of use.

The most significant findings were: a) upload and video call showed the highest differences between 4G and 5G field level distributions; b) 5G emissions are highly concentrated in the lower levels end, with small differences between applications, which is very dissimilar from 4G emissions; c) video call in 4G conducted to the highest slope of field level local accumulation in time; the same was true in 5G, if compared with the other applications

running in the same standard; d) on average the 5G emissions showed coefficient of variations of field levels 45% higher than 4G emissions; e) correlation between 4G and 5G strings of field levels was the largest for file upload but lack of correlation resulted for voice call; f) recurrence quantifications showed a degree of determinism present but no predictability; clear differences between 4G and 5G are emphasized while Poincare plots indicated that short-term variability is always consistently smaller than long-term variability in all 4G applications, and vice-versa is true for 5G emissions; h) time-frequency analysis emphasized again net differences between 4G and 5G emissions mainly for cases of upload, video call and streaming.

Both random and chaotic behaviour of emissions was emphasized so we conclude that too short time-series length might have hidden some significant features in the present preliminary results. Future work will be based on longer time- series data processing and analysis.

https://ieeexplore-ieee-org.libproxy.berkeley.edu/stamp/stamp.jsp?tp=&arnumber=10010000&isnumber=10009039

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Evaluation of Chinese population exposure to environmental electromagnetic field based on stochastic dosimetry and parametric human modelling

Jiang Y, Wang H, Sun X, Li C, Wu T. Evaluation of Chinese populational exposure to environmental electromagnetic field based on stochastic dosimetry and parametric human modelling. Environ Sci Pollut Res Int. 2023 Jan 7. doi: 10.1007/s11356-023-25153-y.

Abstract

This study aimed to estimate the distribution of the whole-body averaged specific absorption rate (WBSAR) using several measurable physique parameters for Chinese adult population exposed to environmental electromagnetic fields (EMFs) of current wireless communication frequencies, and to discuss the effects of these physique parameters in the frequency-dependent dosimetric results. The physique distribution of Chinese adults was obtained from the National Physical Fitness and Health Database comprising 81,490 adult samples. The number of physique parameters used to construct the surrogate model was reduced to three via mutual information analysis. A stochastic method with 40 deterministic simulations was used to generate frequency-dependent and gender-specific surrogate models for WBSAR via polynomial chaos expansion. In the simulations, we constructed anatomically correct models conforming to the targeted physique parameters via deformable human modelling technique, which was based on deep learning from the image database including 767 Chinese adults. Thereafter, we analysed the sensitivity of the physique parameters to WBSAR by covariance-based Sobol decomposition. The results indicated that the generated models were consistent with the targeted physique parameters. The estimated dosimetric results were validated using finite-difference time-domain simulations (the error was < 6% across all the investigated frequencies for WBSAR). The novelty of the study included that it demonstrated the feasibility of estimating the individual WBSAR using a limited number of physique parameters with the aid of surrogate modelling. In addition, the population-based distribution of the WBSAR in Chinese adults was firstly presented in the manuscript. The results also indicated that the different combinations of

physique parameter, dependent on genders and frequencies, significantly influenced the WBSAR, although the general conservativeness of the guidelines of the International Commission on Non-Ionizing Radiation and Protection can be confirmed in the surveyed population.

Conclusion

To characterise the statistical distribution of the WBSAR in the Chinese population, we established a surrogate model using stochastic dosimetry. We reconstructed parametric human models using deformable human models. The number of input variables was reduced to three via a correlation analysis of data obtained from the national population census, which were transformed to make them uncorrelated. We validated the parametric human modelling technique, surrogate models for WBSAR, and estimated WBSAR distribution for the Chinese population. A sensitivity analysis indicated that below 2.4 GHz, HC had the most significant effect on the WBSAR for males, whereas height had the most significant effect on the WBSAR for females. In the frequency range above 2.4 GHz, the influence of the HC for females increased with the frequency, but it decreased at 2.4 and 2.6 GHz for males. The identified morphological parameters can be used as reliable indicators of the individual WBSAR. The proposed method reduced significantly the time cost for numerical simulation and human modelling for individual WBSAR and, for the first time, presented the population-based distribution of WBSAR in Chinese adults. This study advanced our understanding of estimating populational exposure to RF–EMF at the currently used frequencies.

https://pubmed.ncbi.nlm.nih.gov/36609755/

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Assessment of EMF Human Exposure Levels Due to Wearable Antennas at 5G Frequency Band

Gallucci S, Bonato M, Benini M, Chiaramello E, Fiocchi S, Tognola G, Parazzini M. Assessment of EMF Human Exposure Levels Due to Wearable Antennas at 5G Frequency Band. Sensors (Basel). 2022 Dec 22;23(1):104. doi: 10.3390/s23010104.

Abstract

Background: This work aims to assess human exposure to EMF due to two different wearable antennas tuned to two 5G bands.

Methods: The first one was centered in the lower 5G band, around f = 3.5 GHz, whereas the second one was tuned to the upper 5G band, at 26.5 GHz. Both antennas were positioned on the trunk of four simulated human models. The exposure assessment was performed by electromagnetic numerical simulations. Exposure levels were assessed by quantifying the specific absorption rate averaged on 10 g of tissue (SAR10g) and the absorbed power density (Sab), depending on the frequency of the wearable antenna.

Results: the higher exposure values that resulted were always mainly concentrated in a superficial area just below the antenna itself. In addition, these resulting distributions were narrowed around their peak values and tended to flatten toward lower values in farther anatomical body regions. All the exposure levels complied with ICNIRP guidelines when considering realistic input power.

Conclusions: This work highlights the importance of performing an exposure assessment when the antenna is placed on the human wearer, considering the growth of wearable technology and its wide variety of application, particularly regarding future 5G networks.

Excerpt

To evaluate the interaction between the EMF emitted by the simulated wearable antennas and human tissues, the specific absorption rate (SAR) and the absorbed power density (S_{ab}) were evaluated according to ICNIRP guidelines [28]. In more detail, the SAR was calculated as averaged over a cubical mass of 10 g (SAR_{10g}), and the S_{ab} was averaged over a square 4 cm^2 surface area over the skin, that is, the most superficial tissue. Both SAR_{10g} and S_{ab} were obtained with the input power to the antenna set as 1 W. The choice to estimate the SAR over the S_{ab} and vice versa depended on the frequency of the wearable antenna.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9823937/

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A high-resolution pediatric female whole-body numerical model with comparison to a male model

Ntolkeras G, Jeong H, Zollei L, Dmytriw AA, Purvaziri A, Lev MH, Grant PE, Bonmassar G. A high-resolution pediatric female whole-body numerical model with comparison to a male model. Phys Med Biol. 2022 Dec 6. doi: 10.1088/1361-6560/aca950.

Abstract

Objective: Numerical models are central in designing and testing novel medical devices and in studying how different anatomical changes may affect physiology. Despite the numerous adult models available, there are only a few whole-body pediatric numerical models with significant limitations. In addition, there is a limited representation of both male and female biological sexes in the available pediatric models despite the fact that sex significantly affects body development, especially in a highly dynamic population. As a result, we developed Athena, a realistic female whole-body pediatric numerical model with high-resolution and anatomical detail.

Approach: We segmented different body tissues through Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) images of a healthy 3.5-year-old female child using 3D Slicer. We validated the high anatomical accuracy segmentation through two experienced sub-specialty-certified neuro-radiologists and the inter and intra-operator variability of the segmentation results comparing sex differences in organ metrics with physiologic values. Finally, we compared Athena with Martin, a similar male model, showing differences in anatomy, organ metrics, and MRI dosimetric exposure.

Main results: We segmented 267 tissue compartments, which included 50 brain tissue labels. The tissue metrics of Athena displayed no deviation from the literature value of healthy children. We show the variability of brain metrics in the male and female models. Finally, we offer an example of computing Specific Absorption Rate (SAR) and Joule heating in a toddler/preschooler at 7T MRI.

Significance: This study introduces a female realistic high-resolution numerical model using MRI and CT scans of a 3.5-year-old female child, the use of which includes but is not limited to radiofrequency safety studies for medical devices (e.g., an implantable medical device safety in MRI), neurostimulation studies, and radiation dosimetry studies. This model will be open source and available on the Athinoula A. Martinos Center for Biomedical Imaging website.

Open access paper: https://iopscience.iop.org/article/10.1088/1361-6560/aca950

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Human Health Risk Assessment of 4-12 GHz Radar Waves using CST STUDIO SUITE Software

Fereidouni F, Mohammadi ST, Faramarzi Shahraki V, Jahantigh F. Human Health Risk Assessment of 4-12 GHz Radar Waves using CST STUDIO SUITE Software. J Biomed Phys Eng. 2022 Jun 1;12(3):285-296. doi: 10.31661/jbpe.v0i0.1272.

Background: The application of radar systems in telecommunications and aerospace science is important. However, engineering department's staff various tissues are always under chronic radiation generated by the radar fields which may affect health.

Objective: This study aims to evaluate the risk of radar wave exposure and to explore the effects and limitations.

Material and methods: In this simulation study, an adult body model versus 1 watt source with a distance of 50 centimeters exposure has been simulated using the CST STUDIO SUITE. Furthermore, various physical and electrical properties of each tissue and organ for different frequencies and exposure times have been studied. The exposure dose limitations have been considered using the International Commission on Non-Ionizing Radiation Protection (ICNIRP) safety and health guide report.

Results: Total body absorbed doses for 4 GHz, 8 GHz, and 12 GHz frequency, and 6 min, 4 h, and 30 days exposure time, have been calculated as 1.136×10^{-5}, 1.598×10^{-5}, 1.58×10^{-3}, 1.521×10^{-5}, 3.122×10^{-5}, 4.52×10^{-3}, 4.1×10^{-5}, 10^{-4}, and 10^{-2}, respectively.

Conclusion: It has shown that the internal organs of the body and head will be under more risk by reducing radar frequencies from 12 GHz to 4 GHz. On the other hand, the higher frequency can cause a higher risk to the human skin. In addition, the maximum Specific Absorption Rate (SAR) for each case has been calculated. The results show that for this normalized source, the safety criteria have been respected, but for a higher source, the calculations must be repeated.

Conclusion

In this paper, an accurate and comprehensive model of the adult body tissues using the CST Studio Suite software is developed. The effect of EM radiation on the human body was studied for the frequency range of 4 to 12 GHz over a specified period of 6 min, 4 h and 30 days. It can be concluded that the effects are inversely related to the frequency increase. In other words, the longer the wavelength of the electromagnetic field can

cause further penetration in the human body and severe effects in the vital organs of the body. The longer exposure time can cause a severe effect. In addition, by examining the pattern of wave propagation in the body, it was seen that in the oral cavities filled with the air, there is a loss of wavelength and the waves tend to fall into the inner tissues which have absorption coefficient. Excluding the body skin, the power loss in the other organs monolithically decreased with frequency increase, and the power loss increases by the exposure time so that for 30 days exposure, it has nearly 2 orders of magnitude more absorption at different organs. The power loss diagram, SAR diagram, and the body organs risk caused by radar waves show the rate of vulnerability of the abdominal cavity and the head. The risk of the body skin disease in the lower frequencies has increased. Furthermore, the skin surface is more vulnerable and the chance of skin complications increases at higher frequencies up to 12 GHz. It should also be emphasized that for the body of those people whose workplace interact with radar waves exceeding the limit point of -10.96 dB, the critical risk of the body's vital organs increases. As a result, the standard limits should be considered for safety and health of the staff in the radar sites.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9175128/

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Grounding (earthing) as related to electromagnetic hygiene: An integrative review

Jamieson IA. Grounding (earthing) as related to electromagnetic hygiene: An integrative review. Biomedical Journal, 2022, doi:10.1016/j.bj.2022.11.005.

Abstract

There are a growing number of studies investigating how grounding (earthing) the body may benefit biological performance and aid the treatment of non-communicable diseases. Research also indicates how biological grounding initiatives can sometimes be compromised, or inappropriate, and the need to take additional factors into account as potential contributory factors, or confounders, to expected results. It is proposed that expanding electromagnetic hygiene measures beyond biological grounding alone may help reduce spread of communicable diseases, incidence of respiratory conditions, neurodegenerative disease and all-cause mortality. Identifying potential synergies that exist could enable multilevel interventions to further increase the efficacy of measures. It is hoped that this review will help act as a catalyst to inspire and inform multi-disciplinary research within these topic areas, best practices and policies to help drive medical innovation, reduce health burdens, improve bioelectromagnetic-based therapies, and influence the general design of the built environment and next-generation technologies.

Open access paper: https://www.sciencedirect.com/science/article/pii/S2319417022001573

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Assessment of the Electromagnetic Radiation Exposure at Electric Vehicle Charging Facilities

Bae H, Park S. Assessment of the Electromagnetic Radiation Exposure at EV Charging Facilities. Sensors (Basel). 2022 Dec 23;23(1):162. doi: 10.3390/s23010162

Abstract

As the number of electric vehicles (EV) increases, the number of EV chargers also increases. Charging infrastructure will be built into our close environment. Because of this, the assessment of the electromagnetic field exposure generated from the charger is an important issue. This paper valuates the electromagnetic field exposure of six EV chargers. To assess the level of exposure of EV chargers, the electromagnetic fields from six chargers were measured and analyzed. In addition, measured electromagnetic field exposure levels were evaluated against ICNIRP guidelines. Higher electromagnetic fields were measured with standard chargers than with fast chargers. For the fast charger in the charging state, the magnetic field increased with the charging current. Electromagnetic field exposures for all six chargers did not exceed standard limits. The results of the assessment of the electromagnetic field exposure of the six EV chargers will contribute to the establishment of standards for the evaluation of the electromagnetic field exposure of the EV chargers in the future.

Conclusion

In this study, electromagnetic field exposure assessment results of six EV chargers were presented. These results show the location where the electromagnetic field is the highest measured among electric vehicle chargers in the charging situation. They also show the correlation between changes in the electromagnetic field and changes in the SoC. The measured value of the electromagnetic field was analyzed by comparing it with domestic and global electromagnetic field intensity standard. The domestic electromagnetic field intensity standards were in agreement with the ICNIRP guidelines revised in 1998 and were analyzed based on them.

Six EV chargers were selected for measurement. The level of exposure to electromagnetic fields was confirmed by precisely measuring six types of chargers in RMS mode under charging conditions. In addition, the electromagnetic field changed as the SoC changed. Because of RMS precision measurement, a relatively higher electromagnetic field was emitted from a standard charger than from a fast charger. The maximum electric field was measured at the standard stand-type B handle, and it was 430 V/m, corresponding to an EI of 10%. The maximum magnetic field was measured on a standard wall-mounted body and was 46 A/m, corresponding to an EI of 69%. None of the six chargers exceeded the electromagnetic field protection standard.

Changes in electric and magnetic fields were confirmed by the changes in the SoC [state of charge] of six chargers. In the case of fast charging facilities, as the charging power and current gradually decreased, it was confirmed that the level of magnetic field strength decreased accordingly. In the case of standard charging facilities, the correlation between charging power, voltage, current, and electric and magnetic field strength could not be confirmed. In addition, changes in the electromagnetic field were observed with changes in the SoC. Generally, the maximum value of the electromagnetic field was measured in the measurement results by the change in the SoC. This result indicates the need to verify electromagnetic field measurements as the change in the SoC.

Because of these results, the measurement procedure when preparing a method to evaluate the amount of exposure to electromagnetic fields in EV charging facilities is worth reviewing in the future. When charging an

EV, the measurement location of maximum electromagnetic field exposure is necessary. Therefore, first, an understanding of the overall electromagnetic field strength of the charging facility is necessary. The maximum value after measurements according to the change from 0% to 100% of the SoC at the location of maximum exposure is worth recording.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9824816/

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Electromagnetic Radiation Safety on Far-Field Wireless Power Transfer in IoT

Ma F, Liu X, Ansari N. Electromagnetic Radiation Safety on Far-field Wireless Power Transfer in IoT. *GLOBECOM 2022 - 2022 IEEE Global Communications Conference*, Rio de Janeiro, Brazil, 2022, pp. 4995-5000, doi: 10.1109/GLOBECOM48099.2022.10001490.

Abstract

Nowadays, Far-field Wireless Power Transfer (FWPT) has attracted many research efforts to conveniently power the Internet of Things (IoT) devices. Electromagnetic Radiation (EMR) safety in FWPT has brought much attention from the public. Existing works on FWPT mainly focus on improving the remote charging efficiency but overlooking the effects of EMR. A few works consider EMR safety but do not present accurate EMR quantization analysis because there lacks an accurate EMR computing model in IoT wireless charging scenario. In this paper, in order to evaluate and avoid the EMR's harmful impact, we first propose an accurate theoretical calculation equation for EMR and the concept of Charging Restricted Area (CRA). In the wireless charging area on a 2-dimensional plane, according to the EMR computing model, we further maximize the overall charging power by adjusting the power of chargers and ensure that the EMR in this area is lower than the EMR safety threshold. The wireless charging EMR safety problem is formulated as a linear programming problem with infinite constraints. To re-express the wireless charging EMR safety problem as a typical linear programming problem with finite constraints, the Sampling Safety Charging (SSC) algorithm is proposed. We have conducted extensive experiments to validate our proposed algorithm; the simulation results show that the performance achieved by our algorithm outperforms that achieved by the distributed RObustlySafE (ROSE) algorithm.

https://ieeexplore.ieee.org/document/10001490

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Coverage factors for efficient demonstration of compliance of low-frequency magnetic near-field exposures with basic restrictions

Xi J, Christ A, Kuster N. Coverage factors for efficient demonstration of compliance of low-frequency magnetic near-field exposures with basic restrictions. Phys Med Biol. 2022 Dec 2. doi: 10.1088/1361-6560/aca875.

Abstract

Regulators require that wireless power transfer (WPT) systems and other strong magnetic field sources are compliant with the basic restrictions (BR) defined as the limits of the fields induced in the human body, i.e., the

induced electric field/current density/specific absorption rate limits. This can be achieved by demonstrating compliance with the reference levels (RL) defined in air without the human body, i.e., the incident electric/magnetic field limits. Local sources, such as WPT transmitters, generate non-uniform fields that can locally exceed the RL while the induced fields are still well below the BR. In these cases, robust compliance with BR can be demonstrated, generally requiring a large number of simulations. In this study, we proposed an efficient evaluation using a homogeneous phantom and applying a coverage factor to account for the local field enhancements caused by the dielectric contrasts of the highly inhomogeneous human tissues. The generally applicable coverage factors were derived from a statistical analysis of the field enhancements observed on four magnetic near-field sources placed at different separation distances (2-80 mm) and locations on the back of 12 anatomical models. The field enhancements were characterized by the ratios between the peak induced fields in the anatomical models and those in the homogeneous half-space phantom (ε_r= 55, σ = 0.75 S/m, ρ = 1,000 kg/m^3) at the same distance. The resulting 99th percentile coverage factors range from 1 and 9 depending on the dosimetric quantity. The use of these coverage factors reduces the compliance testing effort from hundreds of simulations to only one, and makes experimental testing feasible without the support of simulations. The study also demonstrates that running only a few use-case simulations with anatomical models may underestimate the exposure by more than 10 dB.

https://iopscience.iop.org/article/10.1088/1361-6560/aca875

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Estimating exposure to extremely low frequency magnetic fields near high-voltage power lines and assessment of possible increased cancer risk among Slovenian children and adolescents

Zagar T, Valic B, Kotnik T, Korat S, Tomsic S, Zadnik V, Gajsek P. Estimating exposure to extremely low frequency magnetic fields near high-voltage power lines and assessment of possible increased cancer risk among Slovenian children and adolescents. Radiol Oncol. 2023 Jan 8. doi: 10.2478/raon-2023-0002.

Abstract

Background: Some previous research showed that average daily exposure to extremely low frequency (ELF) magnetic fields (MF) of more than 0.3 or 0.4 µT could potentially increase risk of childhood leukaemia.

Materials and methods: To allow calculations of ELF MF around high voltage (HV) power lines (PL) for the whole Slovenia, a new three-dimensional method including precision terrain elevation data was developed to calculate the long-term average ELF MF. Data on population of Slovenian children and adolescents and on cancer patients with leukaemia's aged 0-19 years, brain tumours at age 0-29, and cancer in general at age 0-14 for a 12-year period 2005-2016 was obtained from the Slovenian Cancer Registry.

Results: According to the large-scale calculation for the whole country, only 0.5% of children and adolescents under the age of 19 in Slovenia lived in an area near HV PL with ELF MF density greater than 0.1 µT. The risk of cancer for children and adolescents living in areas with higher ELF MF was not significantly different from the risk of their peers.

Conclusions: The new method enables relatively fast calculation of the value of low-frequency magnetic fields for arbitrary loads of the power distribution network, as the value of each source for arbitrary load is calculated by scaling the value for nominal load, which also enables significantly faster adjustment of calculated estimates in the power distribution network.

Open access paper: https://sciendo.com/article/10.2478/raon-2023-0002

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Evaluation of cognitive functions and EEG records in rats exposed to 2.45 GHz electromagnetic field

Yucel H, Dundar NO, Doguc DK, Uguz C, Celik O, Aksoy FT, Nazıroglu M, Comlekci S, Dundar B. Evaluation of cognitive functions and EEG records in rats exposed to 2.45 GHz electromagnetic field. Int J Radiat Res 2022, 20(4): 753-760.

Abstract

Background: Electromagnetic fields may primarily affect cognitive functions. It has not been elucidated how electromagnetic radiation affects the brain, particularly in the young age group. We aimed to examine the cognitive function, expression of N-methyl-D-aspartate receptors (NMDA), and EEG alterations in weaned rats exposed to a 2.45 GHz electromagnetic field.

Materials and Methods: Twenty-one weaned (21 days old) male Wistar Albino rats were divided into two groups as experimental group (n=12) and control group (n=9). Animals in the experimental group were exposed to a 2.45 GHz electromagnetic field for one hour a day for more than 28 days. At the end of this period, rats were subjected to training and learning test using Morris Water Maze. After obtaining EEG records, hippocampi were removed. 2A and 2B subunits of NMDA receptors were studied in hippocampal homogenates using the Western Blot method.

Results: There were no statistically significant differences between the two groups in measures of latency to target quadrant, time spent in the target quadrant, and average swim speed as compared in Morris water maze. However, the time to arrive at the visible platform was significantly longer in experimental animals. There were no statistically significant differences in expression of 2A and 2B subunits of NMDA receptors between the two groups. Evaluation of EEG records revealed that spike frequency was significantly higher and time to first spike was significantly shorter in the experimental group.

Conclusion: These results indicated that a 2.45 GHz electromagnetic field might negatively affect EEG, motivation, and attention, particularly in the young age group.

Open access paper: http://ijrr.com/article-1-4460-en.pdf

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Effects of ELF-PEMF exposure on spontaneous alternation, anxiety, motor co-ordination and locomotor activity of adult wistar rats and viability of C6 (Glial) cells in culture

Tekam CKS, Majumdar S, Kumari P, Prajapati SK, Sahi AK, Shinde S, Singh R, Samaiya PK, Patnaik R, Krishnamurthy S, Mahto SK. Effects of ELF-PEMF exposure on spontaneous alternation, anxiety, motor co-ordination and locomotor activity of adult wistar rats and viability of C6 (Glial) cells in culture. Toxicology. 2022 Dec 24;485:153409. doi: 10.1016/j.tox.2022.153409.

Abstract

The effects of ELF-PEMF exposure on spontaneous alternation, anxiety, motor coordination, and locomotor activity have been discussed in various pre-clinical and clinical settings. Several epidemiological and experimental studies have demonstrated the potential effects of ELF-PEMF when exposed > ∼1 h/day; however, very few studies have focused on understanding the influence of ELF-PEMF exposure of 1-3 mT with an exposure duration of < 1 h/day on spontaneous alternation, anxiety, motor coordination, and locomotor activity. Hence, we attempted to study the effects of ELF-PEMF exposure of 1-3 mT, 50 Hz with an exposure duration of 20 min each with a 4 h gap (2 times) on the cellular proliferation and morphologies of C6 (Glial) cells and spontaneous alternation, anxiety, motor coordination and locomotor activity of Wistar rats under in vitro and in vivo conditions, respectively. The results showed that ELF-PEMF exposure did not induce any significant levels of cellular fragmentation and changes in the morphology of glial cells. Also, the outcomes revealed no noticeable effects on spontaneous alternation, anxiety, motor coordination, and locomotor activity in PEMF-exposed groups compared with the control. No undesirable side effects were observed at the highest dose (B=3 mT). We also performed histological analysis of the selected brain sections (hippocampus and cortex) following ELF-PEMF exposure. Incidentally, no significant changes were observed in cortical cell counts, tissue structure, and morphology.

https://pubmed.ncbi.nlm.nih.gov/36572170/

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Influence of electromagnetic fields on the circadian rhythm: Implications for human health and disease

Martel J, Chang SH, Chevalier G, Ojcius DM, Young JD. Influence of electromagnetic fields on the circadian rhythm: Implications for human health and disease. Biomed J. 2023 Jan 18:S2319-4170(23)00003-3. doi: 10.1016/j.bj.2023.01.003.

Abstract

Living organisms have evolved within the natural electromagnetic fields of the earth which comprise atmospheric electricity, Schumann resonances and the geomagnetic field. Research suggests that the circadian rhythm, which controls several physiological functions in the human body, can be influenced by light but also by the earth's electromagnetic fields. Cyclic solar disturbances, including sunspots and seasonal weakening of the geomagnetic field, can affect human health, possibly by disrupting the circadian rhythm and downstream physiological functions. Severe disruption of the circadian rhythm increases inflammation which can induce fatigue, fever and flu-like symptoms in a fraction of the population and worsen existing symptoms in old and diseased individuals, leading to periodic spikes of infectious and chronic diseases. Possible mechanisms underlying sensing of the earth's electromagnetic fields involve entrainment, light-dependent radical pair

formation in retina cryptochromes, and paramagnetic magnetite nanoparticles. Factors such as electromagnetic pollution from wireless devices and antennas, shielding by non-conductive materials used in shoes and buildings, and local geomagnetic anomalies may also affect sensing of the earth's electromagnetic fields by the human body and contribute to circadian rhythm disruption and disease development.

Open access paper: https://www.sciencedirect.com/science/article/pii/S2319417023000033?via%3Dihub

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The Effects of Prenatal and Postnatal Exposure to 50-Hz and 3 mT Electromagnetic Field on Rat Testicular Development

Ersoy N, Acikgoz B, Aksu I, Kiray A, Bagriyanik HA, Kiray M. The Effects of Prenatal and Postnatal Exposure to 50-Hz and 3 mT Electromagnetic Field on Rat Testicular Development. Medicina (Kaunas). 2022 Dec 29;59(1):71. doi: 10.3390/medicina59010071.

Abstract

Background and objectives: It has been shown that electromagnetic fields (EMFs) have negative effects on the reproductive system. The biological effects of EMF on the male reproductive system are controversial and vary depending on the frequency and exposure time. Although a limited number of studies have focused on the structural and functional effects of EMF, the effects of prenatal and postnatal EMF exposure on testes are not clear. We aimed to investigate the effects of 50-Hz, 3-mT EMF exposure (5 days/wk, 4 h/day) during pre- and postnatal periods on testis development. *Materials and Methods:* Pups from three groups of Sprague-Dawley pregnant rats were used: Sham, EMF-28 (EMF-exposure applied during pregnancy and until postnatal day 28), EMF-42 (EMF-exposure applied during pregnancy and until postnatal day 42). The testis tissues and blood samples of male offspring were collected on the postnatal day 42. *Results:* Morphometric analyses showed a decrease in seminiferous tubule diameter as a result of testicular degeneration in the EMF-42 group. Follicle-stimulating hormone (FSH) and luteinizing hormone (LH) levels were decreased in the EMF-42 group. Lipid peroxidation levels were increased in both EMF groups, while antioxidant levels were decreased only in the EMF-28 group. We found decreased levels of vascular endothelial growth factor (VEGF) and insulin-like growth factor-1 (IGF1) in the EMF-42 group, and decreased levels of the SRC homology 3 (SH3) and multiple ankyrin repeat domain (SHANK3) in the EMF-28 group in the testis tissue. *Conclusions:* EMF exposure during pre- and postnatal periods may cause deterioration in the structure and function of testis and decrease in growing factors that would affect testicular functions in male rat pups. In addition to the oxidative stress observed in testis, decreased SHANK3, VEGF, and IGF1 protein levels suggests that these proteins may be mediators in testis affected by EMF exposure. This study shows that EMF exposure during embryonic development and adolescence can cause apoptosis and structural changes in the testis.

Open access paper: https://www.mdpi.com/1648-9144/59/1/71

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Effects of 150 kHz intermediate frequency electromagnetic radiation on fertility indicators in male rats

Sundaram V, Mohammed S, Zyuzikov N. Effects of 150 kHz intermediate frequency electromagnetic radiation on fertility indicators in male rats. Heliyon. 8(12). 2022. doi: 10.1016/j.heliyon.2022.e12228.

Abstract

Background The present study aimed to evaluate the effects of whole-body exposure to 150 kHz Intermediate-frequency electromagnetic radiation (IF EMR) on fertility indicators of male rats since human exposure to this frequency has increased in recent years. Fourteen adult male Sprague-Dawley rats were used in this study. The rats were randomly divided into a control and an EMR group (n = 7/group). The EMR group was continuously irradiated with 150 kHz EMR for 8 weeks. Male fertility indicators, body mass, testicular mass, rectal temperature, testicular histology, histometry, sperm analysis, and serum gonadotrophic hormone levels were evaluated.

Results The study showed no negative effect on body mass (grams) (323.78 ± 37.09 to 305.09 ± 26.36; p = 0.72), rectal temperature (Control: 34.5 °C–35.8 °C; EMR: 34.4 °C–36.1 °C; p < 0.05), and testicular histology. There were significant reductions in left and right testicular mass (1.04 ± 0.10 to 0.96 ± 0.32: p = 0.03 and 1.02 ± 0.08 to 0.96 ± 0.35 p = 0.04, respectively), interstitial cell count/1000 μm2 (5.33 ± 0.56 to 4.47 ± 0.48; p = 0.01), sperm motility trajectories (p = 0.05) and sperm distal cytoplasmic droplet (%) (2.27 ± 2.28 to 6.84 ± 5.01; p = 0.05). A significant increase in follicle-stimulating hormone levels was observed (13.44 ± 6.38 IU/ml to 26.96 ± 8.07 IU/ml; p = 0.01).

Conclusions Most male fertility parameters of rats in the present study were not affected by 8 weeks of whole-body exposure to 150 kHz EMR. However, significant decreases in testicular mass, interstitial cell count/1000 μm2, sperm motility trajectories, and distal cytoplasmic droplets were observed, as well as an increase in FSH level.

Open access paper: https://www.sciencedirect.com/science/article/pii/S2405844022035162

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Magnetic fields produced by subsea high-voltage direct current cables reduce swimming activity of haddock larvae

Cresci A, Durif CMF, Larsen T, Bjelland R, Skiftesvik AB, Browman HI. Magnetic fields produced by subsea high-voltage direct current cables reduce swimming activity of haddock larvae (*Melanogrammus aeglefinus*). PNAS Nexus. 2022 Aug 27;1(4):pgac175. doi: 10.1093/pnasnexus/pgac175.

Abstract

High-voltage direct current (HVDC) subsea cables are used to transport power between locations and from/to nearshore and offshore facilities. HVDC cables produce magnetic fields (B-fields) that could impact marine fish. Atlantic haddock (*Melanogrammus aeglefinus*) is a demersal fish that is at risk of exposure to anthropogenic B-fields. Their larvae drift over the continental shelf, and use the Earth's magnetic field for orientation during

dispersal. Therefore, anthropogenic magnetic fields from HVDC cables could alter their behavior. We tested the behavior of 92 haddock larvae using a setup designed to simulate the scenario of larvae drifting past a B-field in the intensity range of that produced by a DC subsea cable. We exposed the larvae to a B-field intensity ranging from 50 to 150 µT in a raceway tank. Exposure to the B-field did not affect the spatial distribution of haddock larvae in the raceway. Larvae were categorized by differences in their exploratory behavior in the raceway. The majority (78%) of larvae were nonexploratory, and exposure to the artificial B-field reduced their median swimming speed by 60% and decreased their median acceleration by 38%. There was no effect on swimming of the smaller proportion (22%) of exploratory larvae. These observations support the conclusion that the swimming performance of nonexploratory haddock larvae would be reduced following exposure to B-field from HVDC cables. The selective impact on nonexploratory individuals, and the lack of impact on exploratory individuals, could have population-scale implications for haddock in the wild.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9802485/

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Magnetic fields generated by submarine power cables have a negligible effect on the swimming behavior of Atlantic lumpfish

Durif CMF, Nyqvist D, Taormina B, Shema SD, Skiftesvik AB, Freytet F, Browman HI. Magnetic fields generated by submarine power cables have a negligible effect on the swimming behavior of Atlantic lumpfish (*Cyclopterus lumpus*) juveniles. PeerJ. 2023 Jan 23;11:e14745. doi: 10.7717/peerj.14745.

Abstract

Submarine power cables carry electricity over long distances. Their geographic distribution, number, and areal coverage are increasing rapidly with the development of, for example, offshore wind facilities. The flow of current passing through these cables creates a magnetic field (MF) that can potentially affect marine organisms, particularly those that are magnetosensitive. The lumpfish (*Cyclopterus lumpus*) is a migratory species that is widely distributed in the North Atlantic Ocean and Barents Sea. It migrates between coastal spawning grounds and pelagic offshore feeding areas. We tested whether lumpfish respond to MFs of the same intensity as those emitted by high voltage direct current (HVDC) submarine power cables. Laboratory experiments were conducted by placing juvenile lumpfish in an artificial MF gradient generated by a Helmholtz coil system. The intensity of the artificial MF used (230 µT) corresponded to the field at 1 m from a high-power submarine cable. The fish were filmed for 30 min with the coil either on or off. Swimming speeds, and presence in the different parts of a raceway, were extracted from the videos and analyzed. Juvenile lumpfish activity, defined as the time that the fish spent swimming relative to stationary pauses (attached to the substrate), and the distance travelled, were unaffected by exposure to the artificial MF. The swimming speed of juvenile lumpfish was reduced (by 16%) when the coil was on indicating that the fish could either sense the MF or the induced electric field created by the movement of the fish through the magnetic field. However, it seems unlikely that a 16% decrease in swimming speed occurring within 1 m of HVDC cables would significantly affect Atlantic lumpfish migration or homing.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9879148/

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Geomagnetic disturbance associated with increased vagrancy in migratory landbirds

Tonelli BA, Youngflesh C, Tingley MW. Geomagnetic disturbance associated with increased vagrancy in migratory landbirds. Sci Rep. 2023 Jan 9;13(1):414. doi: 10.1038/s41598-022-26586-0.

Abstract

Rare birds known as "accidentals" or "vagrants" have long captivated birdwatchers and puzzled biologists, but the drivers of these rare occurrences remain elusive. Errors in orientation or navigation are considered one potential driver: migratory birds use the Earth's magnetic field-sensed using specialized magnetoreceptor structures-to traverse long distances over often unfamiliar terrain. Disruption to these magnetoreceptors or to the magnetic field itself could potentially cause errors leading to vagrancy. Using data from 2 million captures of 152 landbird species in North America over 60 years, we demonstrate a strong association between disruption to the Earth's magnetic field and avian vagrancy during fall migration. Furthermore, we find that increased solar activity-a disruptor of the avian magnetoreceptor-generally counteracts this effect, potentially mitigating misorientation by disabling the ability for birds to use the magnetic field to orient. Our results link a hypothesized cause of misorientation to the phenomenon of avian vagrancy, further demonstrating the importance of magnetoreception among the orientation mechanisms of migratory birds. Geomagnetic disturbance may have important downstream ecological consequences, as vagrants may experience increased mortality rates or facilitate range expansions of avian populations and the organisms they disperse.

Open access paper: https://www.nature.com/articles/s41598-022-26586-0

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Limiting exposure to radiofrequency radiation: the principles and possible criteria for health protection

Hinrikus H, Koppel T, Lass J, Roosipuu P, Bachmann M. Limiting exposure to radiofrequency radiation: the principles and possible criteria for health protection. International Journal of Radiation Biology. 2022. doi:10.1080/09553002.2023.2159567.

Abstract

Purpose. The current paper is aimed to discuss the principles and criteria for health protection to radiofrequency electromagnetic field (RF EMF) considering both thermal and non-thermal mechanisms to evaluate the reasonable level for the limits relevant to control the level of RF EMF for the general public in the living environment. The study combines the conclusions of analyses published in recent reviews on RF EMF effects and the data from RF EMF measurements in different countries to select the possible criteria and to derive proposals for the health protection limits on the level of RF EMF following the ALARA principle - as low as reasonably achievable.

Conclusions. Consideration of not only energetic but also coherent qualities of RF EMF leads to two different

models for determining the impact of non-ionizing radiation on human health. The thermal model, based on absorption of electromagnetic energy, has a threshold limiting the heating of tissues. The non-thermal model, based on the ability of coherent electric fields to introduce biological effects at constant temperature, has no threshold. Therefore, the impact of RF EMF on human health cannot be excluded but can be minimized by limiting the level of the radiation. The limits can be selected based on indirect criteria. The minimal level of RF EMF that has caused a biological effect is about 2 V/m. The level of long-term broadcast radiation is 6 V/m and the people can be assumed to be adapted to that level without observable health problems. The level of RF EMF measured during last years does not exceed 5 V/m and the level is decreasing with newer generations of telecommunication technology. Limiting the level of RF EMF to the peak value of 6 V/m hopefully reduces the health risk to a minimal level people are adapted to and does not restrict the further development of telecommunication technology.

Conclusions

The consideration of not only energetic but also coherent qualities of RF EMF leads to two different models in investigation of RF EMF biological effects and determining the impact of the non-ionizing radiation on human health. The thermal model based on absorption of electromagnetic energy has a threshold limiting the heating of tissues. The non-thermal model based on the ability of coherent electric fields to introduce biological effects at the constant temperature has no threshold. The impact of RF EMF on human health cannot be excluded but can be reduced, limiting the level of the radiation.

The limit, due to the missing threshold, can be selected based on indirect criteria. The minimal levels of RF EMF that have caused a biological effect are 1.4 - 2.45 V/m. The level of long-term broadcast radiation is 6 V/m; people can be assumed to be adapted to that level. The results of measurements over the last decade indicated the level of RF EMF lower than 5 V/m. The majority of measurements have indicated much lower levels. All these values are of the same order of magnitude.

Limiting the level of EF EMF to the peak value of 6 V/m hopefully reduces the health risk to a minimal level determined by long existing broadcast radiation people are adapted to without restricting the further development of telecommunication technology. The technology of telecommunication systems is in permanent progress. The newer generations of technology employ lower levels of radiation, shorter time intervals and less energy to provide high quality and speed for transmission of information. Switching off older generations (2G, 3G), accompanying the development of technology today, significantly reduces the level of RF EMF and therefore also reduces the possible health risk.

The current level of knowledge allows us to formulate the suggestions only for the threshold and frequency dependence in the models for RF EMF impact. The dynamic relationships between the intensity of the effect and the level of RF EMF or time spent in the radiation are still unknown. The temporal dynamics is most complicated to be assessed because people and animals are living permanently in RF EMF. Further investigations are highly needed for long-term RF EMF effects and in the frequency range higher than 6000 MHz.

https://www.tandfonline.com/doi/full/10.1080/09553002.2023.2159567

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Wireless technology is an environmental stressor requiring new understanding and approaches in health care

McCredden JE, Cook N, Weller S, Leach V. Wireless technology is an environmental stressor requiring new understanding and approaches in health care Front. Public Health, 20 December 2022. doi: 10.3389/fpubh.2022.986315.

Abstract

Electromagnetic signals from everyday wireless technologies are an ever-present environmental stressor, affecting biological systems. In this article, we substantiate this statement based on the weight of evidence from papers collated within the ORSAA database (ODEB), focusing on the biological and health effects of electromagnetic fields and radiation. More specifically, the experiments investigating exposures from real-world devices and the epidemiology studies examining the effects of living near mobile phone base stations were extracted from ODEB and the number of papers showing effects was compared with the number showing no effects. The results showed that two-thirds of the experimental and epidemiological papers found significant biological effects. The breadth of biological and health categories where effects have been found was subsequently explored, revealing hundreds of papers showing fundamental biological processes that are impacted, such as protein damage, biochemical changes and oxidative stress. This understanding is targeted toward health professionals and policy makers who have not been exposed to this issue during training. To inform this readership, some of the major biological effect categories and plausible mechanisms of action from the reviewed literature are described. Also presented are a set of best practice guidelines for treating patients affected by electromagnetic exposures and for using technology safely in health care settings. In conclusion, there is an extensive evidence base revealing that significant stress to human biological systems is being imposed by exposure to everyday wireless communication devices and supporting infrastructure. This evidence is compelling enough to warrant an update in medical education and practice.

Excerpt

Indeed, the data from ODEB (see Table 1) corroborates the above research findings, by showing that the type of signal used: real or simulated, can affect study outcomes. Within the 1,106 relevant experimental papers selected from ODEB using the quality of reporting criteria above, there were proportionally more “Effect” outcomes when the experiments used real-world signals and proportionally more “No Effect” outcomes when simulated signals were used. This relationship between signal type and biological effect outcome was statistically significant ($p < 0.05$), indicating that signal type needs to be clearly articulated in reporting because it can potentially bias outcomes. This result also supports our decision to investigate further only the experimental papers that used real-world signals. For these papers, shown in the final column of Table 1, there was a significantly higher proportion of papers showing effects (79.1%) than those reporting no effects (15.3%).

Conclusion

Man-made radiofrequency signals from everyday devices and communications technology infrastructure constitute an environmental stressor, well-documented as creating various adverse biological effects. Plausible mechanisms in which harm can occur initially on a cellular level have been proposed, and these mechanisms are known to have subsequent downstream health effects. The application of the ICRP radiation protection philosophy and framework for the protection of members of the public is over 90 years in the making and is absent in setting exposure limits for this form of (wireless) radiation. The extensive evidence base is compelling

enough to call for an update in medical education and practice. Out of care for their patients, healthcare workers may develop their understanding using the practical methods introduced in this discussion paper. Furthermore, modern institutional practices need to be reviewed to ensure that any harm from electromagnetic fields is reduced as much as reasonably possible while still providing optimal health care.

Open access paper: https://www.frontiersin.org/articles/10.3389/fpubh.2022.986315/full

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Controversy in Electromagnetic Safety

Chou CK. Controversy in Electromagnetic Safety. Int J Environ Res Public Health. 2022 Dec 16;19(24):16942. doi: 10.3390/ijerph192416942.

Abstract

The dramatic increase in electromagnetic fields (EMFs) in the environment has led to public health concerns around the world. Based on over 70 years of research in this field, the World Health Organization (WHO) has concluded that scientific knowledge in this area is now more extensive than for most chemicals and that current evidence does not confirm the existence of any health consequences from exposure to low-level electromagnetic fields. However, controversy on electromagnetic safety continues. Two international groups, the International Committee on Electromagnetic Safety of the Institute of Electrical and Electronics Engineers (IEEE) and the International Commission on Non-Ionizing Radiation Protection, have been addressing this issue for decades. While the goal of both groups is to provide human exposure limits that protect against established or substantiated adverse health effects, there are groups that advocate more stringent exposure limits, based on possible biological effects. Both biological and engineering complexities make the validity of many EMF studies questionable. Controversies in research, publication, standards, regulations and risk communication concerning electromagnetic safety will be addressed in this article. The WHO is conducting systematic reviews on the RF biological effects literature. If scientists would discuss the safety issues of EMFs based on validated scientific facts and not on unreproducible possible effects and opinions, the controversy would be minimized or resolved.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9778992/

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Conducting evaluations of evidence that are transparent, timely and can lead to health-protective actions

Chartres N, Sass JB, Gee D, Bălan SA, Birnbaum L, Cogliano VJ, Cooper C, Fedinick KP, Harrison RM, Kolossa-Gehring M, Mandrioli D, Mitchell MA, Norris SL, Portier CJ, Straif K, Vermeire T. Conducting evaluations of evidence that are transparent, timely and can lead to health-protective actions. Environ Health. 2022 Dec 5;21(1):123. doi: 10.1186/s12940-022-00926-z.

Abstract

Background: In February 2021, over one hundred scientists and policy experts participated in a web-based Workshop to discuss the ways that divergent evaluations of evidence and scientific uncertainties are used to delay timely protection of human health and the environment from exposures to hazardous agents. The Workshop arose from a previous workshop organized by the European Environment Agency (EEA) in 2008 and which also drew on case studies from the EEA reports on 'Late Lessons from Early Warnings' (2001, 2013). These reports documented dozens of hazardous agents including many chemicals, for which risk reduction measures were delayed for decades after scientists and others had issued early and later warnings about the harm likely to be caused by those agents.

Results: Workshop participants used recent case studies including Perfluorooctanoic acid (PFOA), Extremely Low Frequency - Electrical Magnetic Fields (ELF-EMF fields), glyphosate, and Bisphenol A (BPA) to explore myriad reasons for divergent outcomes of evaluations, which has led to delayed and inadequate protection of the public's health. Strategies to overcome these barriers must, therefore, at a minimum include approaches that 1) Make better use of existing data and information, 2) Ensure timeliness, 3) Increase transparency, consistency and minimize bias in evidence evaluations, and 4) Minimize the influence of financial conflicts of interest.

Conclusion: The recommendations should enhance the production of "actionable evidence," that is, reliable evaluations of the scientific evidence to support timely actions to protect health and environments from exposures to hazardous agents. The recommendations are applicable to policy and regulatory settings at the local, state, federal and international levels.

Open access paper: https://ehjournal.biomedcentral.com/articles/10.1186/s12940-022-00926-z

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Biological Effects of Radiofrequency Electromagnetic Fields above 100 MHz on Fauna and Flora: Workshop Report

Pophof B, Henschenmacher B, Kattnig DR, Kuhne J, Vian A, Ziegelberger G. Biological Effects of Radiofrequency Electromagnetic Fields above 100 MHz on Fauna and Flora: Workshop Report. Health Phys. 2023 Jan 1;124(1):31-38. doi: 10.1097/HP.0000000000001625.

Abstract

This report summarizes the effects of anthropogenic radiofrequency electromagnetic fields with frequencies above 100 MHz on flora and fauna presented at an international workshop held on 5-7 November 2019 in Munich, Germany. Anthropogenic radiofrequency electromagnetic fields at these frequencies are commonplace; e.g., originating from transmitters used for terrestrial radio and TV broadcasting, mobile communication, wireless internet networks, and radar technologies. The effects of these radiofrequency fields on flora, fauna, and ecosystems are not well studied. For high frequencies exceeding 100 MHz, the only scientifically established action mechanism in organisms is the conversion of electromagnetic into thermal energy. In accordance with that, no proven scientific evidence of adverse effects in animals or plants under realistic environmental conditions has yet been identified from exposure to low-level anthropogenic radiofrequency fields in this

frequency range. Because appropriate field studies are scarce, further studies on plants and animals are recommended.

https://pubmed.ncbi.nlm.nih.gov/36480583/

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Biological Effects of Electric, Magnetic, and Electromagnetic Fields from 0 to 100 MHz on Fauna and Flora: Workshop Report

Pophof B, Henschenmacher B, Kattnig DR, Kuhne J, Vian A, Ziegelberger G. Biological Effects of Electric, Magnetic, and Electromagnetic Fields from 0 to 100 MHz on Fauna and Flora: Workshop Report. Health Phys. 2023 Jan 1;124(1):39-52. doi: 10.1097/HP.0000000000001624.

Abstract

This report summarizes effects of anthropogenic electric, magnetic, and electromagnetic fields in the frequency range from 0 to 100 MHz on flora and fauna, as presented at an international workshop held on 5-7 November in 2019 in Munich, Germany. Such fields may originate from overhead powerlines, earth or sea cables, and from wireless charging systems. Animals and plants react differentially to anthropogenic fields; the mechanisms underlying these responses are still researched actively. Radical pairs and magnetite are discussed mechanisms of magnetoreception in insects, birds, and mammals. Moreover, several insects as well as marine species possess specialized electroreceptors, and behavioral reactions to anthropogenic fields have been reported. Plants react to experimental modifications of their magnetic environment by growth changes. Strong adverse effects of anthropogenic fields have not been described, but knowledge gaps were identified; further studies, aiming at the identification of the interaction mechanisms and the ecological consequences, are recommended.

https://pubmed.ncbi.nlm.nih.gov/36480584/

Excerpt

Taken together, the effects of electromagnetic fields on individual organisms have now been widely investigated for a multitude of plant and animal species. However, this does not yet address the ecological consequences of this perception in the context of increased anthropogenic EMF emissions. This will require studies of natural populations in their natural habitat and entire ecosystems, including the evaluation of the relevant physical variables over Earth's surface, along the seabed, in space and time, and detailed biological information on the relevant states of populations. Besides deciphering the action mechanism, this is a field of great demand for assessing the actual environmental effects of steadily increasing EMF emissions. Finally, and importantly, many results from isolated but often paradigm-forming studies have to be independently reproduced.

In particular, due to the ongoing technological development, the following topics are of special importance:

• Wireless charging and safety of small animals;
• Ecological consequences of the known behavioral effects of electric and magnetic fields from widespread marine cables;

• Ecological consequences of electromagnetic noise, known to disrupt animal (e.g., migratory bird) orientation in the laboratory, on animal orientation in the natural environment; • Ecological consequences of observed behavioral effects of ELF-EMFs from powerlines, e.g., on insects and mammals; and
• Pinpointing sensory structures and action mechanism, whereby it is expected that progress for one species can fertilize progress in others

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Effect of Radiofrequency Electromagnetic Radiation Emitted by Modern Cellphones on Sperm Motility and Viability: An In Vitro Study

Chu KY, Khodamoradi K, Blachman-Braun R, et al. Effect of Radiofrequency Electromagnetic Radiation Emitted by Modern Cellphones on Sperm Motility and Viability: An In Vitro Study. Eur Urol Focus. 2022;S2405-4569(22)00247-4. doi:10.1016/j.euf.2022.11.004.

Abstract

Background: Cellphones emit radiofrequency electromagnetic radiation (RF-EMR) for transmission of data for social media communication, web browsing, and music/podcast streaming. Use of Bluetooth ear buds has probably prolonged the time during which cellphones reside in the trouser pockets of men. It has been postulated that RF-EMR increases oxidative stress and induces free radical formation.

Objective: To investigate the effect of wireless-spectrum (4G, 5G, and WiFi) RF-EMR emitted by modern smartphones on sperm motility and viability and explore whether these effects can be mitigated using a physical barrier or distance.

Design, setting, and participants: Semen samples were obtained from fertile normozoospermic men aged 25-35 yr. A current-generation smartphone in talk mode was used as the RF-EMR source. A WhatsApp voice call was made using either 4G, 5G, or WiFi wireless connectivity. We determined if exposure effects were mitigated by either a cellphone case or greater distance from the semen sample.

Outcome measurements and statistical analysis: The semen samples were analyzed according to 2010 World Health Organization laboratory guidelines. Statistical analysis was performed using SPSS v.28.

Results and limitations: We observed decreases in sperm motility and viability with WiFi exposure but not with exposure to 4G or 5G RF-EMR. With large variability among smartphones, continued research on exposure effects is needed.

Conclusions: Our exploratory study revealed that sperm motility and viability are negatively impacted by smartphones that use the WiFi spectrum for data transmission.

Patient summary: We looked at the effect of cellphone use on sperm motility and viability. We found that cellphones using WiFi connectivity for data usage have harmful effects on semen quality in men.

https://pubmed.ncbi.nlm.nih.gov/36379868/

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A Meta-Integrative Qualitative Study on the Hidden Threats of Smart Buildings/Cities and Their Associated Impacts on Humans and the Environment

Raveendran R, Tabet Aoul KA. A Meta-Integrative Qualitative Study on the Hidden Threats of Smart Buildings/Cities and Their Associated Impacts on Humans and the Environment. *Buildings*. 2021; 11(6):251. https://doi.org/10.3390/buildings11060251

Abstract

Smart buildings deploying 5G and the Internet of Things (IoT) are viewed as the next sustainable solution that can be seamlessly integrated in all sectors of the built environment. The benefits are well advertised and range from inducing wellness and monitoring health, amplifying productivity, to energy savings. Comparatively, potential negative risks are less known and mostly relate to cyber-security threats and radiation effects. This meta-integrative qualitative synthesis research sought to determine the possible underlying demerits from developing smart buildings, and whether they outweigh the possible benefits. The study identified five master themes as threats of smart buildings: a surfeit of data centers, the proliferation of undersea cables, the consternation of cyber-security threats, electromagnetic pollution, and E-waste accumulation. Further, the paper discusses the rebound impacts on humans and the environment as smart buildings' actualization becomes a reality. The study reveals that, although some aspects of smart buildings do have their tangible benefits, the potential repercussions from these not-so-discussed threats could undermine the former when all perspectives and interactions are analyzed collectively rather than in isolation.

Excerpt

4.4. Master Theme 4: Electromagnetic Pollution

This is generally an identified problem with the deployment of smart buildings using 5G and IoT devices. Many countries have called to ban 5G in general until impartial research data can be made available, and several researchers around the globe have submitted a "5G appeal" [105]. The radiation effects could range from causing headaches, insomnia, to DNA alteration, along with the possibility of creating other biological damages such as hormonal imbalances, reproductive issues, tumors, nerve damage, and eye damage [65,106]. Belpomme (2015) concluded from a comprehensive study that the EMF effect could worsen health conditions related to oxidative stress, a deficit in melatonin metabolism, and is more reflected among electro-sensitive people [107]. Several studies by bio-chemical and medical researchers found that high frequencies can significantly change the heart rate, chromatin (DNA complex and proteins), and melatonin, as well as other hormonal changes [59,71,108]. Kojima et al., (2018) revealed that though most of the effects were thermally related as millimeter frequencies are quickly absorbed by water, it can induce damaging effects without the heating of the tissues, i.e., nonthermal effects that are more dangerous [109].

As a guideline, the Federal Communication Commission (FCC) adopted the SAR (specific absorption rate) limit value of 1.6 W/Kg for 1 g of tissue approved by ANSI and IEEE [110]. However, current FCC regulations check only the SAR value, which is only a measure of the thermal effects; on the contrary, several studies have concluded that evaluations other than SAR are necessary to fully understand the impact of biological effects other than the thermal effect [111,112]. Scientific evidence suggests that even radiation limits well below the regulatory standards cause severe damage to health even from 2G and 3G [67,105]. Hardell (2017) pointed out that the World Health Organization (WHO) and International Agency for Research on Cancer (IARC) have only classified the risk from wireless cellphones as carcinogenic 2B (for instance, potentially cancerous).

Buildings are generally subjected to electromagnetic radiation (EMR) pollution from two sources: extremely-low-frequency (ELF) and high-frequency wireless devices. Leukemia in children, immunization loss, genes and DNA alteration, cancers, and tumors have been associated with increased exposure from these indoor sources since the 1960s [112]. A smart building that is operated wirelessly with very high frequencies (up to 300 GHz) can put the occupants at risk, particularly the most vulnerable. Moreover, humans have natural bio-electromagnetism [113] in them, and cells, tissues, and skin regeneration, including the sleep process, rely on natural frequencies from 0 to 30 Hz [114,115,116]. It has been reported that, regardless of the frequency level, being exposed to artificial frequencies is detrimental to human health [112].

Furthermore, 5G cellular networks deploy many small cells placed at shorter distances on poles and buildings [117], which can easily aggravate, to a greater extent, the biological effects [68,72]. Hence, many scientists, health professionals, and environmentalists have enquired about the potential problems of continually being in a smart building with numerous IoT devices emitting radiation at high frequencies, including bio-wearable devices [73,94].

Electropollution radiation can also be a hazard to the living organisms of the ecosystem [61,66,69,70]. This problem is specifically crucial for organisms (living on land and in water) that depend strongly on Earth's natural electromagnetic field for their nutrition and survival [63,112]. The most significant example of such phenomena is the collapse of bee colonies as their navigation is affected by wireless radiation, making them unable to return to their hives or even find food [62,118]. A study spanning almost a decade by Selsam et al., (2016) found out that trees are significantly damaged by radiation, particularly those situated near cellular base stations, and the damage intensifies with aging [119].

Open access paper: https://www.mdpi.com/2075-5309/11/6/251

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Multi-objective optimisation of human exposure for various 5G network topologies in Switzerland

Castellanos G, De Gheselle S, Martens L, Kuster N, Joseph W, Deruyck M, Kuehn S. Multi-objective optimisation of human exposure for various 5G network topologies in Switzerland. Computer Networks.216, 2022. doi: 10.1016/j.comnet.2022.109255.

Abstract

The constant increase in the required user capacity and the evolution of wireless network technologies impact the exposure that users experience from wireless networks. This paper evaluates various 5G network topologies regarding human exposure, mobile communication quality, and sustainability. We assess human exposure, based on a novel Exposure Ratio (ER) metric, in 5G networks that include Massive Multiple-Input Multiple-Output (MaMIMO) and compare them with existing 4G deployments in three environments in Switzerland. The quality and sustainability of mobile communication are evaluated by extrapolating data rates from mobile operators to the year 2030. A multi-objective optimisation algorithm is implemented to design the 5G network topologies, maximising the user coverage while minimising the downlink (DL) and uplink (UL) exposure. An extensive set of simulations investigated three municipalities, three operators plus one unified network, three use cases (UL/DL data rates), three scenarios (indoor and outdoor coverage), and two optimisation methods. The study results confirm that the human exposure in a 5G network is dominated by the UL being ten times larger than the DL exposure. Furthermore, comparing a 5G deployment with 10 times the traffic capacity of a real 4G network, DL exposure increases by 36% on average, and UL exposure decreases by up to 75% depending on the scenario. Regarding indoor coverage versus outdoor only, our results show that DL exposure can be reduced by a factor of 10 if only outdoor coverage is targeted. Finally, the study concludes that from the human exposure perspective, the ideal network should use 5G MaMIMO and be optimised for both UL and DL exposure.

https://www.sciencedirect.com/science/article/pii/S1389128622003231

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EMF Exposure Level for Uplink and Downlink of 5G Network Using Ray Tracing Approach

Salem, M.A., Lim, H.S., Chua, M.Y., Chien, S.F., Zarakovitis, C.C., Ng , C.Y., Rahman, N.Z.A., 2022. Investigation of EMF Exposure Level for Uplink and Downlink of 5G Network Using Ray Tracing Approach. International Journal of Technology. Volume 13(6), pp. 1298-1307.

Abstract

To provide enhanced mobile services, the 5G system is expected to further densify its network infrastructure and scale up the deployment of massive antenna arrays that emit high-energy beams using the millimeter wave spectrum. These radically new features will significantly impact the EMF exposure level in the 5G networks. In this paper, EMF exposure for 5G mobile networks in a dense urban environment is investigated using a raytracing approach for the uplink (UL) and downlink (DL). A massive multi-input multi-output antenna with multiuser beamforming capability is considered for the 5G base station. For DL, the maximum rate transmission (MRT) technique is used to direct the beams toward all the active users, and total power density (PD) is used to evaluate the EMF exposure level. On the other hand, EMF exposure due to UL is investigated using electric field strength and specific absorption rate (SAR). The proposed ray-tracing based EMF evaluation framework exploits detailed information of the scenarios, including 3D building geometry, EM characteristics, multipath propagation, user locations and beamforming radiation pattern, to effectively evaluate the EMF's spatial variation levels. Following this evaluation procedure, the impact of different user densities and distributions is

analyzed in terms of PD and SAR. Results show that for DL, the peak PD increases from 6.65 to 24.92 dBm/m2 when the number of active users in the area increases from a single user to 100%. Considering the worst-case scenario, the PD exposure reaches 62% of the ICNIRP's limit. Saturation of the spatial EMF distribution occurs when the number of active DL beams is above 25%. For UL, within 5m radius of the user's location, the average E-field may increase from 2.40 to 3.98 V/m. (increment of 66%) if the number of active users in the area increases from 25% to 100%. Moreover, when 100% of the users are actively transmitting, there is only a 10% probability that the SAR may exceed 0.06 W/kg (or 3% of the ICNIRP's limit).

Open access paper: https://ijtech.eng.ui.ac.id/article/view/5928

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RF-EMF Exposure for sub-6GHz 5G NR Massive MIMO Base Station

Sali A, Wali AQ, Osman AF. Evaluation of RF-EMF Exposure for sub-6GHz 5G NR Massive MIMO Base Station. *2022 IEEE 6th International Symposium on Telecommunication Technologies (ISTT)*, 2022, pp. 16-21, doi: 10.1109/ISTT56288.2022.9966552.

Abstract

The 5G network is intended to accommodate a significant quantity of mobile data traffic and a great number of wireless connections. It improves cost and power consumption; it offers ultra-low latency and ultra-high dependability to enable new services in various sectors. However, the general public is concerned about the possible health dangers linked with 5G equipment's Radio Frequency (RF) radiation, and numerous localities are actively lobbying to prevent 5G implementation. This research measures the maximum exposure emitted by a 5G base station operating on 3.5 GHz. Considering the transmitted power changes over time with data traffic, the analysis is based on a code selective method. Measurements were conducted at two different distances and three different times to investigate the impacts of distance and time on the level of RF-EMF radiation. The maximum radiation from the base station is 11.69 V/m, far less than the accepted limit by the ICNIRP standard.

https://ieeexplore.ieee.org/document/9966552

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Realistic Human Exposure at 3.5 GHz and 28 GHz for Distributed and Collocated MaMIMO in Indoor Environments

R. Wydaeghe *et al*. Realistic Human Exposure at 3.5 GHz and 28 GHz for Distributed and Collocated MaMIMO in Indoor Environments using Hybrid Ray-Tracing and FDTD. *IEEE Access*, doi: 10.1109/ACCESS.2022.3227107.

Abstract

Realistic human downlink exposure at 3.5 and 28 GHz to electromagnetic fields is evaluated for distributed and collocated base stations using a hybrid ray-tracing/finite-difference time-domain method. For the first time, the absorbed power density is computed for distributed massive multiple-input multiple-output (DMaMIMO) 6G

base stations (BS) at 28 GHz. The results are compared with 3.5 GHz 5G base stations. Computational costs are drastically increased at 28 GHz. A large analysis is realized by speed improvements and using two configurations. In the first, exposure distributions of DMaMIMO BS show clusters of low and high exposure. These clusters disappear when results are normalized with respect to the incoming power at the user. In the second, the influence of BS to user distance in line-of-sight (LOS) and non-line-of-sight (NLOS) scenarios shows expected results. This includes a power law relationship in LOS and shadowing in NLOS. The vast majority of exposure quantities are less than 4% of the limits of the International Commission for Non-Ionizing Radiation. Basic restrictions are respected when reference quantities are set to their limits. With equal power, distributed base stations contribute 2 to 3 times less to exposure than collocated base stations. Expressed as a ratio to their limits set by ICNIRP, the basic quantities are 5 to 10 dB lower than the reference quantities.

https://ieeexplore.ieee.org/document/9970725

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Towards Outdoor Electromagnetic Field Exposure Mapping Generation Using Conditional GANs

Mallik M, Tesfay AA, Allaert B, Kassi R, Egea-Lopez E, Molina-Garcia-Pardo JM, Wiart J, Gaillot DP, Clavier L. Towards Outdoor Electromagnetic Field Exposure Mapping Generation Using Conditional GANs. Sensors (Basel). 2022 Dec 9;22(24):9643. doi: 10.3390/s22249643.

Abstract

With the ongoing fifth-generation cellular network (5G) deployment, electromagnetic field exposure has become a critical concern. However, measurements are scarce, and accurate electromagnetic field reconstruction in a geographic region remains challenging. This work proposes a conditional generative adversarial network to address this issue. The main objective is to reconstruct the electromagnetic field exposure map accurately according to the environment's topology from a few sensors located in an outdoor urban environment. The model is trained to learn and estimate the propagation characteristics of the electromagnetic field according to the topology of a given environment. In addition, the conditional generative adversarial network-based electromagnetic field mapping is compared with simple kriging. Results show that the proposed method produces accurate estimates and is a promising solution for exposure map reconstruction.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9784695/

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Occupational health and safety: measurement and analysis of the electromagnetic radiation produced by radiofrequency devices for rejuvenation

Wei S, Zhou C, Huang L. Occupational health and safety: measurement and analysis of the electromagnetic radiation produced by radiofrequency devices for rejuvenation. Lasers Med Sci. 2022 Dec 27;38(1):25. doi: 10.1007/s10103-022-03669-y.

Abstract

With the ongoing development of cosmetic technology, many different types of radiofrequency (RF) devices are widely used for face and body rejuvenation. These, like many other high-power devices, may emit excessive electromagnetic radiation into the surrounding environment. Long-term exposure to this environment can lead to poor health outcomes; therefore, it is important to measure and analyze the electromagnetic radiation levels for the health and safety of therapists. A handheld electronic electromagnetic radiation measuring instrument was used to measure the electric and magnetic field strengths. All results were analyzed using the R software (R Core Team, 2021-02-15). We found that the monopolar and unipolar RF devices that we measured from, in this study, could produce large amounts of electromagnetic radiofrequency emissions during operation, whereas the microneedle RF (bipolar RF) device emitted relatively lower amounts ($P < 0.01$). The strength of electromagnetic radiation is related to power and distance; it increases with power and decreases with distance. This study proved that certain RF devices for rejuvenation could cause severe electromagnetic radiofrequency pollution. The occupational health and safety of therapists require more attention, and effective protective measures need to be taken immediately.

https://pubmed.ncbi.nlm.nih.gov/36574050/

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The dose-dependent effect of 1.5-GHz microwave exposure on spatial memory and the NMDAR pathway in Wistar rats

Wang H, Song L, Zhao L, Wang H, Xu X, Dong J, Zhang J, Yao B, Zhao X, Peng R. The dose-dependent effect of 1.5-GHz microwave exposure on spatial memory and the NMDAR pathway in Wistar rats. Environ Sci Pollut Res Int. 2022 Dec 27:1–13. doi: 10.1007/s11356-022-24850-4.

Abstract

A certain power of microwave radiation could cause changes in the nervous, cardiovascular, and other systems of the body, and the brain was a sensitive target organ of microwave radiation injury. Studies have shown that microwaves can impair cognitive functions in humans and animals, such as learning and memory, attention, and orientation. The dose-dependent effect of microwave radiation is still unclear. Our study aimed to investigate the effects of 1.5-GHz microwaves with different average power densities on locative learning and memory abilities, hippocampal structure, and related N-methyl D-aspartate receptor (NMDAR) signalling pathway proteins in rats. A total number of 140 male Wistar rats were randomly divided into four groups: S group (sham exposure), L5 group (1.5-GHz microwaves with average power density = 5 mW/cm^2), L30 group (1.5-GHz microwaves with average power density = 30 mW/cm^2), and L50 group (1.5-GHz microwaves with average power density = 50 mW/cm^2). Changes in spatial learning and memory, EEG activity, hippocampal structure, and NMDAR signalling pathway molecules were detected from 6 h to 28 d after microwave exposure. After exposure to 1.5-GHz microwaves, rats in the L30 and L50 groups showed impaired spatial memory, inhibited EEG activity, pyknosis and hyperchromatism of neuron nucleus, and changes in NMDAR subunits and downstream signalling molecules. In conclusion, 1.5-GHz microwaves with an average power density of 5, 30, and 50 mW/cm^2 could induce spatial memory dysfunction, hippocampal structure changes, and changes in protein levels in rats, and there was a defined dose-dependent effect.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9792922/

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WiFi Related Radiofrequency Electromagnetic Fields Promote Transposable Element Dysregulation and Genomic Instability in *Drosophila melanogaster*

Cappucci U, Casale AM, Proietti M, Marinelli F, Giuliani L, Piacentini L. WiFi Related Radiofrequency Electromagnetic Fields Promote Transposable Element Dysregulation and Genomic Instability in *Drosophila melanogaster*. Cells. 2022 Dec 13;11(24):4036. doi: 10.3390/cells11244036.

Abstract

Exposure to artificial radio frequency electromagnetic fields (RF-EMFs) has greatly increased in recent years, thus promoting a growing scientific and social interest in deepening the biological impact of EMFs on living organisms. The current legislation governing the exposure to RF-EMFs is based exclusively on their thermal effects, without considering the possible non-thermal adverse health effects from long term exposure to EMFs. In this study we investigated the biological non-thermal effects of low-level indoor exposure to RF-EMFs produced by WiFi wireless technologies, using *Drosophila melanogaster* as the model system. Flies were exposed to 2.4 GHz radiofrequency in a Transverse Electromagnetic (TEM) cell device to ensure homogenous controlled fields. Signals were continuously monitored during the experiments and regulated at non thermal levels. The results of this study demonstrate that WiFi electromagnetic radiation causes extensive heterochromatin decondensation and thus a general loss of transposable elements epigenetic silencing in both germinal and neural tissues. Moreover, our findings provide evidence that WiFi related radiofrequency electromagnetic fields can induce reactive oxygen species (ROS) accumulation, genomic instability, and behavioural abnormalities. Finally, we demonstrate that WiFi radiation can synergize with Ras^{V12} to drive tumor progression and invasion. All together, these data indicate that radiofrequency radiation emitted from WiFi devices could exert genotoxic effects in *Drosophila* and set the stage to further explore the biological effects of WiFi electromagnetic radiation on living organisms.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9776602/

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A Novel Reverberation Chamber for In Vitro Bioelectromagnetic Experiments at 3.5 GHz

R. Orlacchio *et al*.. A Novel Reverberation Chamber for In Vitro Bioelectromagnetic Experiments at 3.5 GHz. *IEEE Transactions on Electromagnetic Compatibility*, doi: 10.1109/TEMC.2022.3216045.

Abstract

In this article, a mode-stirred reverberation chamber (RC) was designed and proposed for the first time as a cell culture incubator for in vitro electromagnetic waves exposure of adherent cells in tissue culture plates (TCPs). Typical cell incubators require specific conditions, such as temperature of 37 °C and humidity rate of 95%, which are challenging conditions for an RC. The chamber was characterized as an RC through an innovative

experimental methodology based on the measurements of the S11 parameter of the emitting antenna. The proposed RC is adapted for in vitro bioelectromagnetic experiments for simultaneous exposure of up to 10 TCPs under highly homogeneous exposure conditions at 3.5 GHz, i.e., the mid-frequency band of the 5G telecommunication networks. Experimental results showed that the specific absorption rate (SAR) in the exposed samples extracted from temperature measurements was similar (an acceptable maximum variation lower than 30% was observed) in reason of the homogeneity and the uniformity of the field within the chamber. Specifically, measured SAR values were around 1.5 and 1 W/kg per 1 W incident, in 6-well or 96-well plates used for biological exposure, respectively. To validate our system, numerical simulations were performed. Overall, we showed that experimental and numerical SARs are in good agreement with differences <30% considering the standard deviation.

https://ieeexplore.ieee.org/document/9975146

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Thermal Effect Estimation of Smartphone Virtual Reality Headsets on Human Eye by Finite Element Method

Uluaydin N, Şeker S. (2022). Thermal Effect Estimation of Smartphone Virtual Reality Headsets on Human Eye by Finite Element Method. Sakarya University Journal of Science, 26(3):590-599. doi:10.16984/saufenbilder.972989.

Abstract

Smartphones (SP) terminals are becoming the most popular media for virtual reality (VR) and augmented reality (AR) effects with their central processing unit (CPU) and video capabilities. Simple VR headsets with reasonable costs can host smartphones, and they can together be used for many different applications. But with the outbreak of Covid-19 pandemic, their usage has become essential for many people working from their homes. VR and AR capabilities provide a much richer experience for entertainment, gaming, and video conferencing. The increasing popularity of 3D virtual worlds add up to this usage. On the technology side, multi-radio connectivity is supported both on terminal and network side. A certain risk may arise when using SP VR headsets for such applications requiring a broadband Internet connectivity. SPs with multi-radio connectivity feature may elevate specific absorption rate (SAR) values in those cases. The smartphone used for VR and AR applications is positioned in front of the eyes; and there is very limited ventilation in VR/AR headsets. Authors' model aims simulate these exposure scenarios in 4G and 5G mobile telecommunication frequencies by finite element method (FEM); and, possible thermal and non-thermal risks of related electromagnetic (EM) radiation on human eye according to the outputs of the model are discussed.

Open access paper: http://www.saujs.sakarya.edu.tr/tr/pub/issue/70993/972989

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Machine Learning Models for Predicting Breast Cancer Risk in Women Exposed to Blue Light from Digital Screens

Mortazavi, S. A., Tahmasebi, S., Parsaei, H., Taleie, A., Faraz, M., Rezaianzadeh, A., Zamani, A., Zamani, A., Mortazavi, S. M. J. (2022). Machine Learning Models for Predicting Breast Cancer Risk in Women Exposed to Blue Light from Digital Screens. Journal of Biomedical Physics and Engineering, 12(6), 637-644. doi: 10.31661/jbpe.v0i0.2105-1341.

Abstract

Background: Nowadays, there is a growing global concern over rapidly increasing screen time (smartphones, tablets, and computers). An accumulating body of evidence indicates that prolonged exposure to short-wavelength visible light (blue component) emitted from digital screens may cause cancer. The application of machine learning (ML) methods has significantly improved the accuracy of predictions in fields such as cancer susceptibility, recurrence, and survival.

Objective: To develop an ML model for predicting the risk of breast cancer in women via several parameters related to exposure to ionizing and non-ionizing radiation.

Material and Methods: In this analytical study, three ML models Random Forest (RF), Support Vector Machine (SVM), and Multi-Layer Perceptron Neural Network (MLPNN) were used to analyze data collected from 603 cases, including 309 breast cancer cases and 294 gender and age-matched controls. Standard face-to-face interviews were performed using a standard questionnaire for data collection.

Results: The examined models RF, SVM, and MLPNN performed well for correctly classifying cases with breast cancer and the healthy ones (mean sensitivity> 97.2%, mean specificity >96.4%, and average accuracy >97.1%).

Conclusion: Machine learning models can be used to effectively predict the risk of breast cancer via the history of exposure to ionizing and non-ionizing radiation (including blue light and screen time issues) parameters. The performance of the developed methods is encouraging; nevertheless, further investigation is required to confirm that machine learning techniques can diagnose breast cancer with relatively high accuracies automatically.

Open access paper: https://jbpe.sums.ac.ir/article_48176.html

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Evaluation of electromagnetic fields in human body exposed to inverter of pure electric vehicle

Dong X, Sun W, Lu M. Evaluation of electromagnetic fields in human body exposed to inverter of pure electric vehicle. Radiat Prot Dosimetry. 2022 Dec 22:ncac269. doi: 10.1093/rpd/ncac269.

Abstract

On the basis of the basic principle of electromagnetic dosimetry, the paper studies the electromagnetic exposure of a passenger's body to a compound electromagnetic field caused by the combined action of DC and AC bus currents of a pure electric vehicle inverter. By building an electromagnetic model of a pure electric

vehicle body, adult human body and inverter, the finite element method is used to calculate the magnetic induction intensity(|B|), induced electric field intensity(|E|) and induced current density(|J|) of the compound electromagnetic field to the human trunk and central nervous system in the driver and front seat passenger. The numerical results are compared with the exposure limits defined by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The fields are well below the safe exposure limits defined by ICNIRP.

https://pubmed.ncbi.nlm.nih.gov/36562627/

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In vivo genotoxicity of high-intensity intermediate frequency magnetic fields in somatic cells and germ cells

Ohtani S, Ushiyama A, Wada K, Suzuki Y, Hattori K. In vivo genotoxicity of high-intensity intermediate frequency magnetic fields in somatic cells and germ cells. J Radiat Res. 2022 Dec 29:rrac081. doi: 10.1093/jrr/rrac081.

Abstract

Intermediate frequency magnetic fields (IF-MFs) at ~85 kHz are one of the components of wireless power transfer (WPT) systems. However, the available data needed for the assessment of the safety of organisms from IF-MF exposure are scarce. Thus, there is an imminent need to accumulate evidence-based assessment data. In particular, if humans are exposed to IF-MF due to an accident or trouble, they are at increased risk of being exposed to high-intensity IF-MF within a short period. The already existing exposure system was improved to a system that could intermittently expose animals at 3 s intervals. This system allows the exposure of a mouse to high-intensity IF-MF (frequency: 82.3 kHz; induced electric field: 87 V/m, which was 3.8 times the basic restriction level for occupational exposure in the ICNIRP guideline), while regulating the heat generated by the coil. In vivo genotoxicity after IF-MF exposure was assessed using micronucleus (MN) test, Pig-a assay, and gpt assay. The results of MN test and Pig-a assay in hematopoietic cells revealed that neither the reticulocytes nor the mature erythrocytes exhibited significant increases in the IF-MF-exposed group compared with that in the sham-exposed group. In germ cells, MN test and gpt assay outcomes showed that IF-MF exposure did not cause any genetic or chromosomal abnormality. Based on these data, there was no genotoxic effect of our set IF-MF exposure on somatic and germ cells. These findings can contribute to the widespread use of WPT systems as effective data of IF-MF safety assessment.

https://pubmed.ncbi.nlm.nih.gov/36579461/

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Biological effects of rotating magnetic field: A review from 1969 to 2021

Wei Y, Wang X. Biological effects of rotating magnetic field: A review from 1969 to 2021. Prog Biophys Mol Biol. 2022 Dec 24:S0079-6107(22)00134-1. doi: 10.1016/j.pbiomolbio.2022.12.006.

Abstract

As one of the common variable magnetic fields, rotating magnetic field (RMF) plays a crucial role in modern human society. The biological effects of RMF have been studied for over half a century, and various results have been discovered. Several reports have shown that RMF can inhibit the growth of various types of cancer cells in vitro and in vivo and improve clinical symptoms of patients with advanced cancer. It can also affect endogenous opioid systems and rhythm in central nerve systems, promote nerve regeneration and regulate neural electrophysiological activity in the human brain. In addition, RMF can influence the growth and metabolic activity of some microorganisms, alter the properties of fermentation products, inhibit the growth of some harmful bacteria and increase the susceptibility of antibiotic-resistant bacteria to common antibiotics. Besides, there are other biological effects of RMF on blood, bone, prenatal exposure, enzyme activity, immune function, aging, parasite, endocrine, wound healing, and plants. These discoveries demonstrate that RMF have great application potential in health care, medical treatment, fermentation engineering, and even agriculture. However, in some cases like pregnancy, RMF exposure may need to be avoided. Finally, the specific mechanisms of RMF's biological effects remain unrevealed, despite various hypotheses and theories. It does not prevent us from using it for our good.

https://pubmed.ncbi.nlm.nih.gov/36574882/

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Low-level EMF effects on wildlife and plants: What research tells us about an ecosystem approach

Levitt BB, Lai HC, Manville AM II. (2022) Low-level EMF effects on wildlife and plants: What research tells us about an ecosystem approach. Front. Public Health 10:1000840. doi: 10.3389/fpubh.2022.1000840.

Abstract

There is enough evidence to indicate we may be damaging non-human species at ecosystem and biosphere levels across all taxa from rising background levels of anthropogenic non-ionizing electromagnetic fields (EMF) from 0 Hz to 300 GHz. The focus of this Perspective paper is on the unique physiology of non-human species, their extraordinary sensitivity to both natural and anthropogenic EMF, and the likelihood that artificial EMF in the static, extremely low frequency (ELF) and radiofrequency (RF) ranges of the non-ionizing electromagnetic spectrum are capable at very low intensities of adversely affecting both fauna and flora in all species studied. Any existing exposure standards are for humans only; wildlife is unprotected, including within the safety margins of existing guidelines, which are inappropriate for trans-species sensitivities and different non-human physiology. Mechanistic, genotoxic, and potential ecosystem effects are discussed.

Excerpt

Radiofrequency radiation is a form of energetic air pollution and should be regulated as such (25). U.S. law (130) [42 USC § 7602 (g)] defines air pollution as:

“The term “air pollutant” means any air pollution agent or combination of such agents, including any physical, chemical, biological, radioactive (including source material, special nuclear material, and byproduct material)

substance or matter which is emitted into or otherwise enters the ambient air. Such term includes any precursors to the formation of any air pollutant, to the extent the Administrator has identified such precursor or precursors for the particular purpose for which the term “air pollutant” is used.”

Unlike classic chemical toxicology pollutants in which a culprit can typically be identified and quantified, RFR may function as a “process” pollutant in the air not unlike how endocrine disruptors function in food and water in which the stressor causes a cascade of unpredictable systemic effects. The stimulus in the RFR analogy would be physical/energetic rather than chemical.

Long-term chronic low-level EMF exposure guidelines, which do not now exist, should be set accordingly for wildlife; mitigation techniques where possible should be developed; full environmental reviews should be conducted prior to the licensing/buildout of major new technologies like 5G; and environmental laws/regulations should be strictly enforced (25). We have a long over-due obligation to consider potential consequences to other species from our current unchecked technophoria—an obligation we have thus far not considered before species go extinct. In the views of these authors, the evidence requiring action is clear.

Open access paper: https://www.frontiersin.org/articles/10.3389/fpubh.2022.1000840

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Biological Effects of Radiofrequency Electromagnetic Fields above 100 MHz on Fauna and Flora: Workshop Report

Pophof B, Henschenmacher B, Kattnig DR, Kuhne J, Vian A, Ziegelberger G. Biological Effects of Radiofrequency Electromagnetic Fields above 100 MHz on Fauna and Flora: Workshop Report. Health Physics. November 4, 2022. doi: 10.1097/HP.0000000000001625.

Abstract

This report summarizes the effects of anthropogenic radiofrequency electromagnetic fields with frequencies above 100 MHz on flora and fauna presented at an international workshop held on 5–7 November 2019 in Munich, Germany. Anthropogenic radiofrequency electromagnetic fields at these frequencies are commonplace; e.g., originating from transmitters used for terrestrial radio and TV broadcasting, mobile communication, wireless internet networks, and radar technologies. The effects of these radiofrequency fields on flora, fauna, and ecosystems are not well studied. For high frequencies exceeding 100 MHz, the only scientifically established action mechanism in organisms is the conversion of electromagnetic into thermal energy. In accordance with that, no proven scientific evidence of adverse effects in animals or plants under realistic environmental conditions has yet been identified from exposure to low-level anthropogenic radiofrequency fields in this frequency range. Because appropriate field studies are scarce, further studies on plants and animals are recommended.

Open access paper: https://journals.lww.com/health-physics/Fulltext/9900/Biological_Effects_of_Radiofrequency.47.aspx

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Mobile phone and base stations: Radiation and its effects on human health and environment: A Review

Jayaraju Nadimikeri, M. Pramod Kumar, G. Sreenivasulu, T. Lakshmi Prasad, B. Lakshmanna, K. Nagalaksmi, M. Madakka. Mobile phone and base stations: Radiation and its effects on human health and environment: A Review. Sustainable Technology and Entrepreneurship. 2022. doi: 10.1016/j.stae.2022.100031.

Abstract

A review of the impact of mobile phone and base station radiation on human health and the environment has been presented here. Cell phone is an important invention in human history that has revolutionized people's lifestyles. As mobile phones have become an integral part of human daily routine, the quality of life around the world has improved significantly. However, concerns about the exposure of people, flora and fauna to radio frequencies are not new. The satisfaction and convenience derived from the use of cellular phones is threatened by claims that the radiation emitted by the devices has unfavorable impacts on human health. The effects of radiation may be classified into non-thermal and thermal. Thermal effects are similar to those of cooking in a microwave oven. The non-thermal effects are not properly defined, but it is been learnt that these effects are three to four times more hazardous than the thermal, which remains controversial. A brief picture of the Indian scenario of cell phone industry and the number of mobile towers in India was discussed. The effects of radiation emitted from cell phones and base stations on wildlife, humans and the environment were summarized with suitable examples and studies conducted by various voluntary organizations.

Conclusion

This study reports and summarises some research done by different institutions and organisations. The work was motivated by the fact that the public is concerned about the threat posed by the use of mobile phones. The use of mobile phones is increasing tremendously day by day, but most people are not aware of the impact of mobile phones on human health. However, operators are competing with each other to attract more customers and are building mobile towers in every possible corner of the country to expand their own network coverage, even though the operators claim there are no health concerns. Some studies (Maregu, N. 2016; Larik et al., 2016; Asl, et al., 2019; Singh et al., 2020;) report that there is a strong correlation between mobile phone radiation to the major health problems in people. However, some studies report that there is no impact on non-ionisation radiation exposure from mobile phones and base stations (Meena et al., 2016; Schüz et al 2006; Schoemaker et al, 2005). On the other hand, some reports suggest that prolonged use of cell phones and exposure to mobile and base stations leads to abnormal mental disorders, sleep disturbances, concentration difficulties, headaches, irritability, dizziness and hypertension (Loenn et al., 2004).

Nevertheless, everyone has observed a sharp decline in the population of house sparrows (passer domesticus), which can be attributed, among other things, to radiation from base stations. Therefore, it is high time to conduct multidisciplinary studies to decipher the effects of radiation from mobile phones and cell towers on humans and the environment. It is also imperative that policy makers and executive bodies enforce stringent radiation norms.

Open access paper: https://www.sciencedirect.com/science/article/pii/S2773032822000311

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Comment on "5G mobile networks and health-a state-of-the-science review of the research into low-level RF fields above 6 GHz" by Karipidis et al.

Weller, S., May, M., McCredden, J. et al. Comment on "5G mobile networks and health-a state-of-the-science review of the research into low-level RF fields above 6 GHz" by Karipidis et al.. J Expo Sci Environ Epidemiol (2022). https://doi.org/10.1038/s41370-022-00497-8.

No abstract

Conclusion

In our opinion, the Karipidis review provides insufficient evidence of safety, which is being used by Industry [3] as justification for the planned densification and ubiquitous use of radiofrequencies >6 GHz as part of the 5G rollout. However, we concur with Karipidis that future experimental studies "should improve the experimental design" and "epidemiological research should continue to monitor long-term health effects in the population related to wireless telecommunications".

Data generated and analysed for the production of this comment article is freely available for download from the Oceania Radiofrequency Scientific Advisory (ORSAA) website at the following address: https://www.orsaa.org/5g-review-supplementary-material.html.

Open access paper: https://rdcu.be/c0teu

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The association between self-reported mobile phone usage with blood pressure and heart rate: evidence from a cross-sectional study

Amiri, F., Moradinazar, M., Moludi, J. et al. The association between self-reported mobile phone usage with blood pressure and heart rate: evidence from a cross-sectional study. BMC Public Health 22, 2031 (2022). doi:10.1186/s12889-022-14458-1.

Abstract

Background With the advancement of technology, the rate of access and use of mobile phones in different communities has increased significantly. Mobile phones emit electromagnetic waves and therefore excessive use of them may have harmful effects on physical and mental health and especially on the cardiovascular system. This study aimed to investigate the association between self-reported mobile phone use duration and blood pressure and heart rate (HR) using data from Ravansar non-communicable diseases (RaNCD) cohort study.

Methods The present cross-sectional study was performed using the data of 8905 out of 10,065 participants in the RaNCD study in Iran. According to the mean self-reported duration of mobile phone usage (min/day) over the previous 12 months, all users were divided into four groups. The first and fourth groups had the least and most time using mobile phones respectively. The relationship between blood pressure and the duration of

mobile phone use was determined using univariate and multiple linear regression.

Results Of 8905 participants aged 35–65 years, 1515 (17.0%) of them didn't use mobile phones. The minimum, maximum, and mean duration of self-reported mobile phone use between users were 3.4, 50.4, and 19.5 min/day, respectively. A decrease in women's systolic and diastolic blood pressure (SBP and DBP) and HR was observed by increasing the duration of mobile phone use. With adjustment for effective confounding factors, there was a significant negative association between SBP [-2.52 (-4.11, -0.94)], DBP [-1.86 (-2.83, -0.89)], and duration of mobile use.

Conclusion In this study, a significant decreasing trend was found between SBP, DBP, and HR and higher mobile phone usage in women. Based on regression analysis, SBP, DBP, and duration of mobile phone use were associated negatively in those who used their phones for at least 8 h.

Conclusion

The findings of the present study revealed that mobile phone use duration significantly affect BP just in females. After adjustment for all confounding factors, in whole population, SBP and DBP, in individuals who used their mobile phone more than 8 h/day (Q2-Q4), were significantly decreased in all three models. In contrast, after adjustment for all confounding factors, there was no significant association between mobile phone use duration and HR in all adjusted models. Since the association between mobile phone use duration and HR was weak for women and absent for men, perhaps this was just a chance finding that needs to be investigated further.

Open access paper: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-022-14458-1

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Swipe Right on Male Infertility: Effect of cell phone radiation on sperm motility

Chu KY, Khodamoradi K, Dullea A, Ramasamy R. Swipe Right on Male Infertility: Effect of cell phone radiation on sperm motility. Fertility and Sterility. 118(5 Suppl):e38-e39. 2022. doi:10.1016/j.fertnstert.2022.09.288.

Abstract

Background Over the past decade, the relationship between humans and their smartphones have been marked with stark symbiosis. The advent of Bluetooth earbuds has presumably prolonged the amount of time the cell phone resides in the trouser pockets of men. This places the smartphone and its respective radiofrequency - electromagnetic radiation (RF- EMR) near the testicles. RF-EMR has been postulated to increase oxidative stress and induce free radical formation.

Objective We hypothesized that RF-EMR from cell phones has deleterious effects on sperm parameters, though these effects can be mitigated with solid mediums or distance.

Materials and Methods We evaluated the impact of current generation smartphone, in talk mode, as the RF-EMR source. We certified the exposure to the specimen using calibrated RF-EMR meter (validated in previous

studies). Initially, we studied the impact of RF-EMR on sperm motility and viability from fertile, normozoospermic men, between the ages of 25-35 years old by exposing their semen in an in vitro study over an 8-hour duration. We then determined whether using a cell phone case and increasing distance from semen sample would make a difference in outcomes. Statistical differences were analyzed using paired t student test for comparisons between two sub-groups where $p<0.05$ was set as significant.

Results At 6 hours after exposure, we identified a decrease in sperm motility and viability in samples exposed to RF-EMR as compared to those samples that were not from fertile controls. With the addition of the case, we noted a smaller impact on total sperm motility and viability ($p = 0.01$, $p = 0.01$) as compared to direct RF-EMR exposure. In fact, moving the cell phone away by 3 inches represented the best mitigation strategy to deleterious effects on sperm motility and viability. Interestingly, when the phones were turned on in the talk-mode, most detrimental effects on sperm motility were identified.

Conclusions In this pilot study, we observe that the sperm parameters of motility and vitality are impacted with RF-EMR exposure from cell phones. Precautionary measures such as physical shields and increased distance from the scrotum dampened the effects of RF-EMR. Further in vivo research on the true impact of cell phone radiation on male fertility potential is warranted.

https://www.sciencedirect.com/science/article/pii/S0015028222017095

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Electromagnetic radiations on the functional potential of spermatozoa

Ranjitsingh AJA., Elizabeth MM., Dhasarathan P, Athinarayanan G. Electromagnetic radiations on the functional potential of spermatozoa. Res. J. Biotech. 17(10);12-17. doi:10.25303/1710rjbt12017; (2022).

Abstract

The growing exposure to digital communication system and tools leads to radiation toxicity to the users. Unaware of the safety measures, even a kid at the age of one starts operating digital gadgets emitting radio frequency-electromagnetic radiations. Radiations from mobile phones, laptops, note pad, Wi-Fi or other devices are reported to be harmful beyond the permissible limit. So there is a growing concern for the overall health, reproductive and hormonal functions. Experimental studies were conducted by using a Wi-Fi network active laptop and live spermatozoa. The exposure of sperms to the source of EMF showed that the activity of the live sperms got reduced and mortality was observed depending on the exposure duration and the distance from EMF sources.

After 5h of exposure to RF-EMF source, the semen quality changed when compared with control. The vitality of sperm in the control was 95±1.0 after 2 hr and it was reduced to 60±1.5 percent at a distance of 1cm and 55 ±2.2 percent at a distance of 10 cm. After 5 hour exposure, the vitality was reduced to 63±1.86 at 1 cm distance and 70± 1.42 at 10 cm distance. The reduction in vitality of sperm after exposure to RFEMF source for 2 hour was 35% at 1cm and 40% at 10cm distance.

Open access paper:
https://worldresearchersassociations.com/Archives/RJBT/Vol(17)2022//October%202022/Electromagnetic%20radiations%20on%20the%20functional%20potential%20of%20spermatozoa.pdf

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Why the psychogenic or psychosomatic theories for electrohypersensitivity causality should be abandoned, but not the hypothesis of a nocebo-associated symptom formation caused by EMF conditioning in some patients

Belpomme D, Irigaray P. Why the psychogenic or psychosomatic theories for electrohypersensitivity causality should be abandoned, but not the hypothesis of a nocebo-associated symptom formation caused by electromagnetic fields conditioning in some patients. Environ Res. 2022;114839. doi:10.1016/j.envres.2022.114839

No abstract

Excerpt

In summary, the Pitron et al. response to the editor is not based on appropriate and sound experimental data, but rather on a general unproved psychogenic somatic theory that posits a nocebo effect as the cause of EHS and/or MCS. This should be abandoned–although it is possible that after conditioning by real EMF stimuli the subsequent role of a nocebo process, a nocebo genesis may account for the formation of some (not all) symptoms. Contrary to Pitron et al.'s nocebo claim, we recall that many years ago, similar psychogenic or psychosomatic theories accounting for the genesis of tuberculosis arose, but were abandoned as soon as the causal role of the Koch's bacillus was discovered (Barberis et al., 2017); and this was also the case more recently with autism, due to the discovery of its environmental causal origin (Volk et al., 2022).

Consequently, contrary to Pitron et al.'s unsupported claim (Belpomme and Irigaray, 2021) there is sufficient available scientific evidence to strongly recommend measures against the current unrestricted electromagnetic pollution, via application of the precautionary principle, to protect people, particularly the most vulnerable such as pregnant women, infants and children, who have been shown to be more susceptible and sensitive to anthropogenic EMFs.

https://pubmed.ncbi.nlm.nih.gov/36423669/

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RF exposure from ten 5G beamforming cell towers (3.6 GHz band) in Germany

Kopacz T, Bornkessel C, Wuschek M. Consideration of current mobile phone antenna technology when determining HF-EMF exposure - project 3619S82463. Federal Office for Radiation Protection (BfS). Nov-2022.

Report number(s): BfS-RESFOR-208/22. URN(s): urn:nbn:de:0221-2022112435660. (The report is in German with an English-language executive summary.)

Abstract (Google translation)

This research project deals with the metrological recording and analysis of immissions from 5G base stations with beamforming antennas in the 3.6 GHz band. As a basis, measurement methods for determining current, typical and maximum possible immissions were proposed, which suitably take into account the time-varying radiation behavior of the antennas. The maximum possible immissions can be determined either by extrapolation based on the difference in antenna gain between traffic and broadcast beams at the measuring point or by direct measurement when the maximum immission is provoked using a 5G terminal device. Immission measurements at 100 systematically selected measuring points in the vicinity of ten 5G beamforming base stations in the 3.6 GHz band resulted in maximum immissions between 0.2% (0.15 V/m) and 28.9% (17.6 V/m m) the field strength limit of the 26th BImSchV (median 4.7% or 2.9 V/m). The instantaneous immissions without provoked traffic were between 0.04% (0.03 V/m) and 1.1% (0.67 V/m) of the field strength limit value (median 0.08% or 0.05 V/m) and the emissions during typical use (ARD live stream) are only slightly higher, between 0.04% (0.03 V/m) and 1.3% (0.8 V/m) of the field strength limit value (median 0.2% or 0.12V/m). The visibility conditions between the place of immission and the 5G antenna have a major influence on the size of the immission, since significant attenuation also occurs in the 3.6 GHz band due to vegetation. The dependence on the vertical angle between the point of immission and the antenna observed in GSM, UMTS and LTE base stations has changed in the 5G beamforming base stations examined in such a way that the immissions are no longer highest at small but at larger vertical angles. len. If the beam does not act at the point of immission, but is shifted azimuthally or radially by a few tens of meters in the cell, the measurements carried out here showed an average immission reduction of 7.5 dB compared to a direct alignment of the beam to the point of immission. Long-term measurements showed that users were only active sporadically at the time of the measurements. Even with targeted provoked typical use, the 6-minute mean value of the field strength at most points could only be significantly raised above the detection limit of the measuring device by downloading a large file. Immission peaks were usually very limited in time.

Open access paper: https://doris.bfs.de/jspui/handle/urn:nbn:de:0221-2022112435660

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Stochastic Dosimetry Assessment of the Human RF-EMF Exposure to 3D Beamforming Antennas in indoor 5G Networks

Bonato M, Dossi L, Chiaramello E, Fiocchi S, Tognola G, Parazzini M. Stochastic Dosimetry Assessment of the Human RF-EMF Exposure to 3D Beamforming Antennas in indoor 5G Networks. Applied Sciences. 2021; 11(4):1751. https://doi.org/10.3390/app11041751

Abstract

The deployment of near future 5G networks will introduce modifications in the population’s exposure levels to radio-frequency electromagnetic fields (RF-EMFs). The present work aimed to face the challenge of studying the

exposure variability in the presence of an access point (AP) at 3.7 GHz with 64 patch elements uniform planar array antenna and 3D beamforming capability. The novelty introduced in the methodology of the exposure's evaluation was the combining of traditional computational methods with a new approach based on stochastic dosimetry, called polynomial chaos kriging method, in order to estimate the exposure levels for 1000 different antenna beamforming patterns with low computational efforts. The simulations were evaluated considering a child model and computing the specific absorption rate (SAR) in different tissues. The analysis of the results highlighted a high exposure variability scenario depending on the beamforming patterns of the array antenna and identified the ranges of elevation and azimuth angles of the main antenna beam that may cause the highest levels of exposure.

Open access paper: https://www.mdpi.com/2076-3417/11/4/1751

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5G Electric Fields Strength With Software Defined Radios

Minucci F. et al. 5G Electric Fields Strength With Software Defined Radios. IEEE Open Journal of the Communications Society, 2022, doi: 10.1109/OJCOMS.2022.3222537.

Abstract

The effect of electromagnetic radiation on public health is a recurring topic in the societal and political discourse, peaking with the introduction of every new generation of cellular technology. With the introduction of 5G, promising high peak download speeds as well as high-power beams, there is a need to revisit traditional measurement approaches. ICNIRP, a.k.a the International Committee on Non-Ionising Radiation Protection, offers a useful guideline to evaluate the electromagnetic field exposure of living tissues and provides some limits to keep exposure well below the threshold where it is considered harmful. However, modern packet radio technologies such as 5G or Wi-Fi are different from old broadcasting technologies. They deliver high power in very short bursts, spread over a wide band, thus increasing the difficulty of measuring electric fields with traditional instruments, such as spectrum analyzers. In addition, 5G promises a high spatial focusing performance, which means that the field can vary significantly even in a small area. Hence, measurements with a higher spatial density than we can achieve with expensive and bulky spectrum analyzers are urgently needed. Software-defined radios (SDRs), as a size-and cost-efficient alternative, can be used to capture signals in the time domain and thus increase measurement accuracy. However, software-defined radios are not designed to be used as RF power meters. They require accurate calibration and data analysis to ensure the measured power is correct. The aim of this work is to provide a general framework to calibrate SDRs, enabling them to measure RF power and extract the corresponding electric field value. Subsequently, the influence of the SDR parameters on the accuracy of the electric field measurement is investigated. To assess the performance of the proposed calibration framework in a real-life scenario, we rely on our private 5G network with a calibrated SDR to measure the RF power from a 5G network. Our measurements show that the average electric field exposure of 5G networks is well below 1 V/m.

Excerpt

The electric field calculation based on our 5G measurements is presented in Table 3. As expected, the electric field is stronger in positions 1 and 6 from Fig. 10, which are next to the UE. In all other positions, the electric fields are considerably lower. The average electric field values are never above 0.6 V/m. However, the electric field for a single transmission from the UE can peak at 40.82 V/m when measured with a near-field probe. Peaks from the base station, on the other hand, never surpassed 2.084 V/m. Measurements performed with two devices do not show any significant change in the electric field value generated by the base station, which is the focus of this research work. One important outcome of this measurement is that, while the regulator is focused on limiting the power of downlink transmission, the greatest contribution to RF exposure on people comes from the UE itself, similarly to what was found in [37]. Another important aspect to consider is that our results are in line with what was measured in [29]. This means that a low-cost SDR based system can be effectively employed for this kind of measurement.

https://ieeexplore-ieee-org.libproxy.berkeley.edu/stamp/stamp.jsp?tp=&arnumber=9955380&isnumber=8901158

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Impact of Electromagnetic Radiation of 4G/5G Base Stations on Medical Short-Range Devices in Urban Area

A. Svistunou, V. Mordachev, E. Sinkevich, M. Ye, A. Dubovik and I. Shakinka. Impact of Electromagnetic Radiation of 4G/5G Base Stations on Medical Short-Range Devices in Urban Area. 2022 International Symposium on Electromagnetic Compatibility – EMC Europe, 2022, pp. 537-542, doi: 10.1109/EMCEurope51680.2022.9901031.

Abstract

The impact of electromagnetic radiation created by micro base stations of 4G/5G cellular networks on receivers of medical short-range devices of different systems (capsule endoscopy system, body area network system, and active implant system) located inside buildings is analyzed for urban area. The analysis is made by the use of computer simulation involving the multipath radiowave propagation model which takes into account outdoor-to-indoor propagation. To perform the simulation, a 3D model of a fragment of urban area containing buildings of a height from 6 m to 60 m is developed. The integrated interference margin is used as a criterion of electromagnetic compatibility. Results of the analysis show that 4G/5G base stations can create the interference to all considered types of medical short-range devices in cases when emitters are located outside buildings and receptors are located inside buildings. In order to achieve electromagnetic compatibility between these base stations and considered medical systems, recommendations on reducing of levels of electromagnetic interference are given. Results of this research can be used to ensure safe operation of 4G/5G base stations with respect to vital medical devices.

https://ieeexplore.ieee.org/document/9901031

Conclusions

As follows from the obtained results, LTE BS and 5G BS located outside buildings can potentially create interference to all considered types of MD SRDs located inside buildings. Compliance with the requirements of standards [2]-[8] does not guarantee the absence of interference to MD SRDs. Therefore, we advise the

following measures to reduce the risk of interference to MD SRD operation: 1) to set more stringent requirements on susceptibility characteristics of the MD SRD receivers in frequency bands of BS operation, as well as on spurious emission of BS transmitters in frequency bands of MD SRD operation; 2) to use additional filters in order to decrease the level of spurious emissions of BS transmitters in MD SRD frequency bands; 3) to locate BS antennas in a way that ensures the absence of the line-of-sight irradiation of hospital buildings; 4) to locate MD SRD in rooms situated on the ground floor; 5) to locate MD SRD far from windows of the room.

In this work, the worst case models of emission spectra and susceptibility characteristics in the frequency domain are employed (the upper envelope of a spectrum and the lower envelope of a susceptibility characteristic). Therefore, the calculated values of the EMC criterion are pessimistic, i.e., these values concern the worst situation. The authors intend to verify the obtained results by experiments in order to define more precisely the restrictions needed to ensure the safe use of 4G/5G BS equipment.

The results of this work can be used in the field of standardization for improving standards intended to ensure the EMC between considered equipment, as well as in the field of design/upgrade/deployment of mobile communication systems for the diagnostics of intersystem EMC between 4G/5G BS and medical devices.

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Analyses of some call factors affecting SAR levels of GSM mobile phones used in Ghana

Osei S, Amoako JK, Sam F, Onyekwere P, Kudozia RY. ANALYSES OF SOME CALL FACTORS AFFECTING SAR LEVELS OF GSM MOBILE PHONES USED IN GHANA. Radiat Prot Dosimetry. 2022 Nov 1:ncac206. doi: 10.1093/rpd/ncac206.

Abstract

In response to mounting radiofrequency health concerns, this study was constituted to provide critical scientific data and assess any potential exposure from global system for mobile communication mobile phones. Specific absorption rate (SAR) from phones approved by the regulator and untested/unapproved phones were measured with a ComoSAR system. The maximum 10 g SAR (0.51 W/kg) and 1 g SAR (0.99 W/kg) measured were 25 and 62% of the International Commission on Non-Ionizing Radiation Protection and Federal Communication Commission limits, respectively. The approved phone produced statistically significant higher SAR values relative to the untested phone. SAR values of the right ear were relatively higher. All maximum SAR values were recorded on the right ear. The regulatory approval status of the phone, phone's orientation to the head, operating frequency channel and in which ear (right or left) the phone is used influenced the SAR measured. The SAR values of the approved phone compared favourably with similar studies while the unapproved phone does not.

https://pubmed.ncbi.nlm.nih.gov/36321330/

Conclusions

The study has revealed that, the regulatory approval status of the GSM mobile phone, the head side of the ear (left or right ear), the orientation of the phone when placed on the ear (left or tilt) and the transmitting frequency channel deployed during phone calls do have a significant impact on the *SAR* levels of the mobile

phone. The SAR levels generally complied with the ICNIRP 10 g *SAR* basic restriction and the FCC 1 g *SAR* limit. The highest measured *10 g SAR* of 0.51 W/kg is 26% of the ICNIRP basic restriction, and the maximum *1 g SAR* of 0.99 W/kg is 62% of the FCC limit. These results generally agree with those recorded in Morga *et al*.[14] but are higher than that of Mahfouz *et al*.[16]. The 1 g SAR at all times exceeded its counterpart 10 g SAR at all reference phone positions as its evaluation involved averaging over 1 g volume of tissue as compared to averaging over 10 g volume of the tissue for the 10 g SAR.

SAR levels of the approved phone were statistically significantly higher compared to the unapproved phone at all reference phone positions with the exception of RCL position. Possible reasons included the difference in phone antenna type, different antenna positions in the mobile phone and also the different brands of phones used. The right ear produced higher *SAR* relative to the left ear, which may be due to the differences in positioning of the phone antenna relative to the ear when used at the right ear and left ear. Specifically, all maximum *SAR* values occurred at the right ear. HEP *SAR* were relatively lower than the approved phone *SAR* even though agreeing with that of *SAR* unapproved phones. The approved phone measured *SAR* agreed with similar works done elsewhere but not in the case of the unapproved.

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Electromagnetic Fields Exposure Assessment in Europe Utilizing Publicly Available Data

Iakovidis S, Apostolidis C, Manassas A, Samaras T. Electromagnetic Fields Exposure Assessment in Europe Utilizing Publicly Available Data. Sensors (Basel). 2022 Nov 4;22(21):8481. doi: 10.3390/s22218481.

Abstract

The ever-increasing use of wireless communication systems during the last few decades has raised concerns about the potential health effects of electromagnetic fields (EMFs) on humans. Safety limits and exposure assessment methods were developed and are regularly updated to mitigate health risks. Continuous radiofrequency EMF monitoring networks and in situ measurement campaigns provide useful information about environmental EMF levels and their variations over time and in different microenvironments. In this study, published data from the five largest monitoring networks and from two extensive in situ measurement campaigns in different European countries were gathered and processed. Median electric field values for monitoring networks across different countries lay in the interval of 0.67-1.51 V/m. The median electric field value across different microenvironments, as evaluated from in situ measurements, varied from 0.10 V/m to 1.42 V/m. The differences between networks were identified and mainly attributed to variations in population density. No significant trends in the temporal evolution of EMF levels were observed. The influences of parameters such as population density, type of microenvironment, and height of measurement on EMF levels were investigated.

Excerpt

Table 4 and Table 5 show that there are cases where the lowest ICNIRP reference level (i.e., 27.7 V/m) [1] was exceeded. In these cases, a frequency-selective measurement and extrapolation to maximum traffic was performed [41]. In those cases where extrapolated E-field levels exceeded the lowest ICNIRP reference level, appropriate actions (shutdown or power reduction in relative transmitters) were taken [33,46,47], measurements were repeated, and finally, compliance was demonstrated.

Conclusions

The continuous monitoring of RF-EMF networks and in situ measurement campaigns are tools largely used for the demonstration of the compliance of environmental EMF with safety limits for the general public. In Europe, five large monitoring networks (Greece, Catalonia in Spain, Romania, Serbia, and France–Belgium) are currently operating, consisting of more than 1200 measuring sensors. Continuous data from monitoring networks are very useful for the analysis of the temporal evolution of exposure [9,12]. Two large in situ measurement campaigns (Catalonia in Spain and France) also provide useful information on exposure. In situ measurement campaigns provide useful data for the variation in exposure in different microenvironments where people spend most of their time [16].

The population density of an area is a factor correlated with E-field levels: The higher the population density, the higher the E-field measured. This can be concluded from the measurements of monitoring networks, where we observed higher E-field values in those countries where the sensors are located in places with higher population density. This conclusion was confirmed from in situ measurements within the same country (France), where the correlation was straightforward due to the large sample available.

However, the population density was not the only factor affecting measurement results. As shown in the case of the monitoring network in France–Belgium, sensor positioning was also an important factor: The higher the sensor was placed, the higher the E-field levels measured. This conclusion was confirmed by the in situ measurement campaign results in Catalonia in Spain, where the level/floor of each measurement location is available.

Differences exist in the design and deployment among different monitoring networks and in situ measurement campaigns. These differences can impose several problems and be misleading when trying to draw general conclusions. Such problems, among others, were faced in the current analysis of results in the cases of (i) the France–Belgium monitoring network (due to different sensor positioning compared with other networks) and (ii) the SMRF monitoring network (Catalonia, Spain) due to the gradual substitution of the probes with others operating in a broader frequency range. Indeed, proper reporting of relevant parameters can mitigate these problems. As an example, we can mention the reporting of (i) indoor/outdoor available information in France's in situ measurement campaign that enabled the demonstration of E-field vs. population density correlation and (ii) the extent of the information available for measurement location (i.e. level) in the case of Catalonia's in situ measurements that enabled the demonstration of E-field vs. level/height correlation. In this context, a common framework for the development and operation of monitoring networks and in situ measurement campaigns could homogenize measurement results among different countries and significantly facilitate the attainment of useful conclusions.

Open access paper: https://www.mdpi.com/1424-8220/22/21/8481

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Comparative Analysis of Electric Field Strength, Magnetic Field Strength and Power Density around the Cell Phone Towers of Varying Characteristics with a Proposed Classification Facilitating Research on Human Population

Baliah J, Subramanian B, Livingstone D, Kanwal B, Zaman MU, Srivastava KC, Abutayyem H, Al-Johani K, David AP, Shrivastava D, Alam MK. Comparative Analysis of Electric Field Strength, Magnetic Field Strength and Power Density around the Cell Phone Towers of Varying Characteristics with a Proposed Classification Facilitating Research on Human Population. International Journal of Environmental Research and Public Health. 2022; 19(21):14157. doi: 10.3390/ijerph192114157

Abstract

The continuous exposure of electromagnetic field (EMF) radiation from cell phone towers may possibly have an influence on public health. Each cell phone tower is unique in terms of number of antennas and its associated attributes; thus, the radiation exposure varies from one tower to another. Hence, a standardized method for quantifying the exposure is beneficial while studying the effects of radiation on the human population residing around the cell phone towers. A mere collection of data or human samples without understanding the cell phone tower differences may show study results such as an increase or decrease in biological parameters. Those changes may not be due to the effects of EMF radiation from cell phone towers but could be due to any other cause. Therefore, a comparative study was designed with the aim of quantifying and comparing the electric field strength (EF), magnetic field strength (MF) and power density (PD) on four sides of cell phone towers with varying numbers of antennas at 50 m and 100 m. Further, an attempt was made to develop a PD-based classification for facilitating research involving human biological samples. Through convenience sampling, sixteen cell phone towers were selected. With the use of coordinates, the geographic mapping of selected towers was performed to measure the distance between the towers. Based on the number of antennas, the cell phone towers were categorized into four groups which are described as group I with 1–5 antennas, group II comprising of 6–10 antennas, group III consisting of 11–15 antennas and group IV comprised of towers clustered with more than 15 antennas. The study parameters, namely the EF, MF and PD, were recorded on all four sides of the cell phone towers at 50 m and 100 m. One-way ANOVA was performed to compare the study parameters among study groups and different sides using the Statistical Package for the Social Sciences (SPSS) version 25.0. The mean MF in Group IV was 2221.288 ± 884.885 μA/m and 1616.913 ± 745.039 μA/m at 50 m and 100 m respectively. The mean PD in Group IV at 50 m was 0.129 ± 0.094 $\mu W/cm^2$ and 0.072 ± 0.061 $\mu W/cm^2$ at 100 m. There was a statistically significant ($p < 0.05$) increase in the MF and PD at 50 m compared to 100 m among cell phone tower clusters with more than 15 antennas (Group IV). On the other hand, a non-significant increase in EF was observed at 50 m compared to 100 m in Group II and IV. The EF, MF and PD on all four sides around cell phone towers are not consistent with distance at 50 m and 100 m due to variation in the number of antennas. Accordingly, a PD-based classification was developed as low, medium and high for conducting research involving any biological sample based on quantile. The low PD corresponds to 0.001–0.029, medium to 0.03–0.099 and high to 0.1–0.355 ($\mu W/cm^2$). The PD-based classification is a preferred method over the sole criteria of distance for conducting human research as it measures the true effects of EMF radiation from the cell phone towers.

Open access paper: https://www.mdpi.com/1660-4601/19/21/14157

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Measurement studies of personal exposure to radiofrequency electromagnetic fields: A systematic review

Ramirez-Vazquez R, Escobar I, Vandenbosch GAE, Vargas F, Caceres-Monllor DA, Arribas E. Measurement studies of personal exposure to radiofrequency electromagnetic fields: A systematic review. Environ Res. 2022 Nov 29:114979. doi: 10.1016/j.envres.2022.114979.

Abstract

The last 25 years have seen an increase in the number of radiofrequency sources with the global adoption of smartphones as primary connectivity devices. The objective of this work was to review and evaluate the measured studies of personal exposure to Radiofrequency Electromagnetic Fields (RF-RMF) and meet the basic quality criteria eligible for inclusion in this Review, according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, following the eligibility criteria of the PECO (Population, Exposure, Comparator, and Outcome) methodology, and the instrument for critical reading Critical Appraisal Skills Programme Español (CASPe). We systematically reviewed the works published between January 1, 1998, and December 31, 2021, yielding 56 publications. Of the different types of studies in which personal exposure to RF-EMF has been measured with two measurement methodologies can be highlighted: Personal measurements with volunteers and Personal measurements with a trained researcher (touring a specific area, one or several microenvironments, an entire city, walking or in some means of transport). Personal exposimeters were used in 83% of the studies. The lowest mean was measured in Egypt with a value of 0.00100 μW/m2 (1.00 nW/m2) in 2007 and the highest mean was measured in Belgium with a value of 285,000 μW/m2 (0.285 W/m2) in 2019. The results of our study confirm that RF-EMF exposure levels are well below the maximum levels established by the ICNIRP guidelines.

https://pubmed.ncbi.nlm.nih.gov/36460078/

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Comparison of personal exposure to Radiofrequency Electromagnetic Fields from Wi-Fi in a Spanish university over three years

Ramirez-Vazquez R, Escobar I, Martinez-Plaza A, Arribas E. Comparison of personal exposure to Radiofrequency Electromagnetic Fields from Wi-Fi in a Spanish university over three years [published online ahead of print, 2022 Nov 8]. Sci Total Environ. 2022;160008. doi:10.1016/j.scitotenv.2022.160008.

Abstract

In this work we present the personal exposure levels to Radiofrequency Electromagnetic Fields (RF-EMF) from Wireless Fidelity (Wi-Fi) 2.4 GHz and 5.85 GHz bands in a Spanish university, specifically, at the Faculty of Computer Science Engineering at the University of Castilla-La Mancha (Albacete, Spain). We present results from three years, 2017, 2018 and 2019 in the same study place and points; and measurements carried out in 2022 inside a classroom and inside a professor's office, with the aim to compare the measurements and verify compliance with reference levels established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The minimum average was 0.0900 μW/m2 in the 2.4 GHz Wi-Fi, in 2019, and the maximum average was 211 μW/m2 in the 5.85 GHz Wi-Fi in 2017, around the building. Comparing the measurements carried out inside the classroom with students and without students, we identified that the maximum value was

278 µW/m2 (classroom with students, in the 5.85 GHz Wi-Fi band) and the minimum value was 37.9 µW/m2 (classroom without students, in the 5.85 GHz Wi-Fi band). Finally, comparing the results of all the measurements (average values) inside the classroom and inside a professor's office, the maximum value was 205 µW/m2 (in the 5.85 GHz Wi-Fi band) inside the classroom with students, and the minimum value was 0.217 µW/m2 inside a professor's office (in the 2.4 GHz Wi-Fi band). These values in no case exceed the limits established by the International Commission on Non-Ionizing Radiation Protection, 10 W/m2 for general public exposure.

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Study of the Electromagnetic Field Generated by Wireless Communication Systems

S. Andreica, C. Munteanu, M. Gliga, C. Pacurar, A. Giurgiuman, C. Constantinescu. Study of the Electromagnetic Field Generated by Wireless Communication Systems. 2022 International Conference and Exposition on Electrical and Power Engineering (EPE), 2022, pp. 218-222, doi: 10.1109/EPE56121.2022.9959779.

Abstract

The aim of this paper is to outline the issue of exposure to electromagnetic radiation from communication systems (wireless routers, mobile phones) and to assess the intensity of the electric field to meet the levels within the limits imposed by law. The theme is a topical one because we use and are close to these devices every day, being exposed to the electromagnetic field both those who use the equipment and those who are close to it, lately this field being more and more publicized with the technological progress. Two generations of wireless routers were analyzed tracking electromagnetic field emissions depending on the position and number of users, this being done for mobile phones. A receiver microstrip antenna was also implemented to compare the results. The results obtained by experimental measurements, numerical modeling is presented and analyzed in this paper.

Conclusions

The values of the electric field intensity increase when we connect several devices, when we approach the field generator but also when we are at the level of the antennas of the wireless router. It is observed that the values of the electric field intensity do not exceed the limit of short-term exposure (61V/m). The highest value measured by us is 3.71 V/m for SMP2 positioning at, 0.1 m from the wireless router and at a height of 0.8 m from the ground, with two laptops connected to the wireless router from generation 4. However, this value exceeds the limit of 0.6 V m at long-term exposure. Following the analyzed studies, it is recommended to position the communication devices as far away from the human body as possible, in the case of the wireless router to position it in more isolated areas.

Comparing the results obtained for the two types of antennas, it can be stated that the antenna implementation was successful due to its functionality as a wireless antenna using it as a receiver, at a frequency of 2.4 GHz, together with the spectral analyzer. Comparing the results obtained with the microstrip antenna with those obtained with the telescopic antenna we can say that the results are similar.

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9959779&isnumber=9959072

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Acute radiofrequency electromagnetic radiation exposure impairs neurogenesis and causes neuronal DNA damage in the young rat brain

Singh KV, Prakash C, Nirala JP, Nanda RK, Rajamani P. Acute radiofrequency electromagnetic radiation exposure impairs neurogenesis and causes neuronal DNA damage in the young rat brain. Neurotoxicology. 2022 Nov 3:S0161-813X(22)00174-7. doi: 10.1016/j.neuro.2022.11.001.

Highlights

• The study investigates the harmful effects of radiofrequency electromagnetic radiation (RF-EMR) exposure on the developing brain.

• RF-EMR exposure causes oxidative damage to lipids and DNA in the cerebral cortex and hippocampus region of the young brain.

• Hippocampal neurogenesis has been markedly reduced after RF-EMR exposure.

• RF-EMR exposure induces degenerative changes in dentate gyrus neurons.

• RF-EMR exposure does not activate the caspase-dependent apoptotic pathway.

Abstract

A mobile phone is now a commonly used device for digital media and communication among all age groups. Young adolescents use it for longer durations, which exposes them to radiofrequency electromagnetic radiation (RF-EMR). This exposure can lead to neuropsychiatric changes. The underlying cellular mechanism behind these changes requires detailed investigation. In the present study, we investigated the effect of RF-EMR emitted from mobile phones on young adolescent rat brains. Wistar rats (5 weeks, male) were exposed to RF-EMR signal (2,115MHz) at a head average specific absorption rate (SAR) of 1.51W/kg continuously for 8h. Higher level of lipid peroxidation, carbon-centered lipid radicals, and single-strand DNA damage was observed in the brain of rat exposed to RF-EMR. The number of BrdU-positive cells in the dentate gyrus (DG) decreased in RF-EMR-exposed rats, indicating reduced neurogenesis. RF-EMR exposure also induced degenerative changes and neuronal loss in DG neurons but had no effect on the CA3 and CA1 neurons of the hippocampus and cerebral cortex. The activity of Pro-caspase3 did not increase upon exposure in any of the brain regions, pointing out that degeneration observed in the DG region is not dependent on caspase activation. Results indicate that short-term acute exposure to RF-EMR induced the generation of carbon-centered lipid radicals and nuclear DNA damage, both of which likely played a role in the impaired neurogenesis and neuronal degeneration seen in the young brain's hippocampus region. The understanding of RF-EMR-induced alteration in the brain at the cellular level will help develop appropriate interventions for reducing its adverse impact.

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The effects of long-term prenatal exposure to 900, 1800, and 2100 MHz electromagnetic field radiation on myocardial tissue of rats

Bozok S, Karaagac E, Sener D, Akakin D, Tumkaya L. The effects of long-term prenatal exposure to 900, 1800, and 2100 MHz electromagnetic field radiation on myocardial tissue of rats. Toxicol Ind Health. 2022;7482337221139586. doi:10.1177/07482337221139586

Abstract

It is well-known that wireless communication technologies facilitate human life. However, the harmful effects of electromagnetic field (EMF) radiation on the human body should not be ignored. In the present study, we evaluated the effects of long-term, prenatal exposure to EMF radiation on the myocardium of rats at varying durations. Overall, 18 pregnant Sprague-Dawley rats were assigned into six groups (n = 3 in each group). In all groups other than the control group, three pregnant rats were exposed to EMF radiation (900, 1800 and 2100 MHz) for 6, 12 and 24 h over 20 days. After delivery, the newborn male pups were identified and six newborn male pups from each group were randomly selected. Then, histopathological and biochemical analysis of myocardial samples were performed. When 24-h/day prenatal exposures to 900, 1800, 2100 MHz EMF radiation were evaluated, myocardial damage was greater in the 2100 MHz EMF-24h group than the other groups. In addition, when malondialdehyde (MDA) and glutathione (GSH) levels associated with reactive oxidative species (ROS) were evaluated, the MDA level was higher in the 2100 MHz EMF-24h group compared with the other groups. The GSH level was also lower in the 2100 MHz EMF-24h group. When the 6, 12 and 24 h/day prenatal exposures to 1800 MHz EMF radiation were evaluated, myocardial damage was greater in 1800 MHz EMF-24h group than the remaining groups ($p < 0.0001$). Also, MDA level was greater in the 1800 MHz EMF-24h group compared with the other groups while the GSH level was lower in this group. It was shown that myocardial tissue was affected more by long-term exposure to EMF radiation at high frequencies. The data raise concerns that the harmful effects of non-ionizing radiation exposure on cardiac tissue will increase with 5G technology.

https://pubmed.ncbi.nlm.nih.gov/36383165/

Excerpts

Control Group: The three pregnant rats in this group formed the sham group and were not exposed to radiation.
900 MHz/24h Group: The three pregnant rats in this group were continuously exposed to non-ionizing 900 MHz EMF radiation for 24 h per day over 20 days.
1800 MHz/6h Group: The three pregnant rats in this group were continuously exposed to non-ionizing 1800 MHz EMF radiation for 6 h per day over 20 days.
1800 MHz/12h Group: The three pregnant rats in this group were continuously exposed to non-ionizing 1800 MHz EMF radiation for 12 h per day over 20 days.
1800 MHz/24h Group: The three pregnant rats in this group were continuously exposed to non-ionizing 1800 MHz EMF radiation for 24 h per day over 20 days.
2100 MHz/24h Group: The three pregnant rats in this group were continuously exposed to non-ionizing 2100 MHz EMF radiation for 24 h per day over 20 days.

Each group was kept separately in the attended experiment boxes throughout study. Also, the control group was kept alone and isolated electromagnetically.
During the gestational period, a digital signal generator (Anritsu MG3670 B type, Japan) with an external antenna placed under the cage centrally was used for 900 MHz EMF exposure. The following parameters were used: maximal peak power, 2W; pulse width, 577 µsec; and modulation frequency, 217 Hz. The whole body average SAR was estimated as 0.087 W/kg using the finite integration technique (Alkis et al., 2019).
The same digital generator was used for 1800 MHz EMF exposure with following parameters: maximal peak power, 2W; pulse width, 577 µsec; and modulation frequency, 217 Hz. The whole body average SAR was estimated as 0.12 W/kg using the finite integration technique (Alkis et al., 2019).

The same digital generator was used for 2100 MHz EMF exposure with following parameters: maximal peak power, 2W; pulse width, 577 µsec; and modulation frequency, 217 Hz. The whole body average SAR was estimated as 0.17 W/kg using the finite integration technique (Alkis et al., 2019). In the study process, the radiation of the radiofrequency source was checked with a spectrum analyzer (Instek GSP 9330 TG, Taiwan) with its different probes....

Since fetal impact in pregnant women cannot be evaluated for ethical reasons, SAR values for EMF exposures ranging from 10 MHz to 2 GHz EMF were evaluated mathematically using a realistic modeling by Nagaoka, T et al. (2007). As a result of this study, in the vertical position, the mean SAR value of the whole body was found as 0.05–0.1 W/kg at 900 MHz EMF exposure whereas 0.125–0.25 W/kg at 2000 MHz exposure. These results were in agreement with the average SAR values generated with vertical EMF exposure in our experimental study....

... it is recommended that a pregnant working woman should be considered a member of the general population to maintain the fetal temperature at the level required by SAR restrictions in the general population. In the recommendations by International Commission on Non-Ionizing Radiation Protection (ICNIRP) in 2020 (ICNIRP, 2020), the limit SAR values recommended at frequencies between 100 KHz and 6 GHz are 0.4 W/Kg for the working population and 0.08 W/Kg for the general population. However, based on experimental studies in the literature, it can be suggested that exposure to EMF at these frequencies can affect biological systems even at lower intensities than the values recommended by ICNIRP (Al-Jarrah and Rababa, 2022). Despite not being a human study, our results support this conclusion given the SAR values in our experimental animal model....

Since wireless communication devices have been widely used in most countries for about 20 years and will be used for longer periods of time, it is not possible to fully predict their effects on human health. It is controversial whether the results of previous studies at lower frequencies and shorter exposures are still valid today. For this reason, further studies are needed to compare the effects of RF waves used in 5G networks with other RF wavelengths used in wireless communication.

In conclusion, it has been shown that myocardial tissue will be affected more by long-term EMF radiation exposure at high frequencies. For this reason, we are concerned that the harmful effects of non-ionizing radiation exposure on cardiac tissue will increase with 5G technology.

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Changes in Histopathology and Proteins Related to the MAPK Pathway in the Brains of Rats Exposed to Pre and Postnatal Radiofrequency Radiation Over Four Generations

Tan B, Canturk Tan F, Yalcin B, Dasdag S, Yegin K, Yay AH. Changes in the histopathology and in the proteins related to the MAPK pathway in the brains of rats exposed to pre and postnatal radiofrequency radiation over four generations [published online ahead of print, 2022 Oct 29]. J Chem Neuroanat. 2022;126:102187. doi:10.1016/j.jchemneu.2022.102187

Highlights

• One of the most important research topics are effect of radiofrequency electromagnetic fields (RF-EMFs) on the central nervous system.

• EMF may cause changes in the function of the MAPK pathway, which affects cognitive processes such as learning and memory in rats.

• EMF may cause damage to both fetal and adult brain tissue in rats.

• Sufficient data are not available on generation studies investigate bio-effects of RF-EMFs.

Abstract

The development of new technologies and industry increases the number and variety of electromagnetic field (EMF) sources. Researchers are increasingly interested in the effects of EMF on brain health. The brain's function is largely dependent on electrical excitability, so it would be expected to be vulnerable to EMF. We therefore investigated the effects of brain development in the fetus, histopathological changes in female rats and the hippocampal level of MAPK proteins in male rats after exposed to pre and postnatal 2450MHz continuous wave (CW) radiofrequency radiation (RFR) over four generations.

Four groups: sham, irradiated female, irradiated male, irradiated male and female, with each consisting of four rats (one male and three females) were created. Rats in the exposure groups were whole-body exposed to 2450MHz CW-RFR for 12h/day during the experiment. Irradiation started one month before fertilization in the experimental group. On the 18th day of the gestational period, one pregnant rat from each group was decapitated under general anesthesia and the fetuses were taken. The remaining two pregnant rats completed the normal gestation period. When the offspring were two months old, four rats, one male and three female, were allocated for the second generation study. Next generation animals also experienced the same processes as the first generation rats. This study evaluated development of brain in fetuses and histopathological changes in brain of female rats using haematoxylin eosin staining, and the hippocampal level of MAPK proteins in brain of male rats by Western Blotting.

We observed hemorrhagic areas, irregular cellular localization and vascular structures in the brain of fetal and adult female rat of exposed groups in the all generations. pERK, ptau, pJNK and pP38 were increased in the brain of adult male rat of exposed groups in all generations ($p<0.005$).

Pre and postnatal 2450MHz continuous wave radiofrequency radiation exposure may cause changes in the function of the MAPK pathway affecting cognitive processes such as learning and memory and may cause damage to both the fetus and adult brain tissue. Also, EMF may have potential to affect brain of future generations.

https://pubmed.ncbi.nlm.nih.gov/36374647/

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Effect of radiofrequency exposure on body temperature: Real-time monitoring in normal rats

Kim HS, Kim Y, Jeon SB, Choi HD, Lee AK, Lee HJ, Pack JK, Kim N, Ahn YH. Effect of radiofrequency exposure on body temperature: Real-time monitoring in normal rats. J Therm Biol. 2022 Dec;110:103350. doi: 10.1016/j.jtherbio.2022.103350.

Abstract

Radiofrequency radiation (RFR) can generate heat in living organisms. In this study, we monitored the body temperature of healthy animals during RFR exposure in real time using an implantable iButton data logger. A reverberation chamber system for small animals was used for this radiofrequency (RF) exposure in vivo study. Healthy male Sprague-Dawley rats were divided into two groups: with versus without iButton implantation (n = 20 per group). Each group was further divided into a sham-exposed and RF-exposed group (n = 10 per subgroup). Rats were exposed to a 1,760-MHz long-term evolution (LTE) signal in the reverberation chamber system at a whole-body average specific absorption rate of 0 W/kg (sham-exposed) or 4 W/kg (RF-exposed) for 6 h. The body temperature of iButton-implanted rats was recorded using an intraperitoneally implanted iButton every minute over 6 h of RF exposure, whereas that of non-implanted rats was measured directly using a rectal thermometer immediately before and after the 6-h RF exposure period. The temperature values measured by the two types of thermometers were significantly positively correlated ($r = 0.63$, $P < 0.01$, linear regression), and changes in body temperatures recorded in iButton-implanted and non-implanted rats measured using two thermometers after 6 h of RF exposure were maintained within <1°C ($P = 0.87$, general linear model, followed by univariate model). Similar results were obtained for rectal thermometer measurements ($P = 0.12$, paired t-test). These results suggest that RF exposure at a whole-body average specific absorption rate of 4 W/kg does not induce significant changes in body temperature in healthy rats over a 6-h RF exposure period.

https://pubmed.ncbi.nlm.nih.gov/36462859/

Highlights

• RF exposure of 4 W/kg wbSAR is known to alter rat behavior, but it is unclear whether it raises body temperature.

• The iButton, an implantable intraperitoneal thermometer, can be used to monitor body temperature in real time.

• Body temperatures measured by both the iButton and the rectal thermometer and the temperature change patterns were similar.

• The body temperature of healthy rats was not altered by RF exposure of 4 W/kg wbSAR.

Reverberation chamber for RF exposure

The methods used in this study were adapted from those of a previous study (Jin et al., 2021). Briefly, a reverberation chamber (IRETEC, Anyang, Korea) was used as the RF exposure system. The external dimensions (L × W × H) of the reverberation chamber were 2,295 × 2,293 × 1,470 mm. An LTE RF source with a center frequency of 1,706 MHz, a bandwidth of 20 MHz, and quadrature phase-shift keying modulation was used in this study. The input signal was amplified using a high-power amplifier (PCS60WHPA_CW; Kortcom Co., Anyang, Korea). The output power level (maximum: 60 W) was controlled using an 11-bit digital PIN diode attenuator (model 349; General Microwave, Farmingdale, NY, USA). Commercial transmitting antennae (patch type, KCAN1900PA; Korea Telecommunication Components, Anyang, Korea) were used. Exposure level and time were set using a computer. The input power was monitored in real time using a power meter (N1912A, Keysight, Santa Rosa, CA, USA) through a 20-dB directional coupler (778D, Keysight). The field uniformity of the reverberation chamber was measured at 24 points within the working volume. An isotropic field probe (HI-6005; ETS-Lindgren) was used for electric field measurements. Uniformity averaged over a period of 1 min was evaluated. The field distribution in the working volume remained within ±2 dB. The chambers were installed at the Korea Institute of Radiological & Medical Sciences in Seoul, Korea. The reverberation chamber was housed at an animal facility, and its ventilation, temperature, and humidity were controlled. The SAR distribution was calculated for each caged rat using a rat phantom (Electronics and Telecommunications Research Institute, Daejon, Korea); the simulation featured 40 tissues and a voxel size of 1 mm. The power output was adjusted to 45.5 W to achieve a wbSAR of 4 W/kg.

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Pre-Exposure to Radiofrequency Electromagnetic Fields and Induction of Radioadaptive Response in Rats Irradiated with High Doses of X-Rays

Borzoueisileh S, Shabestani Monfared A, Mortazavi SMJ, Zabihi E, Pouramir M, Niksirat F, Seyfizadeh N, Shafiee M. Pre-Exposure to Radiofrequency Electromagnetic Fields and Induction of Radioadaptive Response in Rats Irradiated with High Doses of X-Rays. J Biomed Phys Eng. 2022 Oct 1;12(5):505-512. doi: 10.31661/jbpe.v0i0.1271.

Abstract

Background: Some evidence shows that a pre-exposure to RF can mitigate the effects of subsequent exposures to high doses of ionizing radiation.

Objective: We aimed to assess the effect of a pre-exposure to non-ionizing RF radiation on survival, weight changes, food consumption, and water intake of lethally irradiated rats.

Material and methods: In this case-control study, we used a commercial mobile phone (GSM, 900/1800 MHz) as well as a 2.4 GHz Wi-Fi router as the sources of pre-exposure to RF radiation. Forty-eight rats were randomly

divided into six groups of control, "8 Gy X-rays", mobile phone, "mobile phone+8 Gy", Wi-Fi, and "Wi-Fi+8 Gy". Then, the survival fraction, weight loss, water, and food consumption changes were compared in different groups.

Results: The survival analysis indicated that the survival rates in all of the exposed animals ("8 Gy X-rays", "mobile phone+8 Gy", "Wi-Fi+8 Gy") were significantly lower than the control, "Wi-Fi", and "mobile phone" groups. The changes in survival rates of "mobile+8 Gy", "Wi-Fi+8 Gy", and 8 Gy alone were not statistically significant. However, food and water intake were significantly affected by exposure to both RF pre-exposures and exposure to high dose ionizing radiation.

Conclusion: To the best of our knowledge, the existence of a dose window for the induction of AR [adaptive response] can be the cause of the lack of AR in our experiment. Our findings confirm that in a similar pattern with the adaptive responses induced by pre-exposure to ionizing radiation, the induction of adaptive response by RF-pre-exposures requires a minimum level of damage to trigger adaptive phenomena.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9589077/

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Effects of Heat and WiFi (2.4 GHz) Exposure on Rat Cardiovascular System

Jafari M, Masoudi E, Sotoudeh N, Hosseini S F. Effects of Heat and WiFi (2.4 GHz) Exposure on Rat Cardiovascular System. Health Scope. 2022;11(3):e120282. doi:10.5812/jhealthscope-120282

Abstract

Background: Today, wireless communication systems are destructive with increased lipid peroxidation and oxidation state and have adverse biological effects on human health.

Objectives: In this study, we examined the effects of exposure to WiFi wireless frequency (2.4 GHz) on histopathological changes in the cardiovascular system of rats.

Methods: The experimental groups included 32 adult male rats divided into control (not exposed to heat and WiFi), WiFi (exposed to 2.45 GHz for 52 consecutive days (2 h/day)), heat (water bath of 43°C for 52 consecutive days (10 min/day)), and heat+WiFi groups (exposed to 2.45 GHz then water bath of 43°C). On the 52nd day, the heart was removed, and its total volume and weight were determined using stereological techniques. The number of cardiomyocytes nuclei and the volume of the myocardium were determined. Blood samples were collected to measure reduced glutathione (GSH) content, Total Antioxidant Capacity (TAC), and malondialdehyde level (MDA). Data were analyzed by ANOVA, Kruskal-Wallis, and Mann-Whitney U tests.

Results: The heart weight and volume density of the myocardium increased in the WiFi-irradiated group compared to the control group ($P < 0.05$). Also, exposure to WiFi increased MDA levels and decreased TAC and GSH compared to the control group ($P < 0.05$).

Conclusions: This study indicated that RFW might cause structural changes and oxidative stress in the heart. Also, exposure to radiofrequency decreased total antioxidant activity in heart tissue with histological changes, including myocardium hypertrophy and decreased number of myocytes.

Open access paper: https://brieflands.com/articles/healthscope-120282.html

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Histomorphometric Analysis of Chick Embryo Kidneys on Exposure to 1800 MHz and 2100 MHz Radiofrequency Radiation Emitted from Cell Phone

Dsilva MH, Swer RT, Anbalagan J. Histomorphometric Analysis of Chick Embryo Kidneys on Exposure to 1800 MHz and 2100 MHz Radiofrequency Radiation Emitted from Cell Phone. J Clin of Diagn Res. 2022; 16(10):AC01-AC05. doi:10.7860/JCDR/2022/58391/16862

Abstract

Introduction: With its sophisticated and multifunctional features, the cell phone has become an integral part of human life. Scientific reports are still inconclusive, regarding the possible ill effects of Radiofrequency Radiation (RFR) emitted from cell phones on biological tissues.

Aim: To evaluate the possible tissue damage in developing kidneys of chick embryos, following exposure to 1800 MHz and 2100 MHz radiofrequency radiation emitted from 2G and 3G cell phones.

Materials and Methods: This experimental study was conducted in Department of Anatomy at Mahatma Gandhi Medical College and Research Institute, Puducherry, India, from August 2011 to June 2015. Fertilised chick embryos (144Â±20 eggs) were divided into three groups with a sample size of 48 eggs per group. Group A was exposed to 2G radiation (1800 MHz), group B was exposed to 3G radiation (2100 MHz) and group C was a sham exposed control group. The embryos were sacrificed from the 5th-12th day, and processed for routine histological procedures, to check structural and morphometric changes in the kidney. The standard epithelial height and nuclear diameter of both proximal convoluted tubule and distal convoluted tubule, karyorrhexis changes and diameter of urinary space were analysed using an ocular micrometer and square reticle. The results were statistically analysed using one-way Analysis of Variance (ANOVA).

Results: The results showed cytoplasmic changes (vacuolations) and nuclear changes (nucleomegaly, karyorrhexis) in proximal convoluted tubule and distal convoluted tubule, vascular changes (haemorrhage and infiltrations) in the interstitium and increased urinary space in the glomerulus of chick embryo kidneys.

Conclusion: Based on the study findings, it was concluded that RFR exposure from cell phones causes histopathological changes in the developing kidneys of chick embryos.

Open access paper: https://www.jcdr.net//article_fulltext.asp?issn=0973-709x&year=2022&month=October&volume=16&issue=10&page=AC01-AC05&id=16862

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2.4 GHz Electromagnetic Field Influences the Response of the Circadian Oscillator in the Colorectal Cancer Cell Line DLD1 to miR-34a-Mediated Regulation

Olejárová S, Moravčík R, Herichová I. 2.4 GHz Electromagnetic Field Influences the Response of the Circadian Oscillator in the Colorectal Cancer Cell Line DLD1 to miR-34a-Mediated Regulation. Int J Mol Sci. 2022 Oct 30;23(21):13210. doi: 10.3390/ijms232113210. PMID: 36361993.

Abstract

Radiofrequency electromagnetic fields (RF-EMF) exert pleiotropic effects on biological processes including circadian rhythms. miR-34a is a small non-coding RNA whose expression is modulated by RF-EMF and has the capacity to regulate clock gene expression. However, interference between RF-EMF and miR-34a-mediated regulation of the circadian oscillator has not yet been elucidated. Therefore, the present study was designed to reveal if 24 h exposure to 2.4 GHz RF-EMF influences miR-34a-induced changes in clock gene expression, migration and proliferation in colorectal cancer cell line DLD1. The effect of up- or downregulation of miR-34a on DLD1 cells was evaluated using real-time PCR, the scratch assay test and the MTS test. Administration of miR-34a decreased the expression of *per2*, *bmal1*, *sirtuin1* and *survivin* and inhibited proliferation and migration of DLD1 cells. When miR-34a-transfected DLD1 cells were exposed to 2.4 GHz RF-EMF, an increase in *cry1* mRNA expression was observed. The inhibitory effect of miR-34a on *per2* and *survivin* was weakened and abolished, respectively. The effect of miR-34a on proliferation and migration was eliminated by RF-EMF exposure. In conclusion, RF-EMF strongly influenced regulation mediated by the tumour suppressor miR-34a on the peripheral circadian oscillator in DLD1 cells.

Excerpt

To test the effect of RF-EMF on gene expression, DLD1 cells were exposed to a pulsed electromagnetic field, generated by a D-Link GO-RT-N150 Wi-Fi router (D-Link, Taipei, Taiwan), during 24 h. The radiofrequency range was 2426 to 2448 MHz (Wi-Fi channel 6), pulse length was 2.76 ms, pulse frequency was 9.7 Hz, pulse risetime was 0.06–0.08 µs, and pulse falltime was 0.067–0.107 µs.

Radiofrequency field power flux density at the level of the cell layer was 1 W/m^2 (19 V/m) peak, 0.12 W/m^2 (6.6 V/m) RMS. Plates with sham-exposed cells were during this time covered by radiofrequency protective foil YSHIELD HNV100 (YSHIELD GmbH & Co. KG, Ruhstorf an der Rott, Germany). Other conditions were identical for both groups: powerline frequency electric field (50 Hz) at the level of cell layer was below 1 V/m, powerline frequency magnetic field at the level of cell layer was 0.3 µT in both control and experimental groups.

Conclusions

In conclusion, the present study revealed new target genes of miR-34a-5p with key roles in the circadian oscillator functioning– per2, bmal1 and cry1. In the case of per2 and bmal1, miR-34a-5p downregulated gene expression, and this effect was most likely mediated via the 3'UTR region. cry1 mRNA expression was upregulated after miR-34a administration, and this influence is more likely to be mediated by an alternative way of miRNA functioning.

Interestingly, exposure to RF-EMF potentiates the capacity of miR-34a to induce the expression of clock genes with oncogenic capacity—cry1 and cry2. Moreover, the functioning of the miR-34a inhibitor was weakened when cells were exposed to RF-EMF, and consequently, the increase in tumour-suppressive per2 mRNA expression induced by the miR-34a inhibitor was less pronounced under RF-EMF conditions compared to the control. Similarly, miR-34a inhibited the expression of anti-apoptotic protein survivin was diminished when cells were exposed to RF-EMF. RF-EMF have been classified by the WHO as possibly carcinogenic for humans. Our data are in line with this conclusion, as the results indicate that RF-EMF can shift the influence of miR-34a in cancer progression manifested by analysed target genes from typical tumour-suppressive to neutral or slightly oncogenic.

Open access paper: https://www.mdpi.com/1422-0067/23/21/13210

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Effect of Radiofrequency Electromagnetic Radiation Emitted by Modern Cellphones on Sperm Motility and Viability: An In Vitro Study

Chu KY, Khodamoradi K, Blachman-Braun R, et al. Effect of Radiofrequency Electromagnetic Radiation Emitted by Modern Cellphones on Sperm Motility and Viability: An In Vitro Study [published online ahead of print, 2022 Nov 12]. Eur Urol Focus. 2022;S2405-4569(22)00247-4. doi:10.1016/j.euf.2022.11.004.

Abstract

Background: Cellphones emit radiofrequency electromagnetic radiation (RF-EMR) for transmission of data for social media communication, web browsing, and music/podcast streaming. Use of Bluetooth ear buds has probably prolonged the time during which cellphones reside in the trouser pockets of men. It has been postulated that RF-EMR increases oxidative stress and induces free radical formation.

Objective: To investigate the effect of wireless-spectrum (4G, 5G, and WiFi) RF-EMR emitted by modern smartphones on sperm motility and viability and explore whether these effects can be mitigated using a physical barrier or distance.

Design, setting, and participants: Semen samples were obtained from fertile normozoospermic men aged 25-35 yr. A current-generation smartphone in talk mode was used as the RF-EMR source. A WhatsApp voice call was made using either 4G, 5G, or WiFi wireless connectivity. We determined if exposure effects were mitigated by either a cellphone case or greater distance from the semen sample.

Outcome measurements and statistical analysis: The semen samples were analyzed according to 2010 World Health Organization laboratory guidelines. Statistical analysis was performed using SPSS v.28.

Results and limitations: We observed decreases in sperm motility and viability with WiFi exposure but not with exposure to 4G or 5G RF-EMR. With large variability among smartphones, continued research on exposure effects is needed.

Conclusions: Our exploratory study revealed that sperm motility and viability are negatively impacted by smartphones that use the WiFi spectrum for data transmission.

Patient summary: We looked at the effect of cellphone use on sperm motility and viability. We found that cellphones using WiFi connectivity for data usage have harmful effects on semen quality in men

https://pubmed.ncbi.nlm.nih.gov/36379868/

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Electromagnetic interactions in regulations of cell behaviors and morphogenesis

Sun G, Li J, Zhou W, Hoyle RG, Zhao Y. Electromagnetic interactions in regulations of cell behaviors and morphogenesis. *Front Cell Dev Biol*. 2022;10:1014030. Published 2022 Oct 19. doi:10.3389/fcell.2022.1014030

Abstract

Emerging evidence indicates that the cellular electromagnetic field regulates the fundamental physics of cell biology. The electromagnetic oscillations and synchronization of biomolecules triggered by the internal and external pulses serve as the physical basis of the cellular electromagnetic field. Recent studies have indicated that centrosomes, a small organelle in eukaryotic cells that organize spindle microtubules during mitosis, also function as a nano-electronic generator in cells. Additionally, cellular electromagnetic fields are defined by cell types and correlated to the epigenetic status of the cell. These interactions between tissue-specific electromagnetic fields and chromatin fibers of progenitor cells regulate cell differentiation and organ sizes. The same mechanism is implicated in the regulation of tissue homeostasis and morphological adaptation in evolution. Intercellular electromagnetic interactions also regulate the migratory behaviors of cells and the morphogenesis programs of neural circuits. The process is closely linked with centrosome function and intercellular communication of the electromagnetic fields of microtubule filaments. Clearly, more and more evidence has shown the importance of cellular electromagnetic fields in regulatory processes. Furthermore, a detailed understanding of the physical nature of the inter- and intracellular electromagnetic interactions will better our understanding of fundamental biological questions and a wide range of biological processes.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9627210/

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Wave-like patterns in parameter space interpreted as evidence for macroscopic effects resulting from quantum or quantum-like processes in the brain

Kurtev S. Wave-like patterns in parameter space interpreted as evidence for macroscopic effects resulting from quantum or quantum-like processes in the brain. Sci Rep. 2022;12(1):18938. Published 2022 Nov 7. doi:10.1038/s41598-022-22661-8

Abstract

Data from eight numerosity estimation experiments reliably exhibit wave-like patterns in plots of the standard deviations of the response times along the abstract parameter of the magnitude of the error in the numerosity estimation. An explanation for this phenomenon is proposed in terms of an analogy between response times and error magnitude on one hand, and energy and position of quantum particles on the other, constructed using an argument for an overlap between the mathematical apparatus describing Hopfield-type neural networks and quantum systems, established by some researchers. Alternative explanations are presented within the traditional explanatory framework of oscillations due to neural firing, involving hypothetical mechanisms for converting oscillation patterns in time to oscillation patterns in the space of an abstract parameter, such as the magnitude of the error during numerosity estimation. The viability of the proposal of causal influences propagating from the microscale of quantum phenomena to the macroscale of human behavior, needed for the first type of explanation, is exemplified by the phenomenon of magnetoreception in some species of birds, which is allegedly quantum in nature.

Open access paper: https://www.nature.com/articles/s41598-022-22661-8

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New view on the impact of the low-frequency electromagnetic field (50 Hz) on stress responses - hormesis effect

Klimek A, Kletkiewicz H, Siejka A, Wyszkowska J, Maliszewska J, Klimiuk M, Jankowska M, Seckl J, Rogalska J. New view on the impact of the low-frequency electromagnetic field (50 Hz) on stress responses - hormesis effect. Neuroendocrinology. 2022 Nov 2. doi: 10.1159/000527878.

Abstract

Introduction: Low-frequency electromagnetic field (50 Hz) (EMF) can modify crucial neuronal processes. Existing data indicate that exposure to EMF may represent a mild stressor and contribute to disturbances of hypothalamic-pituitary-adrenal (HPA) axis. The important regulatory pathways controlling HPA axis activity include two types of corticosteroid receptors: mineralocorticoid (MR) and glucocorticoid (GR) receptors. There are particularly abundant in the hippocampus, a key locus of HPA axis feedback control. The research aimed at determining whether 1) EMF exhibits hormesis, it means bidirectional action depending on EMF intensity (1 or 7 mT), and 2) repeated EMF exposure changes stress response to subsequent stress factors.

Methods: The exposure (7-day, 1h/day) of adult rats to EMF (1 mT and 7 mT) was repeated 3 times. HPA axis hormones and their receptors were analysed after each following exposure. Moreover, the impact of EMF exposure on hormonal and behavioural responses to subsequent stress factor - open-field test was evaluated.

Results/discussion: Our data suggest that exposure to EMF can establish a new "set-point" for HPA axis activity. The direction and dynamics of this process depend on the intensity of EMF and the number of exposures. EMF of 1 mT induced an adaptive stress response, but 7 mT EMF caused sensitization. Consequently, EMF changed

the vulnerability of the organism to a subsequent stress factor. We have also shown the increase of MR mRNA abundance in hippocampus of 1 mT EMF exposed rats, which can represent the possible neuroprotective response and suggest therapeutic properties of electromagnetic fields.

https://pubmed.ncbi.nlm.nih.gov/36323227/

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Investigation of extremely low-frequency (1 Hz-400 kHz) pollution frequently encountered in social life: a case study of a shopping mall

Emeksiz C. Investigation of extremely low-frequency (1 Hz-400 kHz) pollution frequently encountered in social life: a case study of a shopping mall. Environ Sci Pollut Res Int. 2022 Nov 3. doi: 10.1007/s11356-022-23843-7.

Abstract

It is important to periodically measure, analyze, and map electromagnetic radiation levels due to potential risks. This study aims to draw attention to new electromagnetic pollution caused by radio frequencies and extremely low frequencies. For this reason, electric field and magnetic field measurements were carried out in the 1-Hz-400-kHz frequency band in a shopping mall, where electronic devices cause low-frequency electromagnetic radiation intensively. The measurements were performed with the EHP-50F device for 24 h a day for a week. The measurements were made at 10 points in the shopping mall, and the measurement results were evaluated over five different sectors: electronics, clothing and accessories (male-female), personal care and cosmetics, supermarket, and the playland for children. Magnetic maps of each sector were produced. In addition, the specific absorption rates (SAR) of male and female customers in these workplaces were determined. This is the first study carried out to find SAR caused by low-frequency radiation. Although the safe limit value of SAR for the whole body is 0.08 W/kg, the SAR values calculated in the playland and electronics sectors were obtained to be 0.763 and 0.39 W/kg, respectively. Results clearly demonstrate how especially small children are exposed to danger in the long term.

https://pubmed.ncbi.nlm.nih.gov/36327086/

Conclusions

In this study, five main topics were discussed: the determination of 10 different measurement points at the largest shopping mall in the province of Tokat, Turkey; a grouping of the measurement points by service sectors; measurement of low-frequency electric and magnetic field values; determination of electromagnetic pollution maps of measurement points; and analysis of SAR values.

First of all, workplaces designated for measuring points in the shopping mall were divided into 5 service groups: electronics, clothing and accessories (male–female), personal care and cosmetics, supermarket, and the playland. The coordinates and measurements of the workplaces were carried out meticulously. The information obtained was entered separately to the measurement points in the shopping mall, and a low-frequency electromagnetic pollution map was obtained. Exposure to SAR in male and female customer groups was compared to biological limits defined by ICNIRP, where adverse effects start to appear.

The results obtained are as follows:

1. The evaluation of the data collected from 10 points of measurement for a week showed that the playland region, which serves children, has the highest electric and magnetic field values. In this region, an average electric field of 52.666 V/m and a magnetic field of 0.046 µT were measured for a week. According to the measured electric field, the SAR ratio was found to be 0.763 W/kg, above the maximum values. The electronic service sector was ranked second sector which exceeds the safety limits.
2. The lowest average electric and magnetic field values (1.398 V/m, 0.044 µT) were obtained in the supermarket sector. Accordingly, the lowest SAR value was also determined at the measuring points of this sector.
3. The maximum and minimum electric field values were obtained on different days of the week, as shown in the tables that present the statistical evaluation of the measurement results. Therefore, customers will be exposed to different impacts on different days of the week.
4. In determining the SAR rates, the safety limit for the whole body was taken as a reference. Both male and female customers were evaluated separately. In the calculations, individuals with a normal body mass index were preferred. This is because the overweight and obese groups are more exposed to SAR than the normal groups.
5. Although male and female customers are exposed to high amounts of electromagnetic radiation, the duration of radiation exposure is also of importance. And, although customers are exposed to this radiation for a short period of time, employees in these workplaces are exposed to the radiation for at least 10 h every day.

Consequently, as a common place for a shopping habit that emerged in today's societies, shopping malls are the points where low-frequency electromagnetic radiation is seen intensively. In addition, the decrease in children's play areas due to rapid urbanization causes parents to spend a large part of their children's time in the play areas in shopping malls. Given the literature studies that draw attention to the impact of low-frequency electromagnetic radiation, it is once again seen how important the politicians' responsibilities are in providing a safe and healthy environment for all of us.

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Intermittent ELF-MF Induce an Amplitude-Window Effect on Umbilical Cord Blood Lymphocytes

Zastko L, Makinistian L, Tvarožná A, Belyaev I. Intermittent ELF-MF Induce an Amplitude-Window Effect on Umbilical Cord Blood Lymphocytes. Int J Mol Sci. 2022;23(22):14391. Published 2022 Nov 19. doi:10.3390/ijms232214391

Abstract

In a previous study of the effects of intermittent extremely low frequency (ELF) magnetic fields (MF) on umbilical cord blood lymphocytes (UCBL), we evaluated MF amplitudes between 6 µT and 24 µT and found an effect only for those below 13 µT. This suggested the existence of an amplitude window. In this brief communication, we further tested this hypothesis. UCBLs from healthy newborns were isolated and exposed for 72 h to an intermittent ELF-MF (triangular, 7.8 Hz, 250 s ON/250 s OFF) with 6 different amplitudes between 3 µT and 12 µT, utilizing an oblong coil. Percentage of viable, early apoptotic (EA), and late apoptotic/necrotic (LAN) cells

were determined by flow cytometry. Moreover, reactive oxygen species (ROS) were determined at 1 h and 3 h of the exposure. Like in our previous work, neither EA, nor LAN, nor ROS were statistically significantly affected by the intermittent ELF-MF. However, the percentage of viable cells was decreased by exposure to the fields with intensities of 6.5 µT and 12 µT (p < 0.05; and p = 0.057 for 8.5 µT). ELF-MF decreased the percentage of viable cells for fields down to 6.5 µT, but not for 5 µT, 4 µT, or 3 µT. Combined with our previous findings, the results reported here indicate an amplitude window effect between 6 µT and 13 µT. The obtained data are in line with a notion of amplitude and frequency windows, which request scanning of both amplitude and frequency while studying the ELF-MF effects.

Open access paper: https://www.mdpi.com/1422-0067/23/22/14391

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A 50 Hz magnetic field influences the viability of breast cancer cells 96 h after exposure

Elexpuru-Zabaleta M, Lazzarini R, Tartaglione MF, et al. A 50 Hz magnetic field influences the viability of breast cancer cells 96 h after exposure. 2022 Nov 15]. Mol Biol Rep. 2022;10.1007/s11033-022-08069-7. doi:10.1007/s11033-022-08069-7.

Abstract

Background: The exposure of breast cancer to extremely low frequency magnetic fields (ELF-MFs) results in various biological responses. Some studies have suggested a possible cancer-enhancing effect, while others showed a possible therapeutic role. This study investigated the effects of in vitro exposure to 50 Hz ELF-MF for up to 24 h on the viability and cellular response of MDA-MB-231 and MCF-7 breast cancer cell lines and MCF-10A breast cell line.

Methods and results: The breast cell lines were exposed to 50 Hz ELF-MF at flux densities of 0.1 mT and 1.0 mT and were examined 96 h after the beginning of ELF-MF exposure. The duration of 50 Hz ELF-MF exposure influenced the cell viability and proliferation of both the tumor and nontumorigenic breast cell lines. In particular, short-term exposure (4-8 h, 0.1 mT and 1.0 mT) led to an increase in viability in breast cancer cells, while long and high exposure (24 h, 1.0 mT) led to a decrease in viability and proliferation in all cell lines. Cancer and normal breast cells exhibited different responses to ELF-MF. Mitochondrial membrane potential and reactive oxygen species (ROS) production were altered after ELF-MF exposure, suggesting that the mitochondria are a probable target of ELF-MF in breast cells.

Conclusions: The viability of breast cells in vitro is influenced by ELF-MF exposure at magnetic flux densities compatible with the limits for the general population and for workplace exposures. The effects are apparent after 96 h and are related to the ELF-MF exposure time.

https://pubmed.ncbi.nlm.nih.gov/36378418/

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Hypomagnetic Field Exposure Affecting Gut Microbiota, Reactive Oxygen Species Levels, and Colonic Cell Proliferation in Mice

Zhan A, Luo Y, Qin H, Lin W, Tian L. Hypomagnetic Field Exposure Affecting Gut Microbiota, Reactive Oxygen Species Levels, and Colonic Cell Proliferation in Mice. Bioelectromagnetics. 2022;10.1002/bem.22427. doi:10.1002/bem.22427

Abstract

The gut microbiota has been considered one of the key factors in host health, which is influenced by many environmental factors. The geomagnetic field (GMF) represents one of the important environmental conditions for living organisms. Previous studies have shown that the elimination of GMF, the so-called hypomagnetic field (HMF), could affect the physiological functions and resistance to antibiotics of some microorganisms. However, whether long-term HMF exposure could alter the gut microbiota to some extent in mammals remains unclear. Here, we investigated the effects of long-term (8- and 12-week) HMF exposure on the gut microbiota in C57BL/6J mice. Our results clearly showed that 8-week HMF significantly affected the diversity and function of the mouse gut microbiota. Compared with the GMF group, the concentrations of short-chain fatty acids tended to decrease in the HMF group. Immunofluorescence analysis showed that HMF promoted colonic cell proliferation, concomitant with an increased level of reactive oxygen species (ROS). To our knowledge, this is the first in vivo finding that long-term HMF exposure could affect the mouse gut microbiota, ROS levels, and colonic cell proliferation in the colon. Moreover, the changes in gut microbiota can be restored by returning mice to the GMF environment, thus the possible harm to the microbiota caused by HMF exposure can be alleviated.

https://pubmed.ncbi.nlm.nih.gov/36434792/

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Influence of hypomagnetic field on the heartbeat in zebrafish embryos

Krylov V, Machikhin A, Sizov D, et al. Influence of hypomagnetic field on the heartbeat in zebrafish embryos. Front Physiol. 2022;13:1040083. Published 2022 Oct 21. doi:10.3389/fphys.2022.1040083.

Abstract

The magnetic environment may influence the functioning of the cardiovascular system. It was reported that low-frequency and static magnetic fields affect hemodynamics, heart rate, and heart rate variability in animals and humans. Moreover, recent data suggest that magnetic fields affect the circadian rhythms of physiological processes. The influence of the magnetic environment on heart functionating during early development has been studied insufficiently. We utilized transparent zebrafish embryos to evaluate the effect of the hypomagnetic field on the characteristics of cardiac function using a noninvasive optical approach based on photoplethysmographic microscopic imaging. The embryos were exposed to the geomagnetic and hypomagnetic fields from the second to the 116th hour post fertilization under a 16 h light/8 h dark cycle or constant

illumination. The exposure of embryos to the hypomagnetic field in both lighting modes led to increased embryo mortality, the appearance of abnormal phenotypes, and a significant increase in the embryo's heartbeat rate. The difference between maximal and minimal heartbeat intervals, maximal to minimal heartbeat intervals ratio, and the coefficient of variation of heartbeat rate were increased in the embryos exposed to the hypomagnetic field under constant illumination from 96 to 116 h post fertilization. The dynamics of heartbeat rate changes followed a circadian pattern in all studied groups except zebrafish exposed to the hypomagnetic field under constant illumination. The results demonstrate the importance of natural magnetic background for the early development of zebrafish. The possible mechanisms of observed effects are discussed.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9634549/

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Observed electric charge of insect swarms and their contribution to atmospheric electricity

Hunting ER, O'Reilly LJ, Harrison RG, Manser K, England SJ, Harris BH, Robert D. Observed electric charge of insect swarms and their contribution to atmospheric electricity. iScience. 25(11):105241. 2022. doi:10.1016/j.isci.2022.105241.

Abstract

The atmosphere hosts multiple sources of electric charge that influence critical processes such as the aggregation of droplets and the removal of dust and aerosols. This is evident in the variability of the atmospheric electric field. Whereas these electric fields are known to respond to physical and geological processes, the effect of biotic sources of charge has not hitherto been considered. Here, we combine theoretical and empirical evidence to demonstrate that honeybee swarms directly contribute to atmospheric electricity, in proportion to the swarm density. We provide a quantitative assessment of this finding, by comparing the electrical contribution of various swarming insect species with common abiotic sources of charge. This reveals that the charge contribution of some insect swarms will be comparable with that of meteorologically induced variations. The observed transport of charge by insects therefore demonstrates an unexplored role of biogenic space charge for physical and ecological processes in he atmosphere.

Excerpt

The presented evidence that swarming, migrating insects transport charge in the lower atmosphere indicates that large collections of charged insects will contribute to a hitherto unrecognized source of electrical variability in the atmosphere. This recognition potentially carries various physically- and biologically relevant implications. For instance, entomogenic space charge is not considered in current climate models aimed at capturing the complex interplay between radiation and particulate matter, such as the atmospheric transport of dust. As atmospheric space charge enhances the aggregation and movement of aerial particles (Toth et al., 2020), it is conceivable that insect-derived space charges will also contribute to spatial changes in aerial particles. For example, it could be speculated that insect-driven charged particle collection and transport could contribute to long-range transport of desert dust, providing alternative explanations for the transport of large particles, which

cannot be explained by physical processes alone (Toth et al., 2020; Does Van der et al., 2018). Further, insects are not the only source of biogenic charge in the atmosphere, as birds and microorganisms also carry charge and abound in the lower atmosphere (Badger et al., 2015; de Groot et al., 2021). The observed presence and magnitude of biogenic space charge invites further interdisciplinary research into the dynamic electrical interactions between physical and biological entities in the atmosphere.

Open access paper: https://www.cell.com/iscience/fulltext/S2589-0042(22)01513-9

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Scientific evidence invalidates health assumptions underlying the FCC and ICNIRP exposure limit determinations for radiofrequency radiation: implications for 5G

International Commission on the Biological Effects of Electromagnetic Fields. Scientific evidence invalidates health assumptions underlying the FCC and ICNIRP exposure limit determinations for radiofrequency radiation: implications for 5G. *Environmental Health*. (2022) 21:92. doi.org:10.1186/s12940-022-00900-9.

Abstract

In the late-1990s, the FCC and ICNIRP adopted radiofrequency radiation (RFR) exposure limits to protect the public and workers from adverse effects of RFR. These limits were based on results from behavioral studies conducted in the 1980s involving 40–60-minute exposures in 5 monkeys and 8 rats, and then applying arbitrary safety factors to an apparent threshold specific absorption rate (SAR) of 4 W/kg. The limits were also based on two major assumptions: any biological effects were due to excessive tissue heating and no effects would occur below the putative threshold SAR, as well as twelve assumptions that were not specified by either the FCC or ICNIRP. In this paper, we show how the past 25 years of extensive research on RFR demonstrates that the assumptions underlying the FCC's and ICNIRP's exposure limits are invalid and continue to present a public health harm. Adverse effects observed at exposures below the assumed threshold SAR include non-thermal induction of reactive oxygen species, DNA damage, cardiomyopathy, carcinogenicity, sperm damage, and neurological effects, including electromagnetic hypersensitivity. Also, multiple human studies have found statistically significant associations between RFR exposure and increased brain and thyroid cancer risk. Yet, in 2020, and in light of the body of evidence reviewed in this article, the FCC and ICNIRP reaffirmed the same limits that were established in the 1990s. Consequently, these exposure limits, which are based on false suppositions, do not adequately protect workers, children, hypersensitive individuals, and the general population from short-term or long-term RFR exposures. Thus, urgently needed are health protective exposure limits for humans and the environment. These limits must be based on scientific evidence rather than on erroneous assumptions, especially given the increasing worldwide exposures of people and the environment to RFR, including novel forms of radiation from 5G telecommunications for which there are no adequate health effects studies.

Key points

- ICBE-EMF scientists report that exposure limits for radiofrequency (or wireless) radiation set by ICNIRP and the FCC are based on invalid assumptions and outdated science, and are not protective of human health and wildlife.

- ICBE-EMF calls for an **independent** assessment of the effects and risks of radiofrequency radiation based on scientific evidence from peer-reviewed studies conducted over the past 25 years. The aim of such assessment would be to establish health protective exposure standards for workers, the public, and the environment.
- The public should be informed of the health risks of wireless radiation and encouraged to take precautions to minimize exposures, especially for children, pregnant women and people who are electromagnetically hypersensitive.
- ICBE-EMF calls for an immediate moratorium on further rollout of 5G wireless technologies until safety is demonstrated and not simply assumed.

Open access paper: https://ehjournal.biomedcentral.com/articles/10.1186/s12940-022-00900-9

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It is mandatory to review environmental radiofrequency electromagnetic field measurement protocols and exposure regulations: An opinion article

Lopez I, Rivera M, Feliz N, Maestu C. It is mandatory to review environmental radiofrequency electromagnetic field measurement protocols and exposure regulations: An opinion article. Front. Public Health, 24 October 2022. Sec. Radiation and Health. doi: 10.3389/fpubh.2022.992645

No abstract

Excerpts

"According to the International Telecommunication Union (ITU) World Telecommunication/ICT Indicators Database in 2004 there were 1.76 billion mobile phone subscriptions in the world, in 2020 this figure increased to 8.27 billion (1). By 2023, there are expected to be 13.1 billion mobile terminals, almost 10% of which will be 5G technology (2)."

"Several scientific studies evaluate the possible effects of prolonged exposure to microwaves at the epidemiological level (4–11) and in vitro or in vivo models (12–19). However, the use of different methodologies in radiation measurement processes and different configurations of exposure equipment, such as frequency, radiation power density, and exposure time; do not allow adequate comparison of results, which makes it difficult to draw conclusions."

" Although most countries such as Spain, Germany, France or Finland adopt the limits proposed by the ICNIRP, the existing regulations in other are different, with limits more restrictive in countries such as Denmark, Bulgaria, Italy, Switzerland, China or Russia (21–23)."

"Old standards and measurement methodologies are not adapted to the new communications standards and technologies"

"Underestimation of non-thermal effects in the development of measurement methodologies"

"Many researchers consider the choice of the SAR criterion as the only parameter for assessing effects on biological systems as insufficient, as it only takes into account the thermal effects resulting from exposure (48–50). The ICNIRP guidelines state that a one Celsius degree increase in body temperature is the acceptable limit to avoid adverse health effects (20). Although a reduction factor of 50 is applied to the SAR value capable of increasing the temperature by 1°C, no account is taken of other effects not related to temperature increase. These effects, have been reported in numerous in vitro and in vivo studies to occur at lower intensities than those required to cause thermal effects by low and high frequency EMFs, such as alterations in gene expression (51, 52), oxidation processes (12, 14, 19, 53–56), the flow of calcium ions (57–59), proteins (60) or cell viability (13, 17)."

"The studies assessing the possible effects of RF-EMFs *in vitro* should consider all important parameters in the exposure: intensity, frequency, modulation and time of exposure. The possible existence of bioactive windows in frequency, intensity or modulation, as well as the non-linear response of biological systems that could produce differences in cellular behavior should be considered in the development of measurement methodologies and the establishment of exposure limits and could serve as a precedent to establish mechanisms of action of these RF-EMFs in relation to biological systems."

"In conclusion, two main ideas arise: the review of the environmental EMFs measurement protocols and the need for a comprehensive assessment of all the effects of EMFs not only thermal effects.

Measurement protocols must identify the specific frequencies of each of the currently established major frequency bands, the temporal behavior of the signal and the power density. Measurement systems must not only determine averaged field strengths but must be able to measure the peak amplitude over time and, consequently, the cumulative radiation. This would make the characterization of EMFs much more realistic.

In addition, parameters such as frequency and modulation could be important when considering potential biological effects. Choosing intensity as the only determining parameter for the occurrence of effects is a reductionist conception. The consideration of all EMFs parameters in the assessment of biological response should be mandatory."

Open access paper: https://www.frontiersin.org/articles/10.3389/fpubh.2022.992645/full

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Carcinogenesis from chronic exposure to radio-frequency radiation

James C. Lin. Carcinogenesis from chronic exposure to radio-frequency radiation. Front. Public Health, Sec. Radiation and Health. 31 October 2022. doi: 10.3389/fpubh.2022.1042478.

Abstract

The past two decades have seen exponential growth in demand for wireless access that has been projected to continue for years to come. Meeting the demand would necessarily bring about greater human exposure to microwave and radiofrequency (RF) radiation. Our knowledge regarding its health effects has increased.

Nevertheless, they have become a focal point of current interest and concern. The cellphone and allied wireless communication technologies have demonstrated their direct benefit to people in modern society. However, as for their impact on the radiation health and safety of humans who are unnecessarily subjected to various levels of RF exposure over prolonged durations or even over their lifetime, the jury is still out. Furthermore, there are consistent indications from epidemiological studies and animal investigations that RF exposure is probably carcinogenic to humans. The principle of ALARA—as low as reasonably achievable—ought to be adopted as a strategy for RF health and safety protection.

Excerpts

"Recently, two commonly distributed RF health protection recommendations revised their guidelines and standards. The updated International Commission on Nonionizing Radiation Protection guidelines (5) and Institute of Electrical and Electronic Engineers International Committee on Electromagnetic Safety standards (6) are strongly connected to acute temperature rises induced by RF heating inside the human body. The updated safety guidelines and standards showed without any question the groups' staunch convictions of nothing but heat to worry about with microwave and RF radiation.

A persistent and vexing question lingers concerning these guidelines and standards for safe long-term exposure to RF radiation (in contrast to exposures shorter than 6 or 30 min). A general sense on the absence of appreciation of scientific evidence regarding long-term exposure below the basic restrictions continues with these safety guidelines and standards.

There is also the question of how there can be such divergent evaluations and inferences of the identical scientific findings by WHO's IARC, ICES, and ICNIRP. To be fair, scientists are not impervious to conflicts of interest such as conflicting financial interests or personal relations which could affect the deliberations and reporting through such experiences as groupthink. Also, in some ways, it may parallel the compulsion by big business to choose profit over societal concerns—big businesses often use a range of organized and refined tactics to enhance and protect their commercial interests, and regrettably in some cases these tactics come at the expense of public health.

Human beings repeatedly render decisions and select choices that challenge principled logic. Indeed, science has not been devoid of politics—weird as that may sound. Various biases can impair sensible reasoning and result in bad judgments. Groupthink can mislead human beings and inhibit scientists from making understandable inferences. Regrettably, groupthink or herd mentality is as rampant today as ever. Has science become partisan? And if science becomes partisan, is it science or politics, or would it be political science? At times, science gets wrapped up in politics and politics intervenes with science. It may simply turn out to be a matter of guilelessly being politically correct of the willing. Less than rigorous enforcement of policies in research conduct or full disclosure of financial conflicts can lead to failures in guiding and informing the development of transparent and trustworthy evaluations of scientific evidence for safety protection. Scientists may not always be consistent, coherent, or as transparent as promoted."

"The fact is that the missing pieces according to IARC [the WHO International Agency for Research on Cancer] (4), or the previously coveted experimental animal data (7) as currently provided by NTP/NIEHS (10) and Ramazzini Institute (12) complement IARC's evaluation of human epidemiological studies in support of its classification of RF radiation as a possible carcinogen. It gives rise to the plausibility for IARC to enhance its previous, mostly epidemiology-based classification to the higher level of “probably cancer causing” for RF

exposure.

Furthermore, more recent systematic reviews and meta-analyses of the case-control research on mobile phone use have reported statistically significant increases in brain tumor risk associated with 1,000 or more hours of cellphone use, or about 17 min per day over 10 years (13, 14)."

"The simple and effective public health notion of 'An ounce of prevention is better than a pound of cure' may conjure up old fashioned. It may arouse intense reactions, with enormous defiance especially from individuals who may be beneficiary of modern promotions. The cellphone and allied wireless communication technologies have shown their direct benefit to people in modern society. However, as for their impact on the radiation health and safety of humans who are subjected unnecessarily to various levels of RF exposure over prolonged durations or even over their lifetime, the jury is still out. Furthermore, there are consistent indications from epidemiological studies and animal investigations that RF exposure is, at least, probably carcinogenic to humans. The principle of ALARA—as low as reasonably achievable—ought to be adopted as a strategy for RF health and safety protection."

Open access paper: https://www.frontiersin.org/articles/10.3389/fpubh.2022.1042478/full

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The lack of international and national health policies to protect persons with self-declared electromagnetic hypersensitivity

Leszczynski D. The lack of international and national health policies to protect persons with self-declared electromagnetic hypersensitivity. Rev Environ Health. 2022 Oct 26. doi: 10.1515/reveh-2022-0108.

Abstract

Electromagnetic hypersensitivity (EHS), known also as an idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF) or a microwave sickness, is not considered by the World Health Organization (WHO) as being caused by the exposures to electromagnetic fields (EMF). EHS is not recognized as a disease anywhere in the world. Some studies have roughly estimated that 1-10% of the population might experience some form of EHS. However, because of the lack of diagnostic criteria for EHS, these estimates might be either under- or over-estimates. Because the vast majority of human population is exposed to EMF, the possibility of developing EHS from the EMF is a substantial public health issue that should be dealt with globally, even if the individual risk of developing EHS might be small. The WHO recognizes that the symptoms experienced by the EHS persons might be severe and might significantly hamper everyday life. However, after a broad analysis of international and national documents, there seems to be currently no effort to develop health policies for EHS, no matter what causes it. National governments, follow the opinions of the WHO and the EMF safety standards setting organizations, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Institute of Electrical and Electronics Engineers - International Committee on Electromagnetic Safety (IEEE-ICES), are not developing any practical health policy advisories for self-declared EHS sufferers. However, symptoms experienced by the self-declared EHS persons affect their well-being and, according to the Constitution of the WHO, are a health problem. Hence, independently of what causes EHS symptoms, this admitted well-being-impairment should be dealt with globally by developing an uniform health policy. Furthermore, WHO, ICNIRP

and IEEE-ICES should be advocating and supporting research that would generate reliable scientific evidence on what are the possible cause(s) of EHS. Without such research it is not possible to develop diagnostic methods as well as any possible mitigation approaches. There is an urgent need for the WHO to advocate for the national governments to urgently develop a comprehensive and common EHS health policy.

Open access paper: https://www.degruyter.com/document/doi/10.1515/reveh-2022-0108/html

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Comparison of mobile phone usage and physical activity on glycemic status, body composition & lifestyle in male Saudi mobile phone users

Al-Khlaiwi T, Habib SS, Alshalan M, Al-Qhatani M, Alsowiegh S, Queid S, Alyabis O, Al-Khliwi H. Comparison of mobile phone usage and physical activity on glycemic status, body composition & lifestyle in male Saudi mobile phone users. Heliyon. 2022 Sep 15;8(9):e10646. doi: 10.1016/j.heliyon.2022.e10646.

Abstract

Background & Objectives: This study aimed to compare the effects of mobile phone usage and physical activity on HbA1c, body composition, and lifestyle among male Saudi Arabian mobile phone users.

Methods: The study was conducted in the Department of Physiology, College of Medicine, King Saud University, Riyadh, Saudi Arabia from July 2020 to July 2021. The study sample consisted of 203 non-smoker male Saudi participants aged from 20 to 60 years who used mobile phones. Personal information was obtained through interviews using a proforma. The participants were divided into three groups according to their daily mobile phone usage: Group (1): less than 2 h, Group (2): 2-3 h, and Group (3): more than 3 h, and according to their physical activities: Group (1): sedentary, Group (2): average, and Group (3): athletes. Glycated Hemoglobin (HbA1c), Bioelectrical Impedance Analysis (BIA), and (SF) 36- items survey was performed.

Results: The mean age of 203 Saudi male adult participants was 28.0 ± 10.4 years. Mobile phone usage in the less than 2 h group was (33.5%), between 2-3 h (22.7%), and more than 3 h (43.8%) respectively. The mean age of Group (3), who used mobile phones for more than 3 h, was the lowest (23.9 ± 5.7). The results showed that HbA1C levels were almost equal in all three groups (5.8 ± 0.4, 5.7 ± 0.4, and 5.7 ± 0.3 respectively). In addition, emotional well-being and social functioning showed insignificant decreases in the more than 3 h group compared to other groups of mobile phone usage (69.3 ± 15.7, 70.9 ± 15.5, 65.2 ± 16.0, p = .091 and 82.9 ± 201, 81.2 ± 18.7, 77.6 ± 21.6, p = .267) respectively. No effect was detected between groups regarding various body compositions. Regarding physical activity classifications: the sedentary group constituted (36%) of the sample, whereas the average and athlete groups represented (53.7%) and (10.3%) of the total sample respectively. There was a significant decrease in BMI (29.6 ± 7.8, 25.3 ± 5.1,24.7 ± 5.6, p = .000), fat mass (24.7 ± 15.0, 17.1 ± 9.1, 15.3 ± 10.6, p = .000), and free fat mass (64.0 ± 10.2, 56.8 ± 8.7, 57.5 ± 8.0, p = .000) in the average and the athletic groups compared to the sedentary group. No significant difference was found in HbA1c between physical activity groups (5.8 ± 0.4, 5.7 ± 0.4, 5.7 ± 0.4, p = .218).

Conclusions: Mobile phone usage does not affect HbA1c and body composition parameters. Furthermore, we

found the youngers used mobile phones longer than others. Insignificant decrease in emotional well-being and social functioning parameters of the style of life due to long mobile phone usage which needs more attention.

Conclusions and recommendations

We concluded that mobile phone usage does not affect HbA1c and body composition parameters. Also, youngers were found to use mobile phones more than others. This should increase public awareness about the long usage of mobile phones among society members. More attention should be directed toward teenagers to eliminate the effects of mobile phones on emotions and social functioning. Further study on a large sample size including different age groups, long mobile phone usage, and female gender is highly recommended. The effect of mobile phone usage on visceral fat is of great value to be studied. A well-controlled study that compares differences in the frequency of radiation, exposure time, distance from the source of the radiation, and its effects on age should be carried out, supported, and funded to evaluate the exact effect of Electromagnetic Field Radiation.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9489969/

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Mobile phone induced EMF stress is reversed upon the use of protective devices: results from two experiments testing different boundary conditions

Schneider R. Mobile phone induced EMF stress is reversed upon the use of protective devices: results from two experiments testing different boundary conditions. Electromagn Biol Med. 2022 Oct 3:1-10. doi: 10.1080/15368378.2022.2129380.

Abstract

This work examines (a) the impact of electromagnetic fields (EMF) on heart rate variability (HRV), saliva cortisol, arterial blood oxygenation, and tympanic temperature, and (b) the potential effect of protective devices developed to counter EMF-induced stress. In a pilot study, recordings were taken during a 15-min mobile phone call emitting a high burden of EMF (electric, magnetic, high frequency) after a baseline measurement at rest with very low EMF. In a second visit, this was repeated with participants using three protective devices (insoles, pendant, mobile phone chip). In the main study, four experimental arms were employed, two of which replicated the experimental setup of the pilot study, and two of which examined the effect of only one mobile phone chip in an open-hidden-paradigm. In both experiments, exposure to EMF decreased HRV and increased salivary cortisol. In the protective experimental condition, HRV increased above and cortisol decreased below the level of the baseline measures. All differences were large and specific and not modulated by non-specific effects like placebo effects.

Excerpts

Study 1 (Pilot Study): The sample consisted of N = 6 subjects (three females) who were on average 31 years old (22–46 years).

Study 2: Based on the effect size of HRV (RMSSD) found in the pilot study, the sample size of each experimental group was set at n = 15 to achieve a power of 1- β ≥ .95 (Faul et al. 2009). In total, 60 participants (28 females) were enrolled in study 2. Their mean age was 37.6 years (SD = 13.9).

Conclusion

The use of mobile phones induces physiological stress on a neurocardiac and neuroendocrine level after a short exposure time of 15 minutes. These physiological stress responses can be offset with specially designed protected devices. The technology tested (EssenceX shungite) produces a 'super-optimization' of HRV and cortisol inhibition exceeding normoregulation in non-stressful conditions. These results encourage further investigation of long-term effects of this technology in different environments.

https://pubmed.ncbi.nlm.nih.gov/36189775/

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Time course of health complaints attributed to RF-EMF exposure and predictors of electromagnetic hypersensitivity over 10 years in a prospective cohort of Dutch adults

My note: This study seems methodologically flawed. I think the assessment of IEI-RFin this study was invalid as the results at T4 make no sense -- at T4, 12.4% (108 of 892) reported being electromagnetic hypersensitive but only 1.2% (11 of 892) reported having symptoms which they attributed to RF exposure (i.e.they were classified as IEI-RF). However, in order to be classified as IEI-RF, one first had to answer affirmatively to the question, "Do you currently have health complaints that you attribute to the environment," before responding to several RF-specific questions. I think most people who self-reported as EHS failed to answer this screener question affirmatively because the question is confusing.

Eugenio Traini, Astrid L. Martens, Pauline Slottje, Roel C.H. Vermeulen, Anke Huss. Time course of health complaints attributed to RF-EMF exposure and predictors of electromagnetic hypersensitivity over 10 years in a prospective cohort of Dutch adults. Science of The Total Environment. 2022. doi:10.1016/j.scitotenv.2022.159240.

Highlights

• Time course of attribution of health complaints to RF-EMF exposure.
• Predictors of electromagnetic hypersensitivity.
• Multi-state Markov models to represent how individuals in the cohort transition between states of attribution of health complaints to RF-EMF exposure.
• Attribution of health complaints to RF-EMF exposure appears to be a more transient condition than previously assumed.

Abstract

Background Some individuals attribute health complaints to radiofrequency electromagnetic field (RF-EMF) exposure. This condition, known as idiopathic environmental intolerance attributed to RF-EMFs (IEI-RF) or

electromagnetic hypersensitivity (EHS), can be disabling for those who are affected. In this study we assessed factors related to developing, maintaining, or discarding IEI-RF over the course of 10 years, and predictors of developing EHS at follow-up using a targeted question without the condition of reporting health complaints attributed to RF-EMF exposure.

Methods Participants (n = 892, mean age 50 at baseline, 52 % women) from the Dutch Occupational and Environmental Health Cohort Study AMIGO filled in questionnaires in 2011/2012 (T0), 2013 (T1), and 2021 (T4) where information pertaining to perceived RF-EMF exposure and risk, non-specific symptoms, sleep problems, IEI-RF, and EHS was collected. We fitted multi-state Markov models to represent how individuals transitioned between states ("yes", "no") of IEI-RF.

Results At each time point, about 1 % of study participants reported health complaints that they attributed to RF-EMF exposure. While this percentage remained stable, the individuals who reported such complaints changed over time: of nine persons reporting health complaints at T0, only one reported IEI-RF at both T1 and T4, and two newly reported health complaints at T4. Overall, participants had a 95 % chance of transitioning from "yes" to "no" over a time course of 10 years, and a chance of 1 % of transitioning from "no" to "yes". Participants with high perceived RF-EMF exposure and risk had a general tendency to move more frequently between states.

Conclusions We observed a low prevalence of IEI-RF in our population. Prevalence did not vary strongly over time but there was a strong aspect of change: over 10 years, there was a high probability of not attributing symptoms to RF-EMF exposure anymore. IEI-RF appears to be a more transient condition than previously assumed.

Open access paper: https://www.sciencedirect.com/science/article/pii/S0048969722063392

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A cross-sectional study on smartphone uses among pregnant women attending childbirth classes in the Metropolitan Area of Palermo, Italy: The Stop-Phone study

Costantino C, Mazzucco W, Bonaccorso N, Sciortino M, Cimino L, Pizzo S, Conforto A, Calò I, Giliberti D, Gambino CR, Segreto D, Maiorana A, Vitale F, Casuccio A. A cross-sectional study on smartphone uses among pregnant women attending childbirth classes in the Metropolitan Area of Palermo, Italy: The Stop-Phone study. Ann Ig. 2022 Sep 29. doi: 10.7416/ai.2022.2543.

Abstract

Background: Prevalence of mobile device addiction has increased over the years; both women and men have assimilated the mobile phone as a central component of their personal existence: integrating it into their lifestyle or becoming so dependent on it that life without it has become unimaginable. Smartphones generate radio-frequency electromagnetic fields. While short-term exposure in adults was considered quite safe, effects of long-term exposure or exposure during pregnancy on fetuses or during breastfeeding on newborns are not well studied yet. The objective of the present study was to investigate the prevalence and usage characteristics of smartphones among a sample of pregnant women, and promote the correct and conscious use of the

smartphone.

Methods: A cross-sectional study was conducted, with a questionnaire administered during childbirth classes and - after the questionnaire administration - an educational intervention focused on promoting the correct and conscious use of smartphones was carried out by psychologists and psychotherapists.

Results: The findings of our study suggest that a significant number of the participants suffered addiction to mobile phone usage, but were not aware of it. More than two third of the sample (67.2%) have not changed their smartphone use habits since the beginning of their pregnancy and even more significant data shows that almost all future moms (98.3%) never speak with their doctor about smartphone use during pregnancy.

Conclusions: Data collected suggest a lack of attention to the proposed topic, especially in relation to pregnancy. It seems necessary to sensitize future mothers on this topic. The promotion of a more conscious and controlled use of electronic devices can help reduce the radiation to which the unborn child may be exposed, but has a fundamental role even after birth, to ensure an adequate psychomotor and relational development of the child and do not affect, due to uncontrolled use of smartphones, the mother-child relationship.

Open access paper: https://annali-igiene.it/articoli/2022/online_ahead_of_print/09/Costantino.pdf

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Empirical study on specific absorption rate of head tissues due to induced heating of 4G cell phone radiation

Bindhu Christopher, Sheena Mary Y, Mayeen Uddin Khandaker, P.J. Jojo. Empirical study on specific absorption rate of head tissues due to induced heating of 4G cell phone radiation. Radiation Physics and Chemistry. Volume 178, 2021. doi: 10.1016/j.radphyschem.2020.108910.

Abstract

Exposures to electromagnetic radiation mainly from the extended use of mobile phones may initiate biological damages in the human body at the macromolecular level. Several studies on human and animal models have shown significant changes in the functions of neural cells. Present empirical study analyses the thermal changes and the specific absorption rates (SAR) of brain, eye and skin tissues due to prolonged exposure to mobile phone radiation. A phantom, simulating human head with skin, skull and brain was used for the study. The Phantom was exposed to radiation for longer durations (600 s and more) and the temperature variations at different specific points were studied with sensitive thermocouple probes. SAR (1 g of contiguous tissue) values were determined using the variations of temperature and other parameters. The average rise in brain temperature was found to be 0.10 ± 0.05 °C at 30 mm deep in the brain and the estimated SAR was 0.66 ± 0.35 Wkg-1. The increase in temperature for the eye socket was 0.03 ± 0.02 °C with SAR 0.15 ± 0.08 Wkg-1. The average rise in temperature for skin was 0.14 ± 0.05 °C and the SAR was 0.66 ± 0.42 Wkg-1. Although the measured SAR lie within the safe limit of 2 Wkg-1 recommended by the international regulatory body, considering the tremendous growth in the number of mobile phone users and prolonged use of mobile phone in communication purposes, the cumulative effects could be a real concern for human health.

https://www.sciencedirect.com/science/article/pii/S0969806X20302085

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Assessment of DNA Damage in Chick Embryo Brains Exposed to 2G and 3G Cell Phone Radiation using Alkaline Comet Assay Technique

D'Silva MH, Swer RT, Anbalagan J, Bhargavan R.Assessment of DNA Damage in Chick Embryo Brains Exposed to 2G and 3G Cell Phone Radiation using Alkaline Comet Assay Technique.J Clin of Diagn Res. 2021; 15(1):AC01-AC04. doi: 10.7860/JCDR/2021/47115/14441.

Abstract

Introduction The cellular phones/mobile phones have emerged as the fastest growing man-made phenomenon ever discovered in the history. Controversies still exist among the scientific community regarding the ill-effects of Radiofrequency Radiation (RFR) exposure from cell phones on biological tissues. The present study will provide an insight into the basic mechanisms by which RF fields interact with developing brain in an embryo.

Aim To assess the possible Deoxyribonucleic Acid (DNA) damage in developing brain of chick embryo following chronic exposure to Ultra-High Frequency/Radiofrequency Radiation (UHF/RFR) emitted from 2G and 3G cell phone.

Materials and Methods Fertilised hen eggs were divided into three groups. Experimental Group A (exposed to 2G radiation, 24 eggs), Experimental Group B (exposed to 3G radiation, 24 eggs) and Group C sham exposed control group (24 eggs). After the completion of scheduled duration of exposure (72 minutes per day), the chick embryos were sacrificed from 9^{th}-12^{th} day and the brains were disdivted out. The chick embryo brains were then subjected to alkaline comet assay technique to assess the DNA damage. The results were statistically compared using one-way Analysis of Variance (ANOVA).

Results In the present study, the exposure of chick embryo brains to 2G and 3G cell phone radiation caused increased mean comet length ($p<0.001$), mean tail length ($p<0.001$), mean percentage of DNA in the tail ($p<0.001$) and mean tail moment ($p<0.01$) suggestive of increased DNA damage.

Conclusion The present study concludes that the RFR exposure caused significant increase in DNA damage in developing brain of chick embryos with changes more pronounced in 3G exposure group

Open access paper: https://jcdr.net/article_fulltext.asp?issn=0973-709x&year=2021&volume=15&issue=1&page=AC01&issn=0973-709x&id=14441

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Yang ZZ, Wu DW, Ding B, et al. Long-Term, Low-Level Microwave Radiation Impairs Learning and Memory via Synbindin: Molecular Basis and Underlying Mechanism. Biomed Environ Sci. 2022;35(6):552-557. doi:10.3967/bes2022.074.

No abstract.

Open access paper: https://www.besjournal.com/en/article/doi/10.3967/bes2022.074

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Assessment of incident power density in different shapes of averaging area for radio-frequency exposure above 6 GHz

Morimoto R, Hirata A. Assessment of incident power density in different shapes of averaging area for radio-frequency exposure above 6 GHz. Phys Med Biol. 2022;67(21):10.1088/1361-6560/ac994d. Published 2022 Oct 31. doi:10.1088/1361-6560/ac994d.

Abstract

Objective.The International Commission on Non-Ionizing Radiation Protection guidelines and IEEE C95.1-2019 standard for human protection from local electromagnetic field exposure above 6 GHz state that absorbed (or epithelial) power density (APD) and incident power density (IPD), averaged over a square area, are internal and external physical quantities, respectively, that set the exposure limit. Per exposure standards, the measurement procedure and evaluation of the IPD have been established in technical standards, where a circular averaging area is recommended only for non-planar surfaces in IEC/IEEE 63195-1 and -2. In this study, the effects of two averaging shapes on the APD and IPD are evaluated computationally to provide new insights from the viewpoint of exposure standards.

Approach. The relation between the APD, IPD, and the steady-state temperature rise (heating factor) in rectangular and human models for exposure to a single dipole, dipole arrays, and the Gaussian beams is investigated computationally with finite-difference method.

Main results. The maximum differences in the heating factor of the APD and IPD for square and circular averaging areas were 4.1% and 4.4% for the antenna-model distance >5 mm, respectively. These differences appear when the beam pattern on the model surface has an elliptical shape. For an antenna-model distance ≤5 mm and at frequencies ≤15 GHz, the heating factors for square averaging areas were not always conservative to those for circular ones (-7.8% for IPD), where only the antenna feed point are visible before beam formation.

Significance. The heating factors of the APD and IPD for a circular averaging area are conservative for near-field exposure of canonical sources for frequencies up to 300 GHz, except for a beam with a significant major-to-minor axis ratio and an angle of 30°-60° to a square averaging area. This tendency would help bridge the gap between exposure and product standards.

Open access paper: https://iopscience.iop.org/article/10.1088/1361-6560/ac994d/pdf

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On radar and radio exposure and cancer in the military setting

Peleg M, Berry EM, Deitch M, Nativ O, Richter E. On radar and radio exposure and cancer in the military setting. Environ Res. 2022 Oct 21:114610. doi: 10.1016/j.envres.2022.114610.

Abstract

Introduction: In 2018, we reported a case series of 47 patients diagnosed with cancer following several years of exposure to high-intensity whole-body radiofrequency radiation (RFR) using the parameter of percentage frequency (PF). Consistent high and statistically significant PFs of hematolymphoid (HL) cancers were found in this group and in four previous reports on RFR-exposed groups in Belgium, Poland and Israel together with increased all-cancers rates. In this paper we report a new series of 46 young cancer patients who were exposed during military service to such radiation.

Materials and methods: The new group of patients comprises Israeli soldiers previously exposed to occupational RFR. The patients were self-selected to enroll in the research in cooperation with an NGO assisting patients with administrative counseling and legal and social services. The new group of patients was studied with respect to distribution (proportion) of cancer types using the method of PF. When possible, cancer risk ratios (RR) were estimated too. The results are compared to those of other occupational groups in three countries.

Results: Median age at diagnosis was 23 years; duration of exposure was between 1 and 3 years and the latencies were short, median 4.6 years. The PF of HL cancers was 41.3%, 95% CI (27%-57%), versus 22.7% expected in non-exposed subjects matched for age and gender profiles, $p = 0.003$; 19 out of the 46 patients had HL cancers. The PF of Hodgkin lymphoma cancers was 21.7%, 95%CI (11%-36%), versus 11.6% expected, $p = 0.033$. For a subgroup of 6 patients, the number of soldiers in the units was known, and we were able estimate approximately the overall cancer risk ratio (RR) after 8 years as being 8.0 with 95% CI (2.9, 17), $p < 0.002$, with only 0.75 cases expected from the Cancer Registry data. In this subgroup, there were 3 HL cancer cases and 3 non-HL cases. Sarcoma PF was higher than expected, 7 out of the 46 patients were diagnosed with sarcoma, PF = 15.2%, 95%CI (6.3%-28.9%), $p = 0.04$ versus the expected PF of 7%.

Conclusions: The HL PF was high and consistent with previous reports. Epidemiological studies on excess risk for HL and other cancers, brain tumors in cellphone users, and experimental studies on RFR and carcinogenicity strongly point to a cause-effect relationship. It is mandatory to reduce the RFR exposure of all personnel to that of the typical community levels, including the peak level of radar pulses. Radiation protection, safety instructions, cancer risk warnings and quantitative data on individual exposure together with regular medical monitoring must be instituted for all personnel exposed to such risks. The findings from our study add to the growing body of evidence underscoring the gross inadequacy of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) thermal standards. Based on our findings and on the previous accumulated research, we endorse the recommendations to reclassify RFR exposure as a human carcinogen, International Agency for Research on Cancer (IARC) group 1.

https://www.sciencedirect.com/science/article/abs/pii/S0013935122019375

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Hygienic problems of using information and computer technology devices by children

Grigoriev O.A. Hygienic problems of using information and computer technology devices by children. *Hygiene and Sanitation*. 2022;101(10):1214-1222. (In Russ.) https://doi.org/10.47470/0016-9900-2022-101-10-1214-1222 (The paper is published in Russian.)

Abstract

(English translation from Semantic Scholar: https://www.semanticscholar.org/paper/Hygienic-problems-of-using-information-and-computer-Grigoriev/964b4d1a3cbdeec2665d2d5f8f3c52ac4858c8f7)

There was carried out the analysis of information and computer technologies (ICT), which are the main hygienically significant sources of non-ionizing electromagnetic radiation for children and adolescents. Early forecasts (before 2008) about the adverse impact of the ICT electromagnetic field on the health of children and adolescents, the fundamental scientific basis for forecasts and data on their feasibility to date are considered. According to state statistics, forecasts of an increase in morbidity due to EMF exposure to children and adolescents are likely to come true. **For the period 1995-2019, 15-17 years children, a steady trend was identified for the gain in cerebral malignant neoplasms, diseases of the nervous system, blood, hematopoietic organs, and individual disorders involving the immune mechanism.** The number of recorded malignant neoplasms of the brain in the adolescent contingent allows performing for the first time "case-control" analysis. Uncertainties in assessing the conditionality of the increase in the incidence in children under the influence of non-ionizing ICT electromagnetic radiation are associated with difficulties in determining personal doses. The limits of EMF exposure of the user's head by a mobile device, which were developed in 1994, are now outdated and it is necessary to change the limits, as the devices and parameters of exposure to non-ionizing electromagnetic radiation of ICT have changed. It is necessary to confirm the reliability of the hygienic safety factor of EMF remote control in relation to children's contingents in the conditions of modern and promising information and computer technologies, including taking into account possible synergy under the action of radio frequency EMF, optical screen radiation, sound effects and functional load. Obviously, today what is required is an integrated approach to ensuring the health of children "hygiene in the digital environment". The article substantiates the foreign standards to affect the design and equipment for information and communication technologies of the educational environment in the Russian Federation, which is one of the important reasons for the deterioration of children's health.

https://www.rjhas.ru/jour/article/view/2596

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Editorial: Effects of combined EMF exposures and co-exposures, volume II

Mattsson Mats-Olof, Simkó Myrtill, Scarfi Maria Rosaria, Zeni Olga. Editorial: Effects of combined EMF exposures and co-exposures, volume II. Frontiers in Public Health. 10, 2022. doi: 10.3389/fpubh.2022.1052639.

No abstract.

Conclusions

In summary, the papers presented in this special issue represent a diverse account of the complex exposure situation around specific devices due to combinations of static MF, IF-EMF, and RF-EMF in occupational settings. Since this topic deserves great attention for the purpose of exposure assessment of relevance for compliance with exposure limits and for its central role within the process of health risk assessment, we hope that the readers can find these articles informative and useful to perform ground-breaking research in this area.

The collection is also adding relevant evidence to the question of possible effects on reproduction from exposures to RF EMF at levels below generally recognized exposure limits. Strikingly, such studies are by far lacking combinatorial or co-exposure components.

https://www.frontiersin.org/articles/10.3389/fpubh.2022.1052639

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Personal exposimeter coupled to a drone as a system for measuring environmental electromagnetic fields

García-Cobos FJ, Paniagua-Sánchez JM, Gordillo-Guerrero A, Marabel-Calderón C, Rufo-Pérez M, Jiménez-Barco A. Personal exposimeter coupled to a drone as a system for measuring environmental electromagnetic fields. Environ Res. 2022 Oct 6:114483. doi: 10.1016/j.envres.2022.114483.

Highlights

- The wireless remote controller does not alter the bands of interest.
- The structure of the drone affects the measurements in a quantifiable way.
- Vertical electric field profile consistent with the antenna height and downtilt.
- The attenuation of a building is estimated.

Abstract

Personal exposimeters are currently used in studies assessing human exposure to electromagnetic fields. These devices are usually carried by an individual, but vehicles such as bicycle or car are also used. The aim of the present study was to propose a personal exposimeter attached to a drone to perform environmental radio-frequency measurements. Trials were carried out to determine whether: (i) the wireless communication between the remote controller and the drone affects the downlink mobile telephony bands by a cross-talk effect, and (ii) the structure of the drone alters the measurements of the exposimeter compared to when the meter is on a tripod. To apply this system to a real scenario, a 3D representation of the electric field in a building was obtained, and the attenuation due to the building of radiation from outside was estimated. Measurements of the electromagnetic field with this system will make it possible to monitor without risk the emissions of antennas in their close vicinity, and to validate propagation models experimentally.

Open access paper: https://www.sciencedirect.com/science/article/pii/S0013935122018102?via%3Dihub

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Effects of 3.5 GHz Radiofrequency Radiation on Ghrelin, Nesfatin-1, and Irisin Levels in Diabetic and Healthy Brains

Bektas H, Algul S, Altindag F, Yegin K, Akdag MZ, Dasdag S. Effects of 3.5 GHz radiofrequency radiation on ghrelin, nesfatin-1, and irisin level in diabetic and healthy brains. J Chem Neuroanat. 2022 Oct 8;126:102168. doi: 10.1016/j.jchemneu.2022.102168.

Abstract

Diabetes, mobile phone use, and obesity have increased simultaneously in recent years. The radiofrequency radiation (RFR) emitted from mobile phones is largely absorbed in the heads of users. With 5 G, which has started to be used in some countries without the necessary precautions being taken, the amount of RFR to which living things are exposed will increase. In this study, the changes in energy homeostasis and redox balance caused by 5 G (3.5 GHz, GSM-modulated) were explored. The effects of RFR on the brains of diabetic and healthy rats were investigated and histopathological analysis was performed. Twenty-eight Wistar albino rats weighing 200-250 g were divided into 4 groups as sham, RFR, diabetes, and RFR+diabetes groups (n = 7). The rats in each group were kept in a plexiglass carousel for 2 h a day for 30 days. While the rats in the experimental groups were exposed to RFR for 2 h a day, the rats in the sham group were kept under the same experimental conditions but with the radiofrequency generator turned off. At the end of the experiment, brain tissues were collected from euthanized rats. Total antioxidant (TAS), total oxidant (TOS), hydrogen peroxide (H_2O_2), ghrelin, nesfatin-1, and irisin levels were determined. In addition, histopathological analyses of the brain tissues were performed. The specific absorption rate in the gray matter of the brain was calculated as 323 mW/kg and 195 mW/kg for 1 g and 10 g averaging, respectively. After RFR exposure among diabetic and healthy rats, decreased TAS levels and increased TOS and H_2O_2 levels were observed in brain tissues. RFR caused increases in ghrelin and irisin and a decrease in nesfatin-1 in the brain. It was also observed that RFR increased the number of degenerated neurons in the hippocampus. Our results indicate that 3.5 GHz RFR causes changes in the energy metabolism and appetite of both healthy and diabetic rats. Thus, 5 G may not be innocent in terms of its biological effects, especially in the presence of diabetes.

https://pubmed.ncbi.nlm.nih.gov/36220504/

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Specific electromagnetic radiation in the wireless signal range increases wakefulness in mice

Liu L, Deng H, Tang X, Lu Y, Zhou J, Wang X, Zhao Y, Huang B, Shi Y. Specific electromagnetic radiation in the wireless signal range increases wakefulness in mice. Proc Natl Acad Sci U S A. 2021 Aug 3;118(31):e2105838118. doi: 10.1073/pnas.2105838118.

Abstract

Electromagnetic radiation (EMR) in the environment has increased sharply in recent decades. The effect of environmental EMR on living organisms remains poorly characterized. Here, we report the impact of wireless-range EMR on the sleep architecture of mouse. Prolonged exposure to 2.4-GHz EMR modulated by 100-Hz square pulses at a nonthermal output level results in markedly increased time of wakefulness in mice. These mice display corresponding decreased time of nonrapid eye movement (NREM) and rapid eye movement (REM). In contrast, prolonged exposure to unmodulated 2.4-GHz EMR at the same time-averaged output level has little impact on mouse sleep. These observations identify alteration of sleep architecture in mice as a specific physiological response to prolonged wireless-range EMR exposure.

Excerpts

"Prolonged radiation of mice (Pos9) using the Pulse64W regimen, but not the Conti8W regimen, results in statistically significant increase of wakefulness (Figs. 2, ,4,4, andand5).5). Notably, these two regimens have the same time-averaged radiation level over the 12-h sleep period, suggesting a key role for pulse modulation."

"A distinct implication of this study is the possibility that prolonged exposure to modulated 2.4-GHz radiation, such as the wireless signal, might also increase wakefulness for humans. However, assessing this possibility may take extraordinary effort because of the complex issues for human volunteers. Consistent with our conclusion on the Conti8W group, previous studies found no significant effect on human sleep by unmodulated radiation (33, 36). Whole-night exposure to Wi-Fi was found to affect the sleep microstructure of humans but had no significant acute effects on the sleep macrostructure (42). This result is consistent with prior studies on the effect of mobile phone and base station radiation on human sleep (24, 28, 33). Another study on human subjects found no significant effects of 900-MHz EMR with global system for mobile communications modulation, either on conventional sleep parameters or on power spectra (30)."

"In a collective exposure scenario, the average power density at close proximity is about 0.037 W/m2 for a smartphone, 0.013 W/m2 for a laptop, and 0.13 W/m2 near the Wi-Fi router (1). These values are considerably lower than the time- and whole-body–averaged general public exposure limit of 10 W/m2 or occupational exposure limit of 50 W/m2 for 2–300 GHz suggested by International Commission on Non-Ionizing Radiation Protection (43). In our experiments, the measured spatial averaged power density for Conti8W is 36.80 ± 0.92 W/m2. Pulse64W is expected to have the same power density. Importantly, the effective EMR dose for inducing a biological response in mice is likely to be different from that in humans. Therefore, the relatively high EMR dose of the Pulse64W regimen that causes increased wakefulness in mice could be markedly reduced in humans. An epidemiological survey among those who work under either very high or very low doses of wireless radiation may reveal some clues.

In this study, 2.4-GHz EMR is modulated by 100-Hz square pulses, which have sharp edges and thus might have some unanticipated impact on neural activity in the brain. Additional experiments should be performed to examine whether other modulation functions such as sinusoidal modulation can induce similar increase of wakefulness in mice. In addition, other modulation frequencies such as 10 and 1,000 Hz should be investigated to answer the question of whether increased wakefulness is specific to certain modulation frequencies. Finally, both the intensity and the frequency of the carrier EMR (2.4 GHz in this study) should be scrutinized."

Open access paper: https://www.pnas.org/doi/10.1073/pnas.2105838118

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Effect of Short-time Exposure of Local Extremely Low-Frequency Magnetic Fields on Sleepiness in Male Rats

Azizi E, Ayoobi F, Shamsizadeh A, Moghadam-Ahmadi A, Shafiei S A, Khoshdel A et al . Effect of Short-time Exposure of Local Extremely Low-Frequency Magnetic Fields on Sleepiness in Male Rats. BCN 2022; 13 (4) :519-530.

Abstract

Introduction: Lack of high-quality sleep causes severe side effects like anxiety and changes in plasma concentration of oxalate. The current study investigated the impact of local extremely low-frequency magnetic fields (ELF-MFs) on inducing sleep (sleepiness) and anxiety in male rats.

Methods: In this experimental study, 40 male rats were divided into four groups (n=10 for each group). The ELF-MF exposure (0, 10, and 18 Hz) was applied with an intensity of 200μT for three days (10 min/d). The sham-treated animal did not receive ELF-MF. Serum levels of oxalic acid (OA) and sleepiness were measured before and after the last exposure to ELF-MF or sham. Anxiety, sleepiness, and OA were measured using the elevated plus maze, open-field test (OFT), and ELISA test.

Results: A comparison of oxalate levels before and after exposure to ELF-MF revealed that ELF-MF (10 Hz) decreased the serum level of oxalate ($P<0.05$). Comparing open/closed arm entry (in an elevated plus maze) between before and after exposure to ELF-MF revealed significant differences. Also, frequency, velocity, and distance moved were decreased in the open-field test.

Conclusion: Results of the present study demonstrated that ELF-MF with short-time exposure may modulate the metabolism of OA and may modulate anxiety-like behavior or kind of induction of sleepiness in male rats.

Open access paper: http://bcn.iums.ac.ir/article-1-1805-en.html

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Measurement of Intermediate Frequency Magnetic Fields Generated by Household Induction Cookers for Epidemiological Studies and Development of an Exposure Estimation Model

Kitajima T, Schüz J, Morita A, Ikeda W, Tanaka H, Togawa K, Gabazza EC, Taki M, Toriyabe K, Ikeda T, Sokejima S. Measurement of Intermediate Frequency Magnetic Fields Generated by Household Induction Cookers for Epidemiological Studies and Development of an Exposure Estimation Model. Int J Environ Res Public Health. 2022 Sep 21;19(19):11912. doi: 10.3390/ijerph191911912.

Abstract

Introduction: Exposure assessment of intermediate frequency (IF) electromagnetic fields (EMFs) is difficult and epidemiological studies are limited. In the present study, we aimed to estimate the exposure of pregnant women to IF-EMFs generated by induction cookers in the household using a questionnaire and discussed its applicability to epidemiological studies.

Method: Two main home-visit surveys were conducted: a Phase 1 survey to develop an estimation model and a Phase 2 survey to validate the model. The estimation model included the following variables: wattage, cookware diameter, and distance from the hob center (center of the stove). Four models were constructed to determine the importance of each variable and the general applicability for epidemiological studies. In addition, estimated

exposure values were calculated based on the Phase 2 survey questionnaire responses and compared with the actual measured values using the Spearman rank correlation coefficient.

Result: The average value of the magnetic field measured in the Phase 1 survey was 0.23 μT (variance: 0.13) at a horizontal distance of 30 cm at the height of the cooking table. The highest validity model was inputted distance from the hob center to the body surface that is variable (correlation coefficient = 0.54, 95% confidence interval: 0.22–0.75). No clear differences were identified in the correlation coefficients for each model (z-value: 0.09–0.18, p-value: 0.86–0.93).

Discussion and Conclusions: No differences were found in the validity of the four models. This could be due to the biased wattage of the validation population, and for versatility it would be preferable to use three variables (distance, wattage, and estimation using the diameter of the cookware) whenever possible. To our knowledge, this is the first systematic measurement of magnetic fields generated by more than 70 induction cookers in a real household environment. This study will contribute to finding dose–response relationships in epidemiological studies of intermediate-frequency exposure without the use of instrumentation. One of the limitations of this study is it estimates instantaneous exposure in place during cooking only.

Open access paper: https://www.mdpi.com/1660-4601/19/19/11912

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Effects of medically generated electromagnetic interference from medical devices on cardiac implantable electronic devices: A review

Barmore W, Patel H, Voong C, Tarallo C, Calkins JB Jr. Effects of medically generated electromagnetic interference from medical devices on cardiac implantable electronic devices: A review. World J Cardiol. 2022 Aug 26;14(8):446-453. doi: 10.4330/wjc.v14.i8.446.

Abstract

As cardiac implantable electronic devices (CIED) become more prevalent, it is important to acknowledge potential electromagnetic interference (EMI) from other sources, such as internal and external electronic devices and procedures and its effect on these devices. EMI from other sources can potentially inhibit pacing and trigger shocks in permanent pacemakers (PPM) and implantable cardioverter defibrillators (ICD), respectively. This review analyzes potential EMI amongst CIED and left ventricular assist device, deep brain stimulators, spinal cord stimulators, transcutaneous electrical nerve stimulators, and throughout an array of procedures, such as endoscopy, bronchoscopy, and procedures involving electrocautery. Although there is evidence to support EMI from internal and external devices and during procedures, there is a lack of large multicenter studies, and, as a result, current management guidelines are based primarily on expert opinion and anecdotal experience. We aim to provide a general overview of PPM/ICD function, review documented EMI effect on these devices, and acknowledge current management of CIED interference

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9453256/

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The effect of magnetic resonance imaging on mercury release from dental amalgam at 3T and 7T

James R. Allison, Karthik Chary, Chris Ottley, Quoc C. Vuong, Matthew J. German, Justin Durham, Peter Thelwall. The effect of magnetic resonance imaging on mercury release from dental amalgam at 3T and 7T.

Journal of Dentistry. 127, 2022, doi: 10.1016/j.jdent.2022.104322.

Abstract

Objectives To measure mercury release from standardised hydroxyapatite/amalgam constructs during MRI scanning and investigate the impact of static field strength and radiofrequency (RF) power on mercury release.

Methods Amalgam was placed into 140 hydroxyapatite disks and matured for 14-days in artificial saliva. The solution was replaced, and samples split into five groups of 28 immediately prior to MRI. One group had no exposure, and the remainder were exposed to either a 3T or 7T MRI scanner, each at high and low RF power. Mercury concentration was measured by inductively coupled plasma mass spectrometry. Groups were compared using one-way ANOVA, and two-way ANOVA for main effects/ interaction of field strength/ RF power.

Results Mercury concentration was increased in the 7T groups (high/ low: 15.43/ 11.33 ng mL−1) and 3T high group (3.59) compared to control (2.44). MRI field strength significantly increased mercury release ($p < .001$) as did RF power ($p = .030$). At 3T, mercury release was 20.3 times lower than during maturation of dental amalgam, and for the average person an estimated 1.50 ng kg−1 of mercury might be released during one 3T investigation; this is substantially lower than the tolerable weekly intake of 4,000 ng kg−1.

Conclusion Mercury release from amalgam shows a measurable increase following MRI, and the magnitude changes with magnetic field strength and RF power. The amount of mercury released is small compared to release during amalgam maturation. Amalgam mercury release during MRI is unlikely to be clinically meaningful and highly likely to remain below safe levels.

https://www.sciencedirect.com/science/article/pii/S0300571222003773

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Exposure to Electromagnetic Fields from Submarine Power Cables Can Trigger Strength-Dependent Behavioural and Physiological Responses in Edible Crab

Scott K, Harsanyi P, Easton BAA, Piper AJR, Rochas CMV, Lyndon AR. Exposure to Electromagnetic Fields (EMF) from Submarine Power Cables Can Trigger Strength-Dependent Behavioural and Physiological Responses in Edible Crab, *Cancer pagurus* (L.). *Journal of Marine Science and Engineering*. 2021; 9(7):776. https://doi.org/10.3390/jmse9070776

Abstract

The current study investigated the effects of different strength Electromagnetic Field (EMF) exposure (250 µT, 500 µT, 1000 µT) on the commercially important decapod, edible crab (Cancer pagurus, Linnaeus, 1758). Stress related parameters were measured (L-Lactate, D-Glucose, Total Haemocyte Count (THC)) in addition to

behavioural and response parameters (shelter preference and time spent resting/roaming) over 24 h periods. EMF strengths of 250 µT were found to have limited physiological and behavioural impacts. Exposure to 500 µT and 1000 µT were found to disrupt the L-Lactate and D-Glucose circadian rhythm and alter THC. Crabs showed a clear attraction to EMF exposed (500 µT and 1000 µT) shelters with a significant reduction in time spent roaming. Consequently, EMF emitted from MREDs will likely affect crabs in a strength-dependent manner thus highlighting the need for reliable in-situ measurements. This information is essential for policy making, environmental assessments, and in understanding the impacts of increased anthropogenic EMF on marine organisms.

Conclusions

The results obtained from this study, combined with the data from previous work [13,41], suggests that increased physiological stress will occur if *C. pagurus* is exposed to EMF of 500 µT or above with data obtained at 1000 µT, 2.8 mT and 40 mT confirming this trend. This is mirrored in the behavioural trends noted, which showed an attraction to EMF sources at the same levels despite the physiological ramifications.

This suggests that a working limit of a maximum of 250 µT could result in minimal physiological and behavioural changes within this species and should be considered during MRED design and implementation. Additional research is required to further identify sensitivities to EMF in different life stages and conditions within this species and benthic crustaceans in general.

250 µT = 2,500 Milligauss

Open access paper: https://www.mdpi.com/2077-1312/9/7/776

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Biophysical mechanisms underlying the effects of static magnetic fields on biological systems

Zhang B, Yuan X, Lv H, Che J, Wang S, Shang P. Biophysical mechanisms underlying the effects of static magnetic fields on biological systems. Prog Biophys Mol Biol. 2022 Oct 11:S0079-6107(22)00093-1. doi: 10.1016/j.pbiomolbio.2022.09.002.

Abstract

With the widespread use of static magnetic fields (SMFs) in medicine, it is imperative to explore the biological effects of SMFs and the mechanisms underlying their effects on biological systems. The presence of magnetic materials within cells and organisms could affect various biological metabolism and processes, including stress responses, proliferation, and structural alignment. SMFs were generally found to be safe at the organ and organism levels. However. human subjects exposed to strong SMFs have reported side effects. In this review, we combined the magnetic properties of biological samples to illustrate the mechanism of action of SMFs on biological systems from a biophysical point of view. We suggest that the mechanisms of action of SMFs on biological systems mainly include the induction of electric fields and currents, generation of magnetic effects, and influence of electron spins. An electrolyte flowing in a static magnetic field generates an induced current and an electric field. Magnetomechanical effects include orientation effects upon subjecting biological samples to SMFs and movement of biological samples in strong field gradients. SMFs are thought to affect biochemical

reaction rates and yields by influencing electron spin. This paper helps people how can harness the favorable biological effects of SMFs.

https://www.sciencedirect.com/science/article/abs/pii/S0079610722000931

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The European Union prioritises economics over health in the rollout of radiofrequency technologies

Nyberg NR, McCredden JE, Weller SG, Hardell L. The European Union prioritises economics over health in the rollout of radiofrequency technologies. Reviews on Environmental Health. 2022. doi:10.1515/reveh-2022-0106.

Abstract

The fifth generation of radiofrequency communication, 5G, is currently being rolled out worldwide. Since September 2017, the EU **5G Appeal** has been sent six times to the EU, requesting a moratorium on the rollout of 5G. This article reviews the 5G Appeal and the EU's subsequent replies, including the extensive cover letter sent to the EU in September 2021, requesting stricter guidelines for exposures to radiofrequency radiation (RFR). The Appeal notes the EU's internal conflict between its approach to a wireless technology-led future, and the need to protect the health and safety of its citizens. It critiques the reliance of the EU on the current guidelines given by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), that consider only heating and no other health relevant biological effects from RFR. To counteract the ICNIRP position, the 2021 cover letter briefly presented recent research from the EU's own expert groups, from a large collection of European and other international studies, and from previous reviews of the effects of RFR on humans and the environment. The 5G Appeal asserts that the majority of scientific evidence points to biological effects, many with the potential for harm, occurring below the ICNIRP public limits. Evidence to establish this position is drawn from studies showing changes to neurotransmitters and receptors, damage to cells, proteins, DNA, sperm, the immune system, and human health, including cancer. The 2021 Appeal goes on to warn that 5G signals are likely to additionally alter the behaviour of oxygen and water molecules at the quantum level, unfold proteins, damage skin, and cause harm to insects, birds, frogs, plants and animals. Altogether, this evidence establishes a high priority for the European Union towards (i) replacing the current flawed guidelines with protective thresholds, and (ii) placing a moratorium on 5G deployment so as to (iii) allow industry-independent scientists the time needed to propose new health-protective guidelines. This 2021 Appeal's relevance becomes even more pressing in the context of the EU plans to roll out the sixth generation of wireless technologies, 6G, further adding to the known risks of RFR technology for humans and the environment. This all leads to an important question: Do EU decision makers have the right to ignore EU´s own directives by prioritising economic gain over human and environmental health?

Excerpts

Exposure of captured agencies

The deficits of industry-biased bodies are now beginning to be exposed. In 2021, the US **Federal Communications Commission (FCC)** was deemed by a **US Court of Appeals for the D.C. Circuit ruling** as having

been negligent for two decades in its role as protector of public health, in that when it decided that its 1996 emission guidelines protected public health, it neglected to consider (a) impacts of long term wireless exposure, (b) unique impacts to children, (c) testimony of people injured by wireless radiation, (d) impacts to wildlife and the environment and (e) impacts to the developing brain and reproduction [96]. The book ***Captured Agency*** describes the compromised position of the FCC in its role as public protector [97]. The compromised actions of ICNIRP since their inception, including inviting industry representatives to the table, are described by Maisch [98, Chapter 4]. As noted by the Turin Court of Appeal [43], opinions from such conflicted advisory bodies as ICNIRP are not reliable.

Safety-first

Alternative guidelines to protect citizens have been created by four groups of industry-independent scientists, based on best available scientific evidence; i.e., setting exposure levels lower than where biological effects with health implications have been found. As described in [101] these four groups recommend the following limits for human exposures to RF-EMR:

1. Building biologists [102] suggest a very low radiation level of no more than 0.1 µW/m2 (in sleeping areas);
2. EuropaEM-EMF Environmental Medicine researchers [103] suggest 1 µW/m2 during the night and 10 µW/m2 during the day time;
3. The BioInitiative-group conclusions (2012 update) [20], made by 29 prominent researchers, and based on 2,200+ scientific reports, suggest 3–6 µW/m2 as the upper limit for exposures;
4. The Council of Europe (CoE) Resolution 1815 [104] Section 8.2.1 says *set preventative thresholds for levels of long-term exposure to microwaves in all indoor areas, in accordance with the precautionary principle, not exceeding 0.6 V per metre [1,000 µW/m2], and in the medium term to reduce it to 0.2 V per metre [100 µW/m2].*

While there is some variation in the above recommendations, they are all far lower than the ICNIRP 2020 guidelines [14] which, for all frequencies from 2–300 GHz, allow a 30 min average whole body exposure of 10,000,000 µW/m2 (10 W/m2; Table 5, p. 495). For the more recent, higher 5G frequencies of 6–300 GHz, the ICNIRP guidelines allow an average 6 min local exposure over a 4-cm2 region of 200,000,000 µW/m2 (200 W/m2; p. 490). Furthermore, An additional specification of 400 W m −2 has been set for spatial averages of square 1-cm2 regions, for frequencies >30 GHz ([14], p. 490). These ICNIRP specifications mean that future 5G cell phones may send narrow directional beams that impact small regions of body tissue with intensities of 200,000,000–400,000,000 µW/m2. However, the maximum intensity should be no higher than 1–10 µW/m2, according to recommendations 1), 2), 3) above that are aimed at protecting human health.

The above comparisons reveal that ICNIRP and most European states allow incident power densities at least a million times higher than the first three independent advisory bodies mentioned above. This is because the ICNIRP guidelines consider only temperature rises in “tissue simulants” in plastic “heads” but no other risks, like biological effects on living glial cells, blood or DNA, which have been well documented in EU’s sponsored research and reviews [1, 3, 4, 6, 7].

Concluding remarks

At the current juncture, millions of EU citizens are relying on the EU to address the issues raised in the EU 5G Appeal. The EU decision makers need to put aside their industry-fuelled fantasies of a digital saviour for mankind and instead, ensure that industry acts according to EU laws, made to prioritise humans and planetary health above industry profit or science fiction futures. *Any economic benefits from 5G are likely to be outweighed by the risk of harm to the health of billions of people around the world* [33].

If the EU continues to fail to act on these warnings, Europe may end up being faced with a non-reversible burgeoning health impact on humans, especially children and the environment.

To allow the levels and frequencies of exposures to continue unfettered is to put the world population and the environment at great risk, especially young people [28].

Open access paper: https://www.degruyter.com/document/doi/10.1515/reveh-2022-0106/html

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Some thoughts on the possible health effects of electric and magnetic fields and exposure guidelines

Barnes F, Freeman Jr ER. Some thoughts on the possible health effects of electric and magnetic fields and exposure guidelines. Frontiers in Public Health. Vol. 10. 2022. doi: 10.3389/fpubh.2022.994758.

Abstract

Concerns about the possible health effects from exposure to weak electric and magnetic (EM) fields have been debated since the early 1960s. It is now well established that biological systems respond to exposure to weak EM fields at energy levels well below the current safety guidelines which result in modification of their functionality without significant changes in temperature. These observations are adding to the debate over what should be done to protect the users of cellular telecommunications systems. Experimental results showing both increases and decreases in cancer cell growth rates and concentration of reactive oxygen species for exposure to nano-Tesla magnetic fields at both radio frequencies (RF) and extra low frequencies (ELF) are cited in this paper. Some theoretical models on how variations in EM exposure can lead to different biological outcomes and how feedback and repair processes often mitigate potential health effects due to long-term exposure to low-level EM energy sources are presented. Of particular interest are the application of the radical pair mechanisms that affect polarization of electrons, and nuclear spins and the importance of time-delayed feedback loops and the timing of perturbations to oscillations in biological systems. These models help account for some of the apparently conflicting experimental results reported and suggest further investigation. These observations are discussed with particular emphasis on setting future safety guidelines for exposure to electromagnetic fields in cellular telecommunications systems. The papers cited are a very small fraction of those in the literature showing both biological effects and no effects from weak electric and magnetic fields.

Excerpts

The central problems to be solved include:

1. Determining the exposure amplitude, polarization and duration of electromagnetic fields at specific positions of interest in the body as a function of the exposing fields as a function of time.
2. Determining causal relationships between long duration exposure to low-level EM fields and the various biological responses reported in current research.
3. Quantifying the interactions between EM fields and biology with measurements that are not only accurate but repeatable. Some of the low energy EM effects on micro-biological systems are well documented in laboratory experiments but are difficult to translate to macro-biological system responses.
4. Sorting out which aspects of biological systems are directly driven by RF fields vs. the myriad of other independent variables at work.
5. Understanding how the repair mechanisms in biological systems alter biological processes in the presence of low-level EM fields.

Several issues confront regulators:

1. Should regulations be set that "protect" all the population all the time, including those with other health conditions that make them more susceptible to EM exposure, or should regulations only protect most of the population most of the time. The degree of control has huge implications on cost and efficacy.
2. Simplifying the explanations of the physical mechanisms involved such that there is general acceptance of the need for regulation is a non-trivial part of the regulatory process. Scientists, producers, operators, and users have differing imperatives that need to be considered. Such situations invite a lot of political hubris and conflict.
3. How regulators quantify and then rationalize the tradeoffs between the economic and social benefits of cellular technology vs. potentially damaging health effects of long-term exposure to low levels of EM energy is important in determining the regulations that are proposed.

Four strategies for reducing RF exposure might include:

1. Designing the transmitter in user devices to reduce the instantaneous RF power levels emitted is the most direct way to reduce RF exposure but this has serious system performance implications and high implementation costs. Manufacturers already try to minimize the instantaneous RF power output of cell phones to maximize battery life. Further reductions in RF power output will significantly impact signal to noise ratio and reduce the maximum range of any given phone within a cell phone tower matrix. This will have a significant impact on system infrastructure (number of cell phone towers needed to provide coverage) and operating cost. Another technique for reducing instantaneous power output absorbed by users is to use narrow beam directional antennas in user devices that focuses the output power on the closest cell tower receiver. This approach is being incorporated into 5G systems. Size and weight considerations are a major constraint in mobile devices.

2. Reducing the density of RF power (Watts/M^2) being absorbed by the body of a user can also be accomplished by increasing the distance between the transmitting antenna and the user's body and head. Power density falls off very rapidly with increasing distance from the transmitting antenna typically as $1/R^n$ reduction where n is a number usually >1. It is to be noted that increasing use of data and moving a smart phone away from the body reduces the power levels incident on the head.

3. Research data indicates biological effects of RF signals are frequency dependent. Redesigning transmitters to eliminate frequencies that are proven to produce biological effects could be employed, but this could have a significant impact on system capacity since each frequency band carries a lot of data in today's system.

4. The last, and least expensive approach is to limit cumulative user exposure to RF energy in a given period of time by shutting the phone “Off”. Establishing limits for the maximum accumulated duration of an individual's exposure would require extensive clinical testing on large populations of users. Once those numbers were set, there would be very little cost impact on the operators or the users to implement. Major issues would be lack of access in emergency situations and gaining user acceptance on such limitations and the self-discipline to avoid over exposure. To help with that applications software could be installed on the phone that calculates the accumulated exposure and then reports the data on the phone's visual readout.

Conclusion

The data above and many more papers not cited indicate that biological systems can sense and respond to very weak electric and magnetic field by changing biological parameters such as reactive oxygen species concentrations at the cellular level which affect health and wellbeing of living organisms. High concentrations of reactive oxygen species for extended periods of time are known to be associated with adverse health effects (19). There are also many cases where no damaging effects have been observed. It is presumed that the body's feedback and repair systems keep the concentrations of these molecules within the normal operating ranges and the cumulative effects of RF energy are negligible. We hypothesize that EM effects vary from person to person and are a function of exposure conditions in conjunction with other stresses that affect concentrations of these molecules. Note this degree of variability explains why many papers do not show EM effects while some of the experiments on hypersensitive people show effects. We have chosen not to go into discussion of hypersensitive people as it would take more space than we wish to devote to it in this paper.

It is clear that more research needs to be done to enable definition of standards for RF exposure that are reasonable and allow a simple, low-cost communications system to function safely. Although both industry and government have funded significant amounts of expensive research, relatively few studies have used radical pair theory and other quantum mechanical models to guide their experiments or track the chemical changes induced by exposures to weak electromagnetic fields. Additionally, they have not delt with long term effects of exposure to low-level exposure that take into account biological feedback and repair systems, that may not be able to handle the effects of compounding stresses and the fact that humans have different responses at different time.

Forcing a solution that eliminates all wireless communications is not a reasonable approach. Allowing the telecommunications industry and users to ignore the potential harm indicated by some of the experiments showing the effects of weak field exposures is equally unsatisfactory given the data that are currently available. Imposing operating standards without understanding the root causes in science, and social impacts and costs is tempting, but also potentially dangerous and can potentially lead to health problems for a large fraction of the population.

In the US, most industries can be held liable for not pursuing research on the safety of their products. With such a large number of users, it is incumbent on system designers, operators, managers, and regulators to invest the time and energy to understand the risks of long-term exposure to low-level EM fields to determine potential health hazards. In the short term, implementing ways to reduce exposure voluntarily is likely to be the cheapest solution, but human behavior is often unpredictable and unreliable. Ultimately more research will better define the conditions where EM exposures can lead to changes in the biological system that are not compensated by biological control systems and repair mechanisms.

Open access paper: https://www.frontiersin.org/articles/10.3389/fpubh.2022.994758/full

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Association between electronic device usage and sperm quality parameters in healthy men screened as potential sperm donors

Chen HG, Wu P, Sun B, Chen JX, Xiong CL, Meng TQ, Huang XY, Su QL, Zhou H, Wang YX, Ye W, Pan A. Association between electronic device usage and sperm quality parameters in healthy men screened as potential sperm donors. Environ Pollut. 2022 Sep 1;312:120089. doi: 10.1016/j.envpol.2022.120089.

Highlights

- Semen samples were repeatedly collected from 1454 healthy men.
- Electronic device use was evaluated by comprehensive questionnaire.
- Electronic device use was related to lower semen quality in modest effect size.
- Daily calling time was associated with lower sperm concentration and total count.

Abstract

Cell phone use and radio-frequency electromagnetic radiation (RF-EMF) are rapidly increasing and may be associated with lower semen quality, yet results from epidemiological studies are inconclusive. Information on electronic devices use was collected through standard questionnaires from 1454 men aged 22-45 years old. Semen volume, sperm concentration, total sperm count, total motility, progressive motility, and normal morphology in repeated specimens were determined by trained clinical technicians. Percent changes [95% confidence intervals (CIs)] were estimated as (10β-1) × 100 for electronic devices use associated with repeated sperm quality parameters in the linear mixed-effect models. After adjusting for multiple confounders, we found significant inverse associations of total duration of electronic devices use with sperm progressive motility and total motility, duration of cell phone and computer use with sperm concentration, progressive motility, and total motility (all $P < 0.05$). No significant association was found between cell phone/computer use alone and sperm quality parameters. Moreover, per hour increase of time spent on cell phone talking was associated with decreased sperm concentration and total count by an average of -8.0% (95% CI: -15.2%, -0.2%) and -12.7% (95% CI: -21.3%, -3.1%), respectively. Besides, daily calling time was associated with lower sperm progressive motility and total motility among those who used headsets during a call (P for interaction <0.05). In conclusion, our study suggested that more time spent on electronic devices use had a modest reduction effect on semen quality. Daily calling time was significantly associated with lower sperm concentration and total count, and using headsets during a call appeared to aggravate the negative association between daily calling time and sperm motility. Additional studies are needed to confirm these findings.

https://pubmed.ncbi.nlm.nih.gov/36058315/

Conclusions

In conclusion, more time spent on electronic devices use was associated with decreased semen quality in modest effect size. Daily calling time was significantly associated with lower sperm concentration and total count, and it might interact synergistically with headset use during a call to further decrease sperm progressive motility and total motility. Although our research suggests that electronic devices exert no obvious reproductive hazards to healthy men with good fertility, we still advise men with a pregnancy plan to avoid excessive electronic devices use, especially avoid using headsets during a call. Additional well-designed prospective population studies are required to identify the effects of electronic devices use on semen quality more precisely, and to evaluate the clinical importance of the risk to both sub-fertile men and the general population.

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How Much Exposure from 5G Towers is Radiated over Children, Teenagers, Schools and Hospitals?

L. Chiaraviglio et al., "How Much Exposure from 5G Towers is Radiated over Children, Teenagers, Schools and Hospitals?," in IEEE Open Journal of the Communications Society, 2022, doi: 10.1109/OJCOMS.2022.3208938.

Abstract

The rolling-out of 5G antennas over the territory is a fundamental step to provide 5G connectivity. However, little efforts have been done so far on the exposure assessment from 5G cellular towers over young people and “sensitive” buildings, like schools and medical centers. To face such issues, we provide a sound methodology for the numerical evaluation of 5G (and pre-5G) downlink exposure over children, teenagers, schools and medical centers. We then apply the proposed methodology over two real scenarios. Results reveal that the exposure from 5G cellular towers will increase in the forthcoming years, in parallel with the growth of the 5G adoption levels. However, the exposure levels are well below the maximum ones defined by international regulations. Moreover, the exposure over children and teenagers is similar to the one of the whole population, while the exposure over schools and medical centers can be lower than the one of the whole set of buildings. Finally, the exposure from 5G is strongly lower than the pre-5G one when the building attenuation is introduced and a maturity adoption level for 5G is assumed.

Summary

We have assessed the impact of 5G towers on the EMF exposure over children/teenagers, school buildings and medical buildings. After introducing a novel methodology for the analysis of exposure over population and buildings, we have applied it in two meaningful scenarios that are subject to different urbanization levels as well as tower deployments. Our results reveal that, although 5G exposure radiated by towers is initially lower than the pre-5G one, 5G will become the dominant source of exposure from cellular towers when a maturity level will be reached. However, the scaling factors applied to the maximum power radiated by mid-band/mm-Wave antennas, the tower distribution and the positioning of the buildings are important aspects heavily influencing the exposure levels over young people and “sensitive” places. Eventually, the actual level of exposure over children and teenagers is largely impacted by the building attenuation level, which has a stronger effect over mid-band and mm-Wave 5G frequencies compared to pre-5G ones. Overall, our results indicate that the total exposure levels are always lower than the EMF limits reported in international regulations. Moreover, children and teenagers receive similar amount of exposure compared to the whole population. Eventually, the positioning of the “sensitive” building has an impact on the exposure level, but, however, the observed exposure trends are similar compared to the ones of the whole set of buildings.

As future work, we plan to extend our assessment to entire municipalities/cities, including zones covered by 5G small cells. In addition, as propagation has a strong effect over the exposure received by children and teenagers, massive campaigns of EMF measurements from 5G towers should be performed, especially inside the buildings. Finally, the investigation of joint uplink and downlink 5G exposure is another avenue of research.

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9900418

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Six Months in the Life of a Cellular Tower: Is 5G Exposure Higher than pre-5G One?

L. Chiaraviglio, C. Lodovisi, D. Franci, S. Pavoncello, T. Aureli. Six Months in the Life of a Cellular Tower: Is 5G Exposure Higher than pre-5G One? 2022 IEEE International Symposium on Measurements & Networking (M&N), 2022, pp. 1-6, doi: 10.1109/MN55117.2022.9887670.

Abstract

5G service is already available in many countries, including Italy. Currently, 5G networks are run in parallel to the already deployed pre-5G ones (including 4G). In this work, we face the problem of continuously monitoring the exposure from a vantage point over a very long period of time (i.e., several months). After designing and validating a measurement setup suitable for our aims, we extensively collected 5G and pre-5G exposure data from the considered location. Results show that, although the share of 5G exposure is in general lower than pre-5G one, both intensity and occurrence of 5G exposure peaks are rapidly increasing over the months, suggesting a growth of 5G exposure levels in the near future.

https://ieeexplore-ieee-org.libproxy.berkeley.edu/stamp/stamp.jsp?tp=&arnumber=9887670&isnumber=9887532

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Measurement of personal radio frequency exposure in Japan: The Hokkaido Study on the Environment and Children's health

Yamazaki K, Ikeda-Araki A, Miyashita C, Tamura N, Yoshikawa T, Hikage T, Omiya M, Mizuta M, Ikuyo M, Tobita K, Onishi T, Taki M, Watanabe S, Kishi R. Measurement of personal radio frequency exposure in Japan: The Hokkaido Study on the Environment and Children's health. Environ Res. 2022 Sep 26:114429. doi: 10.1016/j.envres.2022.114429.

Abstract

The opportunities for exposure to radiofrequency electromagnetic fields (RF-EMF) among children are increasing. Children's exposure to RF-EMF in Japan was recorded using a personal exposure meter (ExpoM-RF), and factors associated with the exposure examined. A total of 101 children, aged 10-15 years old, participated in the prospective birth cohort "Hokkaido study". RF-EMF data were recorded in the 700 MHz-5.8 GHz frequency range for 3 days. The recorded data were summarized into six groups of frequency bands: downlink from mobile phone base stations (DL), uplink from mobile phones to a base station (UL), Wireless Local Area Network (LAN), terrestrial digital TV broadcasting (digital TV), 2.5 GHz and 3.5 GHz Time Division Duplex (TDD), 1.9 GHz TDD, and total (the summation of power density in all measured frequency bands). A questionnaire was used to document the internet environment (at home) and mobile phone usage. Personal RF-EMF exposure in Japanese children was lower than that reported in studies in Europe. The DL signals from mobile phone base stations were the most significant contributors to total exposure, while Wireless LAN and digital TV were only higher at home. The urban residence was consistently associated with increases in the four groups of frequency bands (DL, UL, digital

TV, and TDD). TDD level has several associations with mobile phone usage (calls using mobile phones, video viewing, text message service, and online game). The association between inattention/hyperactivity subscale of the Strengths and Difficulties Questionnaire (SDQ) and higher Wireless LAN exposure at nighttime was also noted. Further studies with additional data will shed light on factors involved in RF-EMF exposure among Japanese children.

Excerpts

Regarding microenvironments, RF exposure from outdoor environmental sources was higher when outdoors than indoors, similar to findings of other studies (Birks et al., 2018; Gallastegi et al., 2018; Joseph et al., 2010; Verloock et al., 2014). The exposure levels for DL, digital TV from outdoor environmental sources (e.g. base station) were higher outside, and that in Wireless LAN was higher in the home. Regarding the contribution of each band to the total exposure level, the exposure to the DL contributed the most to the total exposure in all microenvironments....

... Interestingly, Wireless LAN levels at nighttime were significantly higher among those with high hyperactivity/inattention scores of SDQ, one of the common symptoms of ADHD, than those with low scores. Although the association between ADHD symptoms and internet addiction has been reported (Ho et al., 2014; Wang et al., 2017; Yen et al., 2009), there was no relationship between internet addiction and RF-EMF exposure in the present study. Tateno et al. (2016) suggested that ADHD traits, such as impulsivity, could be related to difficulty in controlling internet use and online gaming. Therefore, the exposure to Wireless LAN recorded by the exposure meter might increase for those who could not limit the use of wireless electrical devices (mobile phones, gaming devices, among others) at nighttime because of impulsivity, rather than internet addiction....

Conclusions

We recorded children's personal RF-EMF exposures using the exposure meter and examined related factors for their exposure. The personal RF-EMF exposure in Japanese children was lower than that reported in previous European studies. Downlink from mobile phone base stations was the most significant contributor to the total exposure, while Wireless LAN and digital TV were higher at home than in other microenvironments. There were several significant associations between internet environment and mobile phone usage and exposure level in the daytime analysis. Among them, the urban residence and related characteristics were consistently associated with higher levels of DL, UL, digital TV, and TDD band. At nighttime, the association between the inattention/hyperactivity subscale of SDQ and Wireless LAN exposure was found in addition to associations between the internet environment or mobile phone usage and the RF-EMF exposure. Further studies with additional data and robust study designs are required to explore the most possible factors involved in RF-EMF exposure among Japanese children.

https://pubmed.ncbi.nlm.nih.gov/36174753/

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Association of increased pain intensity, daytime sleepiness, poor sleep quality, & quality of life with mobile phone overuse in patients with migraine

Butt M, Chavarria Y, Ninmol J, Arif A, Tebha SS, Daniyal M, Siddiqui UM, Shams SS, Sarfaraz Q, Haider SF, Essar MY. Association of increased pain intensity, daytime sleepiness, poor sleep quality, and quality of life with mobile phone overuse in patients with migraine: A multicenter, cross-sectional comparative study. Brain Behav. 2022 Sep 20:e2760. doi: 10.1002/brb3.2760.

Abstract

Background: The number of regular smartphone users has increased dramatically worldwide. Headaches, followed by sleep difficulties, forgetfulness, dizziness, and other ailments, are among the most prevalent complaints among smartphone users during or after use. In addition, migraine is a debilitating disease and is the world's second leading cause of disability. Hence, we performed this study to determine how smartphone overuse influenced migraine patients' level of disability, pain intensity, sleep quality, and overall quality of life.

Methods: In this observational study, the patients were divided into two groups high mobile phone use group (HMPUG) and the low mobile phone user group (LMPUG) using the Mobile Phone Problematic Use Scale. We assessed, for each group, patients' level of disability, pain intensity, sleep quality, daytime sleepiness, and quality of life through the Migraine Disability Assessment Scale, Visual Analogue Scale, Pittsburgh Sleep Quality Index, Epworth Sleepiness Scale, and 24-h Migraine Quality of Life Questionnaire, respectively.

Results: Our study showed that the respondents' average age was 27.59 (9.79) years. The average number of family members was 5.98 (2.3251). A total of 65.8% (n = 263) of the 400 participants were female, while 34.3 % (n = 137) were male. Greater pain intensity, poor sleep quality, and reduced medication effectivity were found in HMPUG compared to LMPUG ($p < .05$). However, increased duration of migraine and medication intake was reported in the LMPUG ($p < .05$).

Conclusion: We observed that smartphone overuse could worsen pain, sleep, and reduce treatment efficacy in individuals with migraine. Therefore, controlled smartphone use is recommended to avoid worsening symptoms.

https://onlinelibrary.wiley.com/doi/full/10.1002/brb3.2760

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A qualitative approach to experiential knowledge identified in focus groups aimed at co-designing a provocation test in the study of electrohypersensitivity

Bordarie J, Dieudonné M, Ledent M, Prignot N. A qualitative approach to experiential knowledge identified in focus groups aimed at co-designing a provocation test in the study of electrohypersensitivity. Ann Med. 2022 Dec;54(1):2363-2375. doi: 10.1080/07853890.2022.2114605.

Abstract

Patients' experiential knowledge is increasingly recognised as valuable for biomedical research. Its contribution can reveal unexplored aspects of their illnesses and allows research priorities to be refined according to theirs. It

can also be argued that patients' experiential knowledge can contribute to biomedical research, by extending it to the most organic aspects of diseases. A few examples of collaboration between medicine and patient associations are promising, even if there is no single, simple methodology to apply. This article provides feedback on a project involving the experiential knowledge of electrohypersensitive persons with a view to developing an experimental protocol to study their condition. It presents the participatory approach with focus groups that was implemented and reflects on ways to take advantage of experiential knowledge. It also demonstrates the complexity of the electrohypersensitivity syndrome and reflects on the difficult transition between the experiential knowledge and the experimental design of provocation studies.

KEY MESSAGES Experiential knowledge is a valuable source of information for research and the design of investigation protocols.The participatory approach allows co-designing protocols by drawing on experiential knowledge.The controversial dimension of EHS reveals the complexity of translating experiential knowledge into an experimental protocol.

https://www.tandfonline.com/doi/full/10.1080/07853890.2022.2114605

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Disease Burden, Risk Factors, and Trends of Primary Central Nervous System (CNS) Cancer: a global study of registries data

Huang J, Chan SC, Lok V, Zhang L, Lin X, Lucero-Prisno DE, Xu W, Zheng ZJ, Elcarte E, Withers M, Wong MCS; NCD Global Health Research Group, Association of Pacific Rim Universities (APRU). Disease Burden, Risk Factors, and Trends of Primary Central Nervous System (CNS) Cancer: a global study of registries data. Neuro Oncol. 2022 Sep 1:noac213. doi: 10.1093/neuonc/noac213.

Abstract

Background: This study aimed to evaluate the global incidence, mortality, associated risk factors, and temporal trends of central nervous system (CNS) cancer by sex, age, and country.

Methods: We extracted incidence and mortality of CNS cancer from the GLOBOCAN (2020), Cancer Incidence in Five Continents series I-X, WHO mortality database, the Nordic Cancer Registries, and the Surveillance, Epidemiology, and End Results Program. We searched the Global Health data exchanges for the prevalence of its associated risk factors. We tested the trends by Average Annual Percentage Change (AAPC) from Joinpoint regression analysis with 95% confidence intervals in different age groups.

Results: The age-standardized rates (ASRs) of CNS cancer incidence and mortality were 3.5 and 2.8 per 100,000 globally. Southern Europe (ASR=6.0) and Western Asia (ASR=4.2) had the highest incidence and mortality, respectively. The incidence was associated with Human Development Index, Gross Domestics Products per capita, prevalence of traumatic brain injuries, occupational carcinogens exposure, and mobile phone use at the country level. There was an overall stable and mixed trend in the CNS cancer burden. However, increasing incidence was observed in younger male population from five countries, with Slovakia (AAPC=5.40; 95% CI=1.88, 9.04; p=0.007) reporting the largest increase.

Conclusions: While the overall global trends of cancer have been largely stable, significant increasing trends were found in the younger male population. The presence of some higher-HDI countries with increasing mortality suggested an ample scope for further research and exploration of the reasons behind these epidemiological trends.

https://pubmed.ncbi.nlm.nih.gov/36048182/

Key points

Brain cancer burden was higher in more developed countries and male population.
Brain cancer was related to HDI, GDP, brain injuries, carcinogens, and phone use.
There was an increasing trend of brain cancer in the younger male population.

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Road User Exposure from ITS-5.9 GHz Vehicular Connectivity

Benini M, Parazzini M, Bonato M, Gallucci S, Chiaramello E, Fiocchi S, Tognola G. Road User Exposure from ITS-5.9 GHz Vehicular Connectivity. Sensors (Basel). 2022 Sep 15;22(18):6986. doi: 10.3390/s22186986.

Abstract

This study addressed an important but not yet thoroughly investigated topic regarding human exposure to radio-frequency electromagnetic fields (RF-EMF) generated by vehicular connectivity. In particular, the study assessed, by means of computational dosimetry, the RF-EMF exposure in road users near a car equipped with vehicle-to-vehicle (V2V) communication antennas. The exposure scenario consisted of a 3D numerical model of a car with two V2V antennas, each fed with 1 W, operating at 5.9 GHz and an adult human model to simulate the road user near the car. The RF-EMF dose absorbed by the human model was calculated as the specific absorption rate (SAR), that is, the RF-EMF power absorbed per unit of mass. The highest SAR was observed in the skin of the head (34.7 mW/kg) and in the eyes (15 mW/kg); the SAR at the torso (including the genitals) and limbs was negligible or much lower than in the head and eyes. The SAR over the whole body was 0.19 mW/kg. The SAR was always well below the limits of human exposure in the 100 kHz-6 GHz band established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The proposed approach can be generalized to assess RF-EMF exposure in different conditions by varying the montage/number of V2V antennas and considering human models of different ages.

Open access paper: https://www.mdpi.com/1424-8220/22/18/6986

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Study of microwave non-thermal effects on hydrogen bonding in water by Raman spectroscopy

Han G, Liu F, Zhang T, Xu W, Zhang Y, Wu N, Ouyang S. Study of microwave non-thermal effects on hydrogen bonding in water by Raman spectroscopy. Spectrochim Acta A Mol Biomol Spectrosc. 2022 Sep 22;285:121877. doi: 10.1016/j.saa.2022.121877.

Abstract

Microwave chemistry plays an important role in organic synthesis. It has been debatable whether or not there are microwave non-thermal effects. Through analyzing the Raman spectra of pure water under two different heating methods (oil bath and microwave), the existence of microwave non-thermal effect is verified in this paper. The findings demonstrate that temperature has a significant impact on the Raman shift of the OH stretching band, which shifts to a high wave number as temperature rises and deforms the hydrogen bond (HB) network structure. Because microwave electric fields selectively heat water molecules (polar molecules) and destroy hydrogen bond structures in water, results in microwave heating more severe destruction of fully hydrogen-bonded structure than oil bath and transforms it more quickly into the partially hydrogen-bonded and free H_2O structure. Under the non-thermal effects of microwaves, hydrogen bonds that initially existed as stable tetrahedral structures are transformed into chain-like structures more rapidly. By comparing the Raman shift, it can be found that the microwave non-thermal effect can affect the hydrogen bonding in water for a long time (>1h). This study provides an experimental basis for enriching the mechanism of microwave non-thermal effects on hydrogen bonding.

https://pubmed.ncbi.nlm.nih.gov/36174402/

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Molecular Dynamics Research of Spatial Orientation and Kinetic Energy of Active Site Collision of Carnosine under Weak Microwave Irradiation

Gou D, Huang K, Liu Y, Shi H, Wu Z. Molecular Dynamics Research of Spatial Orientation and Kinetic Energy of Active Site Collision of Carnosine under Weak Microwave Irradiation. J Phys Chem B. 2022 Sep 22. doi: 10.1021/acs.jpcb.2c03930.

Abstract

The molecular mechanism of the microwave nonthermal effect is still not clear. This work investigated the spatial orientation and kinetic energy of active site collision of carnosine, a natural bioactive dipeptide, under the weak microwave irradiation using the molecular dynamics simulation. Our results showed the influences of the temperature, microwave intensity, microwave frequency, and microwave polarization mode (linear polarization and circular polarization) on the spatial orientation and kinetic energy of active site collision of carnosine. First, under the constant intensity and frequency of linear polarization microwave irradiation, the increment of the collision probability between the 6N atom of carnosine and the 28H atom of the other carnosine at effective space angle decreases from 85.0% to 3.5% with increasing temperature. Second, with the increase of microwave intensity, the change of spatial orientation and kinetic energy becomes more and more significant. However, the change of circular polarization microwaves on the spatial orientation and kinetic energy of collision is weaker than that of linear polarization. Third, under the constant intensity of linear polarization microwave irradiation, the collision probability between the 6N atom and the 28H atom at effective space angle decreases from 70.2% to 14.7% with increasing frequency. Finally, under the microwave polarization, the spatial orientation and kinetic energy of molecular collision are changed, which is summarized as the microwave postpolarization effect (MWPPE). The dependence of MWPPE on temperature, microwave

intensity, microwave frequency, and polarization mode is very complicated. In the end, this effect can provide a new insight into the molecular mechanism of the microwave nonthermal effect.

https://pubmed.ncbi.nlm.nih.gov/36134752/

Conclusions

The goal of this investigation is to study the spatial orientation and kinetic energy of active site collision of carnosine under weak microwave irradiation. In this work, the effects of temperature, microwave intensity, microwave frequency, and microwave polarization mode (linear polarization and circular polarization) on carnosine active site collision were inves- tigated using molecular dynamics simulation. For the active site collision of carnosine, we mainly targeted the collision between the 6N atom of carnosine and the 28H atom of the other carnosine and the collision between the 6N atom of carnosine and the 30H atom of the other carnosine. The influence of weak microwave irradiation on active site collision of carnosine is affected by many factors mentioned above.

First, for linear polarization microwave radiation with the constant microwave intensity and frequency, the increment of total collision number decreases with the increase of temperature. Similarly, the increment of collision probability at specific spatial angle also decreases, and the fraction of high-energy collisions also decreases. This confirms that the molecular thermal motion becomes more intense as the temperature rises, which weakens the polarization effect of microwaves. Second, with the increase of microwave intensity, the influence of spatial orientation and kinetic energy becomes more and more significant. However, the effect of circular polarization on the spatial direction and kinetic energy of collision is weaker than that of linear polarization. This shows that, compared with linear polarization microwaves, the direction of the electric field in circular polarization changes faster, and the orientation effect of dipole molecules is obviously weaker than that of linear polarization. Third, under the constant intensity of linear polarization microwave radiation, with the increase of microwave frequency, the influence of spatial direction and kinetic energy becomes weaker and weaker. This proves that the orientation effect of molecules following the direction of electric field decreases with increasing microwave frequency. Finally, we determine the effect of the microwave radiation on the spatial orientation and kinetic energy of collision. The higher intensity is the more obvious the effect will be. However, the higher temperature, the higher frequency, and circular polarization will weaken the effect.

On the basis of the collision theory, we further verify the total effect of weak microwave irradiation on spatial orientation and kinetic energy of active site collision by analyzing the effective molecular collision number and introduce electromagnetic action factor. The conclusion is consistent with that described above. At last, the effect of the weak microwaves on the spatial orientation and kinetic energy of active site collision is called the microwave postpolarization effect (MWPPE). The MWPPE provides a new way to understand the molecular mechanism of the microwave nonthermal effect. In addition, it can also provide useful reference for designing experiments to verify the nonthermal effect of weak microwave irradiation.

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Human Exposure Influence Analysis for Wireless Electric Vehicle Battery Charging

El-Shahat A, Danjuma J, Abdelaziz AY, Abdel Aleem SHE. Human Exposure Influence Analysis for Wireless Electric Vehicle Battery Charging. *Clean Technologies*. 2022; 4(3):785-805. https://doi.org/10.3390/cleantechnol4030048

Abstract

Wireless charging schemes aim to counter some drawbacks of electric vehicles' wired charging, such as the fact that it does not encourage mobility, leads to safety issues regarding high voltage cables, power adapters high cost, and has more battery waste by companies. In this paper, a comparative study of wireless power transfer multiple coil geometries is performed to analyze the efficiency, coupling coefficient, mutual inductance, and magnetic flux density production for each geometry. Results show that coil geometry, current excitation, and shielding techniques within the Wireless Electric Vehicle Charging (WEVC) system substantially influence magnetic flux leakage. In addition, the paper proposes an analytical framework for a WEVC scheme via electromagnetic resonance coupling. Safety considerations of the WEVC system, including the effects on humans, are investigated in several scenarios based on the relative location of the human while EV charging is conducted as the leading paper's goal. The exposure measurements are performed across various radial distances from the coils using 3-D FEA ANSYS Maxwell Software (American technology company, Pennsylvania, United States). The analysis shows that WEVC systems can achieve high power transfer, resulting in increased magnetic flux leakage around the coils. The safe distance for humans and animals during the charging sequence is attained from research results. For instance, in the 120 mm spiral coil, 120 mm square coil, and 600 mm spiral coil operating at 1 A, excitation, the SAR levels are under the threshold of 700 mm away from the coils. For the 600 mm spiral coil excited at 8 A, the SAR levels fall under the threshold at 900 mm away from the coils. When shielding is utilized, the safe distance is improved by up to 350 mm. Considering the regulations of the Non-Ionizing Radiation Protection (ICNIRP) standards, 600 mm is a safe distance away from the coils, and, vertically, anywhere past 300 mm is safe for humans.

Open access paper: https://www.mdpi.com/2571-8797/4/3/48

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Physical Differences between Man-Made & Cosmic Microwave Electromagnetic Radiation & Exposure Limits, & Radiofrequencies as Generators of Biotoxic Free Radicals

Georgiou CD, Kalaitzopoulou E, Skipitari M, Papadea P, Varemmenou A, Gavriil V, Sarantopoulou E, Kollia Z, Cefalas A-C. Physical Differences between Man-Made and Cosmic Microwave Electromagnetic Radiation and Their Exposure Limits, and Radiofrequencies as Generators of Biotoxic Free Radicals. *Radiation*. 2022; 2(4):285-302. doi: 10.3390/radiation2040022.

Simple Summary

There is an inconsistency between the position that radio frequencies are sources of minor thermal effects in cells, tissues and living organisms and the experimental evidence indicating that non-ionising radiation is harmful, even at shallow power density radiation levels. A quantum mechanical survey of the interaction between microwaves and matter points to free radical-associated cytotoxic alterations of biomatter upon microwave irradiation.

Abstract

The critical arguments for radiofrequency radiation exposure limits are currently based on the principle that radio frequencies (RF) and electromagnetic fields (EMFs) are non-ionising, and their exposure limits are even 100-fold lower than those emitted from the Sun in the whole RF-EMF spectrum. Nonetheless, this argument has been challenged by numerous experimental and theoretical studies on the diverse biological effects of RF-EMF at much lower power density (W/m^2) levels than today's exposing limits. On the other hand, less attention has been given to counterarguments based on the differences in the physics concepts underlying man-made versus natural electromagnetic radiation (EMR) and on the fact that man's biology has been adapted to the natural EMR levels reaching Earth's surface at single EMF wavelengths, which are the natural limits of man's exposure to EMFs. The article highlights the main points of interaction of natural and man-made radiation with biomatter and reveals the physical theoretical background that explains the effects of man-made microwave radiation on biological matter. Moreover, the article extends its analysis on experimental quantum effects, establishing the "ionising-like" effects of man-made microwave radiation on biological matter.

Excerpt

The current man-made power density exposure limits are compared to nature's limits, and some observed biological effects are shown in Figure 3. The biological effects are based on studies presented in the BioInitiative 2012 Report [34,80–139], which have been updated in the present study. Nonetheless, the number of such studies has grown since then, listing as indicative ones that focus on oxidative stress [2,44,53,54,106,128,140,141], DNA damage [54,142] and carcinogenesis [143–147].

Indeed, the lowest power density of 1 × 10−9 W/m2 (1 × 10−6 mW/m2) with observed biological effects (oxidative damage, reactive oxygen species generation, DNA damage/repair failure) is ~10 13-fold higher than a natural exposure limit of ~1 × 10−22 W/m2 (10−19 mW/m2) of exposure to the cosmic frequencies and 10 10-fold lower than the today's power density exposure limit of 10 W/m2 (1 × 10 4 mW/m2). Even the 3 to 6 × 10−6 W/m2 (3 to 6 × 10−3 mW/m2) limit proposed by the BioInitiative 2012 Report [148] is 10 14− to 10 18−fold higher than the natural exposure limit.

Open access paper: https://www.mdpi.com/2673-592X/2/4/22

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Investigation of oxidative damage, antioxidant balance, DNA repair genes, and apoptosis due to radiofrequency-induced adaptive response in mice

Kucukbagriacik Y, Dastouri M, Ozgur-Buyukatalay E, Akarca Dizakar O, Yegin K. Investigation of oxidative damage, antioxidant balance, DNA repair genes, and apoptosis due to radiofrequency-induced adaptive response in mice. Electromagn Biol Med. 2022 Sep 5:1-13. doi: 10.1080/15368378.2022.2117187.

Abstract

This study aims to determine whether exposure to non-ionizing radiofrequency fields could induce an adaptive response (AR) in adult mice and to reveal potential molecular mechanisms triggered by RF-induced AR. The study was performed on 24 adult male Swiss-Albino mice. The average mass of the mice was 37 g. Four groups of adult mice, each consisting of 6, were formed. The radiofrequency group (R) and the adaptive response group

(RB) were exposed to 900 MHz of global system for mobile communications (GSM) signal at 0.339 W/kg (1 g average specific absorption rate) 4 h/day for 7 days, while the control group (C) and the bleomycin group (B) were not exposed. 20 minutes after the last radiofrequency field (RF) exposure, the mice in the B and RB groups were injected intraperitoneal (ip) bleomycin (BLM), 37.5 mg/kg. All the animals were sacrificed 30 minutes after the BLM injection. Oxidative damage and antioxidant mechanism were subsequently investigated in the blood samples. Changes in the expression of the genes involved in DNA repair were detected in the liver tissue. TUNEL method was used to determine the apoptosis developed by DNA fragmentation in the liver tissue. The RB group, which produced an adaptive response, was compared with the control group. According to the results, the increase of reactive oxygen species (ROS) in the RB group may have played an important role in triggering the adaptive response and producing the required minimum stress level. Furthermore, tumor suppressor 53(p53), oxo guanine DNA glycosylase (OGG-1) levels responsible for DNA repair mechanism genes expression were increased in conjunction with the increase in ROS. The change in the poly (ADP-ribose) polymerase 1 (PARP-1) and glutathione peroxidase 1 (GPx-1) gene expression were not statistically significant. The antioxidant enzyme levels of superoxide dismutase (SOD), catalase (CAT), and total antioxidant capacity (TAC) were decreased in the group with adaptive response. According to the data obtained from terminal deoxynucleotidyl transferase dUTP nick end labeling (TUNEL) analysis, apoptosis was decreased in the RB group due to the decrease in cell death, which might have resulted from an increase in gene expression responsible for DNA repair mechanisms. The results of our study show that exposure to RF radiation may create a protective reaction against the bleomycin. The minimal oxidative stress due to the RF exposure leads to an adaptive response in the genes that play a role in the DNA repair mechanism and enzymes, enabling the survival of the cell.

https://www.tandfonline.com/doi/full/10.1080/15368378.2022.2117187

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2.45 GHz microwave radiation induced oxidative stress: Role of inflammatory cytokines in regulating male fertility through estrogen receptor alpha in Gallus gallus domesticus

Gupta V, Srivastava R. 2.45 GHz microwave radiation induced oxidative stress: Role of inflammatory cytokines in regulating male fertility through estrogen receptor alpha in Gallus gallus domesticus. Biochem Biophys Res Commun. 2022 Sep 8;629:61-70. doi: 10.1016/j.bbrc.2022.09.009.

Abstract

Due to the growing number of gadgets emitting electromagnetic radiation (EMR), particularly microwave (MW) radiation, in our daily lives, it is believed that EMR have both long-term and short-term biological impacts that are quite concerning for avian as well as human health. Due to the negative impact of MW emitting equipment on the biological system this study looks into the mechanistic approach by which low-level of 2.45 GHz MW radiation causes an oxidative stress and inflammatory response in the testes micro-environment which further gets regulated by estrogen receptor alpha (ERα) expression in immature Gallus gallus domesticus leading to male infertility. Two weeks old immature male chickens were exposed to non-thermal low-level 2.45-GHz MW radiation for 2 h/day for 30 days (power density = 0.1264 mw/cm^2 and SAR = 0.9978 W/kg). In the exposed group, morphometric examination of the testes revealed decreased testicular weight, volume and gonado-somatic index. Further, histological staining demonstrated a substantial reduction in the diameter of

seminiferous tubules in the exposed group as compared to the control. The degree of oxidative stress was also determined showing an increase in oxidative stress parameters after exposure. The radiation exposed testes showed a significant increase in IL-1β immunoreactivity and decline in IL-10 immunoreactivity, indicating a sense of MW radiation-induced oxidative stress-regulated inflammatory response. A substantial reduction in ERα expression was also observed in exposed testes by Western blotting. Our investigations conclude that testes being vulnerable to free radical damage become an easy target organ for MW exposure induced oxidative and inflammatory stress. Therefore it becomes evident that it may cause male infertility in chicks via downregulation of ER-α in testis.

https://pubmed.ncbi.nlm.nih.gov/36113179/

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The Effect of Electromagnetic Radiation Transmitted from Routers on Antibiotic Susceptibility of Bacterial Pathogens

Pegios A, Kavvadas D, Zarras K, Mpani K, Soukiouroglou P, Charalampidou S, Vagdatli E, Papamitsou T. The Effect of Electromagnetic Radiation Transmitted from Routers on Antibiotic Susceptibility of Bacterial Pathogens. J Biomed Phys Eng. 2022 Aug 1;12(4):327-338. doi: 10.31661/jbpe.v0i0.2111-1433.

Abstract

Background: Electromagnetic non-ionizing radiation has both thermal and non-thermal outcomes on biological systems, such as humans, animals, and bacteria.

Objective: This study aimed to investigate the effect of non-ionizing radiofrequency radiation, emitted by Wi-Fi routers, on bacterial strains and the modification of their susceptibility to modern antibiotics.

Material and methods: In this case-control paired study, four bacteria were selected, and one colony from each bacterial strain was exposed to Wi-Fi radiation forming the exposure group. Another set of colonies was not exposed to Wi-Fi radiation, forming the control group. Eight different antibiotic disks were set on the bacterial plates, and the inhibition zone was measured every 3 h for each colony.

Results: Electromagnetic radiation affects bacterial colonies and their susceptibility to antibiotics. Analysis revealed statistically significant differences, correlated with the bacterial strain, the antibiotic agent, and the time of the exposure, in the inhibition zones, mostly after 6 and 24 h (p-value < 0.05).

Conclusion: A correlation was observed between antibiotic susceptibility and non-ionizing radiofrequency exposure. Studying the effects of radiofrequency radiation on prokaryotic organisms could clarify more complicated cell structures and organisms, such as eukaryotic. Further experiments, in vitro and in vivo, could provide more information about these outcomes and cause experts to discuss the current guidelines of exposure limits.

Open access paper: https://jbpe.sums.ac.ir/article_48472.html

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Effects of Radiofrequency EMF from Mobile Phones and Wi-Fi Router on the Growth Rate and Susceptibility of *Enterococcus faecalis to Antibiotics*

Mortazavi SMJ, Taheri M, Paknahad M, Khandadash S. Effects of Radiofrequency Electromagnetic Fields Emitted from Mobile Phones and Wi-Fi Router on the Growth Rate and Susceptibility of *Enterococcus faecalis to Antibiotics*. J Biomed Phys Eng. 2022 Aug 1;12(4):387-394. doi: 10.31661/jbpe.v0i0.1268.

Abstract

Background: During the last decade, people have been dramatically exposed to radiation emitted from widely-used radiofrequency electromagnetic fields (RF-EMF) generating devices.

Objective: This study aimed to evaluate the effects of exposure to RF-EMF emitted from smart phones and Wi-Fi routers on the growth rate and antibiotic sensitivity of Enterococcus faecalis (E. faecalis) as a pathogen in the root canals of teeth.

Material and methods: In this experimental study, E. faecalis ATCC 19115 was used, characterized and confirmed by morphological and biochemical tests. Antibiotic susceptibility test was measured for several common antibiotics. To perform antibiotic susceptibility tests, disk diffusion (Kirby-Bauer) method on Mueller-Hinton agar plates was used before and after exposure to RF-EMFs emitted from a commercial Wi-Fi router or a mobile phone simulator. Moreover, we measured the optical density at 625 nm after different exposure times using a calibrated UV-visible spectrophotometer to evaluate the effect of RF-EMF exposure on the bacterial growth rate.

Results: Exposure to RF-EMF significantly altered the antimicrobial sensitivity of the E. faecalis. While the susceptibility of the bacteria decreased significantly after 6 h of exposure, longer exposure time (e.g. exposure for 24 h) increased the susceptibility of the bacteria to all antibiotics. Furthermore, it was found that the bacteria tended to regress to their early state. Moreover, the non-exposed E. faecalis showed a slower growth rate than the bacteria exposed to RF-EMFs.

Conclusion: Exposure to RF-EMF emitted by Wi-Fi routers or mobile phone simulator can significantly change the antibiotic susceptibility and growth rate of E. faecalis.

Open access paper: https://jbpe.sums.ac.ir/article_47590.html

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ELF-MF Exposure, Actual and Perceived, and Associated Health Symptoms: A Case Study of an Office Building in Tel Aviv-Yafo, Israel

Raz-Steinkrycer LS, Dubnov J, Gelberg S, Jia P, Portnov BA. ELF-MF Exposure, Actual and Perceived, and Associated Health Symptoms: A Case Study of an Office Building in Tel Aviv-Yafo, Israel. *Sustainability*. 2022; 14(17):11065. https://doi.org/10.3390/su141711065.

Abstract

Empirical studies link exposure to extremely low frequency magnetic fields (ELF-MFs) to several health symptoms. However, it is unclear whether these symptoms are associated with actual or perceived exposure. In this study we attempted to answer this question by studying the health complaints of employees working in a multi-story office building located near a major high-voltage power line. ELF-MF measurements were conducted in the building using a triaxial sensor coil device on all 15 floors. In parallel, questionnaires were administered to evaluate the prevalence of various health symptoms among the employees. Multivariate logistic regressions were used next to quantify the associations between actual and perceived ELF-MF exposure and the employees' health complaints. The analysis revealed that feelings of weakness, headache, frustration, and worry were associated with both measured and perceived ELF-MF exposure ($p < 0.01$), while perceived ELF-MF exposure was also found to be associated with eye pain and irritation (OR = 1.4, 95% CI = 1.2–1.6), sleepiness (OR = 1.3, 95% CI = 1.1–1.5), dizziness and ear pain (OR = 1.2, 95% CI = 1.0–1.4). We conclude that high-voltage power lines produce both physiological and psychological effects in nearby workers, and, hence, proximity to such power lines should become a public health issue.

Conclusions

The main findings of this study can be summarized as follows:

- The analysis revealed no significant association between instrumentally measured and perceived ELF-MF exposure, which implies that individuals cannot detect actual ELF-MF exposure accurately;
- The analysis revealed that feelings of weakness, headache, frustration and worries were associated with both measured and perceived ELF-MF exposure, while perceived ELF-MF exposure was also found to be associated with eye pain and irritation, sleepiness, as well as dizziness and ear pain.
- As we conclude, working near a high voltage power line appears to produce not only psychological but also physiological effects, and should thus become a public health concern.

As several reported symptoms (including headache, frustration/worry, and exhaustion/weakness) were found to be significantly related to measured exposure, not just perceived exposure, the results should lead to revisiting ELF-MF exposure standards. Moreover, follow-up studies should attempt to estimate other effects of ELF-MF exposure, such as its effects on employee productivity, the number of visits to physicians, absenteeism, and medication intake.

Open access paper: https://www.mdpi.com/2071-1050/14/17/11065

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Extremely Low-Frequency Electromagnetic Field Impairs the Development of Honeybee

Li Y, Sun C, Zhou H, Huang H, Chen Y, Duan X, Huang S, Li J. Extremely Low-Frequency Electromagnetic Field Impairs the Development of Honeybee (*Apis cerana*). Animals (Basel). 2022 Sep 14;12(18):2420. doi: 10.3390/ani12182420.

Abstract

Increasing ELF-EMF pollution in the surrounding environment could impair the cognition and learning ability of honeybees, posing a threat to the honeybee population and its pollination ability. In a social honeybee colony, the numbers of adult bees rely on the successful large-scale rearing of larvae and continuous eclosion of new adult bees. However, no studies exist on the influence of ELF-EMFs on honeybee larvae. Therefore, we investigated the survival rate, body weight, and developmental duration of first instar larvae continuously subjected to ELF-EMF exposure. Moreover, the transcriptome of fifth instar larvae were sequenced for analyzing the difference in expressed genes. The results showed that ELF-EMF exposure decreases the survival rate and body weight of both white-eye pupae and newly emerged adults, extends the duration of development time and seriously interferes with the process of metamorphosis and pupation. The transcriptome sequencing showed that ELF-EMF exposure decreases the nutrient and energy metabolism and impedes the degradation of larvae tissues and rebuilding of pupae tissues in the metamorphosis process. The results provide an experimental basis and a new perspective for the protection of honeybee populations from ELF-EMF pollution.

Open access paper: https://www.mdpi.com/2076-2615/12/18/2420

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Suppression of Glucocorticoid Response in Stressed Mice Using 50 Hz Electric Field According to Immobilization Degree and Posture

Harakawa S, Hori T, Hiramoto T, Nedachi T, Shinba T, Suzuki H. Suppression of Glucocorticoid Response in Stressed Mice Using 50 Hz Electric Field According to Immobilization Degree and Posture. Biology (Basel). 2022 Sep 9;11(9):1336. doi: 10.3390/biology11091336.

Abstract

Various studies on immobilized BALB/c mice to evaluate changes in hormone levels associated with stress responses have advanced the characterization of multiple aspects of the biological actions of extremely low-frequency (ELF) electric fields (EFs). In this study, we aimed to investigate the effect of mouse posture on its stress responses and evaluate the importance of adjusting the stress degree in the model. Mice were immobilized inside centrifuge tubes and exposed to an ELF EF generated between parallel plate electrodes. Blood was collected under anesthesia immediately after EF exposure, and plasma glucocorticoids were assayed. The inhibitory effects of EFs on glucocorticoid elevation by immobilization were reproduced regardless of whether mice were in the abdominal or lateral recumbent position, for the EF vector delivered to mice through the sagittal or frontal plane. The effect of ELF EF was reproduced in moderately and mildly stressed mice but not in severely immobilized mice. Hence, adjusting the stress degree is critical to the reproducibility of the results for this model. We characterized the effects of ELF EF on homeostasis, including the stress response, and provided valuable information for the scientific evaluation of the biological risks and medical applications of ELF EF.

Open access paper: https://www.mdpi.com/2079-7737/11/9/1336

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Magnetic field interactions of smartwatches and portable electronic devices with CIEDs - Did we open a Pandora's box?

Badertscher P, Vergne C, Féry C, Mannhart D, Quirin T, Osswald S, Kühne M, Sticherling C, Knecht S, Pascal J. Magnetic field interactions of smartwatches and portable electronic devices with CIEDs - Did we open a Pandora's box? Int J Cardiol Heart Vasc. 2022 Sep 8;43:101122. doi: 10.1016/j.ijcha.2022.101122.

Abstract

Introduction: Magnetic interaction of portable electronic devices (PEDs), such as state-of-the art mobile phones, with cardiovascular implantable electronic devices (CIEDs) has been reported. The aim of the study was to quantify the magnetic fields of latest generation smartwatches and other PEDs and to evaluate and predict their risk of CIED interactions.

Methods: High resolution magnetic field characterization of five smartwatches (Apple Watch 6/7, Fitbit Sense, Samsung Galaxy 3, Withings Scanwatch) was performed using a novel magnetic field camera. *Ex vivo* measurements of the minimal safety distance (MSD) at which no mode switch can be observed were performed between 11 PEDs and six representative CIEDs.

Results: Maximal 1 mT distances ranged between 10 mm (Withings) and 19 mm (Fitbit and AppleWatch), and 1 mT volumes between 6 cm^3 (Withings) and 19 cm^3 (Fitbit). All these measures were observed only for the back side of the smartwatches. While most smartwatches with measured 1 mT distance < 15 mm posed low *ex vivo* interaction within a distance of < 10 mm, PEDs such as electronic pens and in-ear-headphones with measured 1 mT distance > 15 mm showed device interaction up to > 15 mm. Linear regression analysis showed a linear relationship of the MSD with 1 mT distance (B coefficient: 0.46; 95 %-CI: 0.25-0.67, $p < 0.001$).

Conclusion: Smartwatches are safer compared to other PEDs such as electronic pens or in-ear headphones with regards to CIED interaction. With a standardized magnetic field camera, the risk assessment of CIED interaction of novel PEDs is feasible.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9467892/

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Radical triads, not pairs, may explain effects of hypomagnetic fields on neurogenesis

Ramsay J, Kattnig DR. Radical triads, not pairs, may explain effects of hypomagnetic fields on neurogenesis. PLoS Comput Biol. 2022 Sep 15;18(9):e1010519. doi: 10.1371/journal.pcbi.1010519.

Abstract

Adult hippocampal neurogenesis and hippocampus-dependent cognition in mice have been found to be adversely affected by hypomagnetic field exposure. The effect concurred with a reduction of reactive oxygen species in the absence of the geomagnetic field. A recent theoretical study suggests a mechanistic interpretation of this phenomenon in the framework of the Radical Pair Mechanism. According to this model, a flavin-superoxide radical pair, born in the singlet spin configuration, undergoes magnetic field-dependent spin dynamics such that the pair's recombination is enhanced as the applied magnetic field is reduced. This model

has two ostensible weaknesses: a) the assumption of a singlet initial state is irreconcilable with known reaction pathways generating such radical pairs, and b) the model neglects the swift spin relaxation of free superoxide, which abolishes any magnetic sensitivity in geomagnetic/hypomagnetic fields. We here suggest that a model based on a radical triad and the assumption of a secondary radical scavenging reaction can, in principle, explain the phenomenon without unnatural assumptions, thus providing a coherent explanation of hypomagnetic field effects in biology.

Author Summary

The hippocampal region of the brain plays a major role in learning and memory functionality. In male mice, shielding of the Earth's magnetic field was found to decrease hippocampal neurogenesis, i.e. the formation of new neurons, following from a decrease in levels of reactive oxygen species. In this study, we suggest an explanation in terms of spin dynamics of a three radical system composed of flavin-semiquinone, superoxide and ascorbyl radical. This model agrees with the experimental data whilst retaining realistic parameters for a biological system, unlike the Radical Pair Mechanism.

Open access paper: https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1010519

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Hsp72-Based Effect and Mechanism of Microwave Radiation-Induced Cardiac Injury in Rats

Li D, Xu X, Gao Y, Wang J, Yin Y, Yao B, Zhao L, Wang H, Wang H, Dong J, Zhang J, Peng R. Hsp72-Based Effect and Mechanism of Microwave Radiation-Induced Cardiac Injury in Rats. Oxid Med Cell Longev. 2022 Aug 18;2022:7145415. doi: 10.1155/2022/7145415.

Abstract

The purpose of this study was to determine the role of heat shock protein 72 (Hsp72) changes in cardiac injury caused by microwave radiation, aimed at providing novel insights into the mechanism of this damage. A digital thermometer was used to measure the rectal temperature of the rats' pre- and post-radiation. On the 1^{st}, 7^{th}, 14^{th}, and 28^{th} days post-radiation, the changes in electrocardiogram (ECG) were analyzed by a multi-channel physiological recorder. The myocardial enzyme activities and ion concentrations were detected by an automatic biochemical analyzer. Additionally, the levels of myocardial injury markers were established by the enzyme-linked immunosorbent assay (ELISA), and those of hormones were measured by radioimmunoassay. The structure and ultrastructure of the myocardial tissue were observed using an optical microscope and transmission electron microscopy (TEM). The expression of Hsp72 was measured by Western blot and immunofluorescence analyses. Post-exposure, the rectal temperature in the R-group increased significantly, ECG was disordered, and the concentrations of ions were decreased. Furthermore, the activities of myocardial enzymes were changed, and the contents of myocardial injury markers and hormones were increased. We observed damage to the structure and ultrastructure and significantly increased expression of Hsp72. As a whole, the results indicated that S-wave microwave radiation at 30 mW/cm^2 for 35 min resulted in damage to the cardiac functionality organigram, caused by a combination of the thermal and nonthermal effects.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9410832

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Genomic DNA damage induced by co-exposure to DNA damaging agents and pulsed magnetic field

López-Díaz B, Mercado-Sáenz S, Burgos-Molina AM, González-Vidal A, Sendra-Portero F, Ruiz-Gómez MJ. Genomic DNA damage induced by co-exposure to DNA damaging agents and pulsed magnetic field. Int J Radiat Biol. 2022 Sep 7:1-31. doi: 10.1080/09553002.2022.2121873.

Abstract

Purpose: Many articles describe the effects of extremely low-frequency magnetic fields (MF) on DNA damage induction. However, the mechanism of MF interaction with living matter is not yet known with certainty. Some works suggest that MF could induce an increase in the efficacy of Reactive Oxygen Species (ROS) production. This work investigates whether pulsed MF exposure produces alterations in genomic DNA damage induced by co-exposure to DNA damaging agents (bleomycin and methyl methanesulfonate (MMS)).

Materials and methods: Genomic DNA, prepared from S. cerevisiae cultures, was exposed to pulsed MF (1.5 mT peak, 25 Hz) and MMS (0-1%) (15-60 minutes), and to MF and bleomycin (0-0.6 IU/ml) (24-72 hours). The damage induced to DNA was evaluated by electrophoresis and image analysis.

Results: Pulsed MF induced an increment in the level of DNA damage produced by MMS and bleomycin in all groups at the exposure conditions assayed.

Conclusions: Pulsed MF could modulate the cytotoxic action of MMS and bleomycin. The observed effect could be the result of a multifactorial process influenced by the type of agent that damages DNA, the dose, and the duration of the exposure to the pulsed MF.

https://pubmed.ncbi.nlm.nih.gov/36069754/

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Investigation of Fetuin-A pathway in diabetes mellitus formation in rats exposed to ELF magnetic fields

Sert C, Delin M, Eren MA, Çakmak Y. Investigation of Fetuin-A pathway in diabetes mellitus formation in rats exposed to elf magnetic fields. Electromagn Biol Med. 2022 Sep 8:1-7. doi: 10.1080/15368378.2022.2117189.

Abstract

The presence of technological devices in our lives has increased exposure to environmental electromagnetic fields. As a result of this, especially Cancer and Diabetes are increasing.Rats were divided into 3 groups with 12 rats in each group. The 1st experimental group (n = 12) was exposed to a 50 Hz ELF magnetic field of 0.4 mT for 6 hours a day for 5 days, the 2nd experimental group (n = 12) was exposed for 10 days, and the control group (n = 12) was never exposed to a magnetic field. After completing the applications, blood collection from the rats was performed under appropriate conditions, measurements were made in the laboratory, and statistical analysis was performed between the groups. There was no significant difference between the groups in the results of transaminases and lipid profiles and C-Peptide. There was no significant difference in insulin, urea, creatinine, Na, K, Ca, and uric acid parameters between the groups. However, there was a significant increase in

glucose, HbA1c, and Hba1 IFCC values between the control group and the experimental groups ($p < .001$). There was a significant increase in the level of Fetuin-A between the control group and the experimental groups ($p < .05$). There was an increase in the Fetuin-A, Glucose, HbA1c, and Hba1c IFCC values in both of the experimental groups compared to the control group. We believe that an increase in these values may cause Type 3 diabetes.

https://pubmed.ncbi.nlm.nih.gov/36073511/

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Biological experimental study on cumulative effect of vehicle electromagnetic radiation

J. Li, W. Changyuan and Z. Yujie. Biological experimental study on cumulative effect of vehicle electromagnetic radiation. *2022 Asia-Pacific International Symposium on Electromagnetic Compatibility (APEMC)*, 2022, pp. 261-263, doi: 10.1109/APEMC53576.2022.9888471.

Abstract

Compared with power frequency magnetic field or mobile phone, electric vehicles are equipped with more and more high-voltage components, more and more electronic components, and their frequency, waveform and modulation mode are more flexible, which may make the electromagnetic exposure scene of passengers in the vehicle more complex. With the acceleration of the comprehensive electrification trend of public transport, people are exposed to electric vehicles more and more frequently, and the time is also gradually increasing. Whether the cumulative effect of vehicle electromagnetic radiation has an impact on occupant health is a matter of general concern to consumers. At present, there is still a lack of relevant research and standards on the cumulative effect of vehicle electromagnetic radiation at home and abroad. In this paper, a pure electric vehicle is taken as the test object, and the test mice are taken as an example to verify whether the cumulative effect of vehicle electromagnetic radiation has an impact on the body weight and blood immune cells of mice. The results showed that there were significant gender differences in body weight. However, the test time needs to be further increased to judge whether the cumulative effect causes the impact.

Conclusion

The results showed that the test had a significant effect on the body weight of female mice. Weight is not only a comprehensive index to measure growth and development, but also an overall response to the operation of various physiological functions of the body. In the past, it has been reported that radiation can cause loss of appetite, affect human endocrine system and slow growth and development. Although the mechanism of this effect is not particularly clear and lack of relevant evidence, it is a problem worthy of attention. However, with the increase of exposure time, the change trend needs to be further verified.

In addition, the environmental noise, temperature and humidity of the exposure group and the control group are slightly different in the design of this test, which may have a certain impact on the test results more or less. Therefore, in order to eliminate the interference of environmental factors, laboratory animal experiments will be carried out later to further verify whether the cumulative effect of vehicle electromagnetic radiation will affect the normal immune function of animals.

https://ieeexplore-ieee-org.libproxy.berkeley.edu/stamp/stamp.jsp?tp=&arnumber=9888471&isnumber=9888262

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Unveiling the space weather during the Starlink satellites destruction event on 4 February 2022

Dang, T., Li, X., Luo, B., Li, R., Zhang, B., Pham, K., et al. (2022). Unveiling the space weather during the Starlink satellites destruction event on 4 February 2022. *Space Weather*, 20, e2022SW003152. doi: 10.1029/2022SW003152

Abstract

On 4 February 2022, 38 Starlink satellites were destroyed by the geomagnetic storm, which brought significant financial, aerospace and public influences. In this letter, we reveal the space weather process during 3–4 February 2022 geomagnetic disturbances, from the Sun all the way to the satellite orbiting atmosphere. Initiated by an M1.0 class flare and the following coronal mass ejection (CME), a moderate geomagnetic storm was stimulated on 3rd February by the CME arrival at Earth. Subsequently, another moderate storm was triggered on 4th February by the passage of another CME. Model simulations driven by solar wind show that the first geomagnetic storm induced around 20% atmospheric density perturbations at 210 km altitude on 3rd February. The unexpected subsequent storm on 4th February led to a density enhancement of around 20%–30% at around 210 km. The resulting atmospheric drag can be even larger, since the regional density enhancement was over 60% and the satellite orbits were continuously decaying. This event brings forth the urgent requirements of better understanding and accurate prediction of the space weather as well as collaborations between industry and space weather community.

Open access paper:
https://agupubs.onlinelibrary.wiley.com/share/HIHAVJHGFSXJ7C7MEIVM?target=10.1029/2022SW003152

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Protocol for a systematic review of the in vivo studies on radiofrequency (100 kHz–300 GHz) electromagnetic field exposure and cancer

Pinto R, Ardoino L Giardullo P, Villani P, Marino C. Protocol for a systematic review of the in vivo studies on radiofrequency (100 kHz–300 GHz) electromagnetic field exposure and cancer. Syst Rev 11, 29 (2022). https://doi.org/10.1186/s13643-022-01898-4

Abstract

Background An Italian project aims to review the scientific literature on the possible carcinogenicity of radiofrequency (100 kHz–300 GHz) electromagnetic field (RF-EMF) exposure. The ENEA team has to carry out a systematic review of the in vivo studies on this topic.

Objectives Development of a protocol for a systematic review (meta-analysis included) to investigate the potential carcinogenic risk following RF-EMF in vivo exposure to doses above or within legal limits. The aims of this review are (1) to provide a descriptive and, if possible, a quantitative summary of the results of the

examined RF-EMF in vivo studies, together with an assessment of the consistency of observations and of the causes of heterogeneity, and (2) to assess the weight of evidence to support or refute the hypothesis of carcinogenic effects caused by RF-EMF exposure and to draw conclusions about the potential for carcinogenicity of RF-EMF exposure.

Methods We will search for relevant studies in electronic academic databases and in the reference list of selected papers and reviews on the topic, including the descriptive reviews on RF-EMF carcinogenic effect carried out by international panels of experts since 2011. The following elements of the PECO question were defined*:* experimental studies on rodents of both sexes, all ages and species, all genetic backgrounds (Population) exposed to RF-EMF alone, or in combination with other physical or chemical agents (Exposure); only studies reporting outcome data in exposed and sham control groups (Comparison); and all types of cancer with all tumor-related outcome measures (Outcome) will be included.

Only peer-reviewed articles written in English will be considered without limit in the publication date.

Eligibility criteria were defined for papers to be included. A risk of bias assessment will be performed using a tool specifically developed for animal studies. A meta-analysis will be performed, if feasible, for all outcome measures; for subgroup analysis, a minimum of 3 studies per subgroup will be required. If meta-analysis will not be possible, a narrative synthesis of the results will be reported.

Systematic review registration: PROSPERO CRD42020191105

Open access paper: https://systematicreviewsjournal.biomedcentral.com/articles/10.1186/s13643-022-01898-4

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Base transceiver station antenna exposure and workers' health

Hosseinali Rangkooy, Afshin Rahmati, Behzad Fouladi Dehaghi. Base transceiver station antenna exposure and workers' health. International Journal of Occupational Safety and Ergonomics. 04 Aug 2022. doi: 10.1080/10803548.2022.2085892.

Abstract

Objectives. With the rapid development of technologies related to the communications industry, human exposure to electromagnetic fields has increased during recent decades. The study aimed at investigating the effect of exposure to waves emitted from the base transceiver stations (BTS) on workers' health.

Methods. 240 workers participated in the study. In order to determine the general health conditions in two groups, along with electromagnetic waves exposure measurement, the general health questionnaire (GHQ) was completed and the data on blood parameters were assessed.

Results. The mean age and job experience in the case and control groups were 34.1 ± 4.8 and 10.1 ± 6 years and 31.6 ± 5.5 and 8.8 ± 7 years, respectively. According to the GHQ results, only anxiety and insomnia subscales

showed a significant difference between the two groups. The white blood cell and red blood cell counts in the case and control groups were 6715.6 ± 1591 and 7594 ± 2416, 5.3 × 106 ± 4.6 × 105 and 5.05 × 106 ± 5.39 × 105 per ml, respectively. Analysis of the results showed that the difference between the two groups was significant.

Conclusion. The results revealed that blood parameters in the BTS operators showed more changes. Thus, it can be concluded that these health impacts result from occupational exposure to BTS waves.

https://doi.org/10.1080/10803548.2022.2085892

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Simulating the Dispersion of the Energy Flux Density of the Electromagnetic Field Generated by Antennas for Mobile Communications

Buckus R, Chlebnikovas A, Strukcinskiene B, Stukas R, Austys D, Caban J, Bogucki M, Sidlauskiene A, Seleviciene V, Kilikevičius A, Matijošius J, Kilikevičienė K, Vainorius D. Simulating the Dispersion of the Energy Flux Density of the Electromagnetic Field Generated by Antennas for Mobile Communications. *Electronics*. 2022; 11(15):2431. https://doi.org/10.3390/electronics11152431.

Abstract

The last two decades have faced a significantly increased number of telecommunication antennas emitting electromagnetic radiation in residential areas. The theoretical simulation of the dispersion of the energy flux density of the electromagnetic field has been performed applying the physical peculiarities of the waves generating electromagnetic radiation. Having evaluated studies on simulation, the visual representation of the spread of electromagnetic radiation has been carried out according to the results obtained applying the AutoCad package. A comparison of the simulated value of the energy flux density radiated from antennas for mobile telecommunications with the measured one has disclosed an overlap of 30%. The simulation of the energy flux density showed that, in the close proximity zone (under a distance of 30 m), antennas radiate values within the range 10–10,000 μW/cm^2. At a distance larger than 30 m, the values of energy flux density fluctuate from 10 to 0.001 μW/cm^2.

Conclusions

The simulation of the energy flux density of the electromagnetic field allows estimating electromagnetic radiation emitted by antennas for mobile telecommunications, which results in the termination of the conducted experiments. A comparison of the simulated value of the energy flux density radiated from antennas for cell telecommunications with the measured one point to an overlap of 30%, because simulation encounters difficulties in precisely measuring a variety of natural and human-made obstacles and reflections. Thus, the properly selected simulation software allows understanding and preliminarily estimating the electromagnetic fields of mobile telecommunications as well as visually determining places where electromagnetic radiation exceeds the established standards.

The simulation of the energy flux density of the electromagnetic field of antennas for mobile telecommunications showed that, in the close proximity zone (under a distance of 30 m), antennas radiate

values from 10 to 10,000 μW/cm^2, whereas the values fluctuate between 10 and 0.001 μW/cm^2 at a distance larger than 30 m. The values of the energy flux density of the electromagnetic field decrease according to square dependence in free space, while at distances exceeding 100 m fluctuate in the range from 0.01 to 1 μW/cm^2. The maximum density was equal to 10–100 μW/cm^2 under the distance less than 25 m from the antenna in the direction of the most intensive radiation.

The examination of the upcoming or available antenna or other powerful source of radio waves includes calculating the theoretical parameters of the density taking into account the qualities of the antenna and accepting surrounding terrain as an area with no significant unevenness. Similar places have most frequently installed antennas, and, although the obtained measurement results are satisfactory enough, in order to determine necessary safety requirements, the impact of land relief is unnecessarily downgraded. The wave propagated outwards the antenna is dispersed and, having reflected from terrain, is summed up with the previous one, thus creating a maximum. Uneven terrain changes the maximum position of this electromagnetic field, which needs further examination. Thus, if the simulated values are lower than the established standard, it is still advisable to check them experimentally.

Open access paper: https://www.mdpi.com/2079-9292/11/15/2431/htm

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Microwave Radiation and the Brain: Mechanisms, Current Status, and Future Prospects

Mumtaz S, Rana JN, Choi EH, Han I. Microwave Radiation and the Brain: Mechanisms, Current Status, and Future Prospects. *International Journal of Molecular Sciences*. 2022; 23(16):9288. https://doi.org/10.3390/ijms23169288

Abstract

Modern humanity wades daily through various radiations, resulting in frequent exposure and causing potentially important biological effects. Among them, the brain is the organ most sensitive to electromagnetic radiation (EMR) exposure. Despite numerous correlated studies, critical unknowns surround the different parameters used, including operational frequency, power density (i.e., energy dose), and irradiation time that could permit reproducibility and comparability between analyses. Furthermore, the interactions of EMR with biological systems and its precise mechanisms remain poorly characterized. In this review, recent approaches examining the effects of microwave radiations on the brain, specifically learning and memory capabilities, as well as the mechanisms of brain dysfunction with exposure as reported in the literature, are analyzed and interpreted to provide prospective views for future research directed at this important and novel medical technology for developing preventive and therapeutic strategies on brain degeneration caused by microwave radiation. Additionally, the interactions of microwaves with biological systems and possible mechanisms are presented in this review. Treatment with natural products and safe techniques to reduce harm to organs have become essential components of daily life, and some promising techniques to treat cancers and their radioprotective effects are summarized as well. This review can serve as a platform for researchers to understand the mechanism and interactions of microwave radiation with biological systems, the present scenario, and prospects for future studies on the effect of microwaves on the brain.

Open access paper: https://www.mdpi.com/1422-0067/23/16/9288

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Specific Absorption Rate Analysis of Smartphone

M. Garvanova, I. Garvanov, D. Borissova. Specific Absorption Rate Analysis of Smartphone. *2022 22nd International Symposium on Electrical Apparatus and Technologies (SIELA)*, 2022, pp. 1-4, doi: 10.1109/SIELA54794.2022.9845756.

Abstract

This paper discusses and analyzes the process of absorbing electromagnetic energy emitted by a smartphone. The study of the specific absorption rate (SAR) at the depth of the human head was carried out using a computer model simulated with COMSOL Multiphysics software. The computer model takes into account the technical parameters of a working smartphone and the biological characteristics of the human head. The model simulates the absorption process, depending on the type of radiation pattern of the antenna on a smartphone. To validate the results of the model in depth of the human head, an analysis of the brain activity of a person, using a smartphone, was performed.

Excerpts

This study confirms the hypothesis that prolonged use of mobile phones changes a person's brain activity, which may be a prerequisite for fatigue, distraction and stress of the body. This study largely confirms the assumption that SAR affects brain activity, but further research is needed in this direction....

In the places with the greatest absorption of electromagnetic energy, the most significant change in brain activity is observed. Here, statistically significant differences in the theta, alpha and beta ranges of the EEG signal were obtained, established by paired samples t-test. The results with p-values less than 0.05 indicate statistically significant differences in EEG power in T3 (θ, a, and β), T5 (θ and *a)*, and F7 (θ and a) points as shown in Figure 6.

From the computer model for SAR (Fig. 7), it can be seen that the locations with the highest absorption levels of the electromagnetic field coincide with the locations of the most significant change in the spectrum of the EEG signals. Due to the computer model for simulating SAR from an EMF, it can be physically explained why a change in the signal spectrum occurs at several points in the human head. With the help of the computer model it is possible to study the effects of elevated values of electromagnetic radiation, which can be harmful to human health. Through the model it is also possible to visualize invisible processes that predict various negative effects from prolonged use of a mobile phone....

Conclusions

This article examines the SAR caused by the use of a smartphone. The EMF absorption level at the depth of the human head is simulated using a computer model. Depending on the parameters of the smartphone and the

characteristics of the tissues of the human head, different SAR results are obtained. The computer model was tested by processing the EEG signals and analyzing the spectra of the EEG signals from all electrodes. It is interesting that the results of the model coincide with the results of the EEG analysis. The places with the highest EMF absorption values coincided with the places of greatest change in brain activity induced by smartphone operation. In our future research, we will focus on the analysis of the excessive use of smartphones by children and adolescents.

https://ieeexplore.ieee.org/document/9845756

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Interference with Implanted Upper Airway Stimulation Device by Phones with Magnet Technology (iPhones 12 and 13)

Plawecki A, Tripathi N, Tovar Torres M, Yaremchuk K. Interference with Implanted Upper Airway Stimulation Device by Phones with Magnet Technology. Laryngoscope. 2022 Aug 17. doi: 10.1002/lary.30348.

Abstract

Newer iPhone models [12 and 13] with MagSafe magnetic technology can cause electromagnetic interference with the Inspire upper airway stimulator device (a surgical implant for the treatment of obstructive sleep apnea).

https://www.ncbi.nlm.nih.gov/pubmed/35975894

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Simulating the Dispersion of the Energy Flux Density of the Electromagnetic Field Generated by Antennas for Mobile Communications

My note: The FCC exposure limit is 1 mW/cm^2 or 1000 $\mu W/cm^2$ which means within 30 meters of a cellular antenna the electromagnetic field could be up to 10 times the limit at some locations.

Buckus R, Chlebnikovas A, Strukcinskiene B, Stukas R, Austys D, Caban J, Bogucki M, Sidlauskiene A, Seleviciene V, Kilikevičius A, Matijošius J, Kilikevičienė K, Vainorius D. Simulating the Dispersion of the Energy Flux Density of the Electromagnetic Field Generated by Antennas for Mobile Communications. *Electronics*. 2022; 11(15):2431. doi:10.3390/electronics11152431.

Abstract

The last two decades have faced a significantly increased number of telecommunication antennas emitting electromagnetic radiation in residential areas. The theoretical simulation of the dispersion of the energy flux density of the electromagnetic field has been performed applying the physical peculiarities of the waves generating electromagnetic radiation. Having evaluated studies on simulation, the visual representation of the spread of electromagnetic radiation has been carried out according to the results obtained applying the AutoCad package. A comparison of the simulated value of the energy flux density radiated from antennas for mobile telecommunications with the measured one has disclosed an overlap of 30%. The simulation of the energy flux

density showed that, in the close proximity zone (under a distance of 30 m), antennas radiate values within the range 10–10,000 μW/cm^2. At a distance larger than 30 m, the values of energy flux density fluctuate from 10 to 0.001 μW/cm^2.

Conclusions

The simulation of the energy flux density of the electromagnetic field allows estimating electromagnetic radiation emitted by antennas for mobile telecommunications, which results in the termination of the conducted experiments. A comparison of the simulated value of the energy flux density radiated from antennas for cell telecommunications with the measured one point to an overlap of 30%, because simulation encounters difficulties in precisely measuring a variety of natural and human-made obstacles and reflections. Thus, the properly selected simulation software allows understanding and preliminarily estimating the electromagnetic fields of mobile telecommunications as well as visually determining places where electromagnetic radiation exceeds the established standards.

The simulation of the energy flux density of the electromagnetic field of antennas for mobile telecommunications showed that, in the close proximity zone (under a distance of 30 m), antennas radiate values from 10 to 10,000 μW/cm^2, whereas the values fluctuate between 10 and 0.001 μW/cm^2 at a distance larger than 30 m. The values of the energy flux density of the electromagnetic field decrease according to square dependence in free space, while at distances exceeding 100 m fluctuate in the range from 0.01 to 1 μW/cm^2. The maximum density was equal to 10–100 μW/cm^2 under the distance less than 25 m from the antenna in the direction of the most intensive radiation.

The examination of the upcoming or available antenna or other powerful source of radio waves includes calculating the theoretical parameters of the density taking into account the qualities of the antenna and accepting surrounding terrain as an area with no significant unevenness. Similar places have most frequently installed antennas, and, although the obtained measurement results are satisfactory enough, in order to determine necessary safety requirements, the impact of land relief is unnecessarily downgraded. The wave propagated outwards the antenna is dispersed and, having reflected from terrain, is summed up with the previous one, thus creating a maximum. Uneven terrain changes the maximum position of this electromagnetic field, which needs further examination. Thus, if the simulated values are lower than the established standard, it is still advisable to check them experimentally

Open access paper: https://www.mdpi.com/2079-9292/11/15/2431/htm

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Regular measurements of EMF in a representative Norwegian city-constant exposure over time despite introduction of new technologies

Markussen AC, Sjoemoen TM, Unander EH, Klaeboe L. Regular measurements of EMF in a representative Norwegian city-constant exposure over time despite introduction of new technologies. Environ Monit Assess. 2022 Aug 19;194(10):694. doi: 10.1007/s10661-022-10231-4.

Abstract

The rapid growth of the wireless communication industry has resulted in the installation of numerous base stations, everywhere in our surroundings. The population is exposed to Radio Frequency Electromagnetic Fields of varying frequency and strength. This, and introduction of new systems have risen public concerns regarding potential health effects from this RF-EMF exposure. The purpose of this project is to get an overview of any changes in exposure when new technologies are introduced. From June 2013 to October 2019, measurements were made at 16 measurement points in Kristiansand and surrounding areas in the same order, on the same day of the week and at the same time of day. The measurements are performed on the frequency bands 390, 450, 800, 900, 1800, 2100, 2400, and 2600 MHz. When we summed up the exposure for all the frequency bands relative to the limit values in a measuring point, the total values per measuring point showed that the exposure outdoors in most cases is less than 1‰ of the limit value. In 2017, a temporary increase was registered for most measurement points, but during 2018 the levels returned to the levels registered before 2017. During the increase, the levels were still low, around 3‰ of the limit values. The increase may be due to the fact that two mobile operators during this period made a comprehensive reconfiguration of their networks. The measurements presented in this report show that the exposure of the population is low, thousandths of the limit values, and relatively constant over time even though new technologies are introduced.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9391237/

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Comments on Measurements and Analysis of Personal Exposure to RF-EMF Inside and Outside School Buildings

E. Arribas, R. Ramirez-Vazquez, I. Escobar. Comments on “Measurements and Analysis of Personal Exposure to RF-EMF Inside and Outside School Buildings: A Case Study at a Kosovo School." *IEEE Access*, 2022, doi: 10.1109/ACCESS.2022.3198975.

Abstract

In this comment we present a table with the measurements of the personal exposure in the two Wi-Fi frequency bands inside educational centers such as colleges and universities, in different countries, with the aim of complementing and comparing the measurements carried out in a large school in the city of Pristina, Kosovo. We obtained that the maximum value was recorded in Spain with 120 $\mu W/m^2$ and the minimum value was recorded in Switzerland with 1.19 $\mu W/m^2$. The mean value of the data in Table 2 is 36.9 $\mu W/m^2$, the median is 22.2 $\mu W/m^2$, and the 95^{th} percentile is 110 $\mu W/m^2$.

https://ieeexplore.ieee.org/document/9772682

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Trends in brain cancers (glioma) in New Zealand from 1995 to 2020, with reference to mobile phone use

My note: The study has several shortcomings: (1) it did not examine incidence rates over time for Glioblastoma (GBM), the most common type of glioma (brain cancer). Phillips et al (2018) found that GBM increased substantially over time in England despite a flat trend for glioma. (2) The authors combined temporal and

parietal lobe tumors and examined the incidence over time. Their rationale was that these lobes received the most exposure to cell phone radiation; however, Cabré-Riera et al (2020) found that the temporal and frontal lobes received the most exposure; the parietal lobe received the least exposure.

Philips et al (2018). Brain Tumours: Rise in Glioblastoma Multiforme Incidence in England 1995–2015 Suggests an Adverse Environmental or Lifestyle Factor. Journal of Environmental and Public Health, doi:10.1155/2018/7910754.

Cabré-Riera et al (2020). Estimated whole-brain and lobe-specific radiofrequency electromagnetic fields doses and brain volumes in preadolescents. Environ Int. 142:105808. doi:10.1016/j.envint.2020.105808.

J Mark Elwood, Shwe Sin Win, Phyu Sin Aye, Masoumeh Sanagou. Trends in brain cancers (glioma) in New Zealand from 1995 to 2020, with reference to mobile phone use. Cancer Epidemiol. 2022 Aug 9;80:102234. doi: 10.1016/j.canep.2022.102234.

Highlights

- Hypothesis is that mobile phone use increases brain cancers such as glioma.
- Mobile phone use in New Zealand increased greatly between 1990 and 2006.
- Incidence of glioma from 1995 to 2020 showed no increase at ages 10–69
- No evidence that phone use increases risk even after many years.

Abstract

Background: Some case-control studies have suggested substantial increased risks of glioma in association with mobile phone use; these risks would lead to an increase in incidence over time.

Methods: Incidence rates of glioma from 1995 to 2020 by age, sex, and site in New Zealand (NZ) recorded by the national cancer registry were assessed and trends analysed. Phone use was based on surveys.

Results: In these 25 years there were 6677 incident gliomas, giving age-standardised rates (WHO world standard) of 6.04 in males, and 3.95 in females per 100,000. The use of mobile phones increased rapidly from 1990 to more than 50% of the population from about 2000, and almost all the population from 2006. The incidence of glioma from ages 10-69 has shown a small decrease over the last 25 years, during which time the use of mobile phones has become almost universal. Rates in the brain locations receiving most radiofrequency energy have also shown a small decrease. Rates at ages of 80 and over have increased.

Conclusion: There is no indication of any increase related to the use of mobile phones. These results are similar to results in Australia and in many other countries. The increase in recorded incidence at ages over 80 is similar to that seen in other countries and consistent with improved diagnostic methods.

Excerpts

In contrast, the incidence of glioma at ages 70 and over has shown a substantial increase over time (Fig. 5), the annual percentage changes being in males 1.5% (95% limits 0.3–2.8), and in females 1.3% (95% limits 0.3–2.3). The increase has been regular throughout the 1995–2020 period in females. In men, the rates rose more quickly from 1995 to 2011, and have since declined: however, this change is not significant and a linear increase gives the best fit to the data.

Further examination shows that the increase is significant in the 80–84 and 85 + age groups, while the 70–74 and 75–79 year old groups show no significant increase (Fig. 6, Table 2). These older groups have a lower incidence of glioma than the 75–79 and 70–75 year old groups, but their rising rates have reduced this difference over time.

In conclusion, the incidence of glioma in the New Zealand population from ages 10–69 has shown a small decrease over the last 25 years, during which time the use of mobile phones has become almost universal. There is no indication of any increase related to the use of mobile phones. There has been an increase in recorded incidence at ages over 80, similar to that seen in other countries and consistent with improved diagnostic methods.

https://pubmed.ncbi.nlm.nih.gov/35961280/

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Time trends in mobile phone use and glioma incidence among males in the Nordic Countries, 1979-2016

Isabelle Deltour, Aslak Harbo Poulsen, Christoffer Johansen, Maria Feychting, Tom Børge Johannesen, Anssi Auvinen, Joachim Schüz. Time trends in mobile phone use and glioma incidence among males in the Nordic Countries, 1979-2016. Environment International. 2022. 107487. doi:10.1016/j.envint.2022.107487.

Abstract

Introduction In the Nordic countries, the use of mobile phones increased sharply in the mid-1990s especially among middle-aged men. We investigated time trends in glioma incidence rates (IR) with the perspective to inform about the plausibility of brain tumour risks from mobile phone use reported in some case-control studies.

Methods We analysed IR of glioma in Denmark, Finland, Norway, and Sweden among men aged 40-69 years, using data from national cancer registries and population statistics during 1979-2016, using log-linear joinpoint analysis. Information on regular mobile phone use and amount of call-time was obtained from major studies of mobile phones in these countries. We compared annual observed incidence with that expected under various risk scenarios to assess which of the reported effect sizes are compatible with the observed IR. The expected numbers of cases were computed accounting for an impact of other factors besides mobile phone use, such as improved cancer registration.

Results Based on 18,232 glioma cases, IR increased slightly but steadily with a change of 0.1% (95%CI 0.0%, 0.3%) per year during 1979-2016 among 40–59-year-old men and for ages 60-69, by 0.6 % (95%CI 0.4, 0.9) annually. The observed IR trends among men aged 40-59 years were incompatible with risk ratios (RR) 1.08 or

higher with a 10-year lag, RR ≥ 1.2 with 15-year lag and RR ≥ 1.5 with 20-year lag. For the age group 60-69 years, corresponding effect sizes RR ≥ 1.4, ≥ 2 and ≥ 2.5 could be rejected for lag times 10, 15 and 20 years.

Discussion This study confirms and reinforces the conclusions that no changes in glioma incidence in the Nordic countries have occurred that are consistent with a substantial risk attributable to mobile phone use. This particularly applies to virtually all reported risk increases reported by previous case-control studies with positive findings.

Excerpts

"Our analyses are based on 18,232 male glioma cases, which occurred in the male population aged 40-69 years in Denmark, Finland, Norway and Sweden with 162 million person-years at risk. Rates of glioma showed a slow and constant increase with no marked changes in the trend in the recent years."

"... our study also has some limitations. The exposure prevalence was obtained from two sources with different recruitment methods, age and questionnaire characteristics; the prevalence in the age group 60-69 years was less accurately registered than for the age group 40-59 years, because both studies had small sample sizes in this age range at recruitment, and in addition, the data had to be extrapolated for the distant past. Therefore, using these estimates of exposure prevalence could at best provide a range of possible exposure distributions in the population. The use of hands-free devices was not accounted for, but this was not frequent in these populations (data not shown). Our study is not free of assumptions. The induction period for an effect of mobile phone use on glioma risk, if one exists, is unknown, as is the magnitude of the risk, if any, and the real patterns may be more complex than the scenarios that we simulated. In addition, there are several factors that we were not able to account for. The coverage of the Nordic cancer registries was not perfectly complete, some 1.5% to 10% of the malignant brain tumours were missed in these age groups, but there is no reason to believe this proportion has increased over time. In Sweden, it has been estimated that completeness would not have changed over the period 1998-2014 for the age group 20-69 years, but has increased among ≥70 year olds; completeness might have improved in the other countries due to introduction of automated registration routines (Tettamanti et al., 2019, Gjerstorff, 2011, Leinonen et al., 2017, Larsen et al., 2009). Our analyses incorporated the possibility that other, currently unknown, risk factors, as well as improvement in glioma detection and reporting had a smooth, gradual impact, over the period 1979−2016, consistent with the gradually increasing IRs."

"Our findings indicate that glioma incidence trends among men aged 40-59 years in the Nordic countries are not consistent with increased risks of moderate effect size (RR>1.2-1.4) assuming latency up to 20 years. This means that increased risks reported in some case-control studies are implausible and likely attributable to biases and errors in self-reported use of mobile phone. Our results were consistent with results from prospective cohort studies showing no association between mobile phone use and risk of glioma.

Funding: This study was supported by the German Federal Office for Radiation Protection (BfS; grant FM 8867)."

https://www.sciencedirect.com/science/article/pii/S0160412022004147

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5G Electromagnetic Radiation Attenuates Skin Melanogenesis In Vitro by Suppressing ROS Generation

Kim K, Lee YS, Kim N, Choi H-D, Lim K-M. 5G Electromagnetic Radiation Attenuates Skin Melanogenesis In Vitro by Suppressing ROS Generation. *Antioxidants*. 2022; 11(8):1449. https://doi.org/10.3390/antiox11081449

Abstract

Recently, the impacts of 5G electromagnetic radiation (EMR) with 28 GHz on human health have been attracting public attention with the advent of 5G wireless communication. Here, we report that 5G (28 GHz) EMR can attenuate the skin pigmentation in murine melanoma cells (B16F10) and a 3D pigmented human epidermis model (Melanoderm™). B16 cells were exposed to 5G (28 GHz) with or without α-MSH for 4 h per day. Interestingly, 5G attenuated α-MSH-induced melanin synthesis. Fontana–Masson staining confirmed that the dendritic formation of α-MSH stimulated B16 cells was diminished by 5G exposure. To confirm the anti-melanogenic effect of 5G EMR, MelanoDerm™ was irradiated with 5G at a power intensity of 10 W/m^2 for 4 h a day for 16 days and melanin distribution was detected with Fontana–Masson staining, which supported the anti-melanogenic effect of 5G EMR. Consistently, 5G EMR suppressed α-MSH induced upregulation of melanogenic enzymes; tyrosinase, TRP-1, and TRP-2. Of note, 5G EMR attenuated ROS production stimulated by α-MSH and H_2O_2, suggesting that 5G EMR may dissipate ROS generation, which is pivotal for the melanin synthesis. Collectively, we demonstrated that 5G EMR can attenuate skin pigmentation by attenuating ROS generation.

Open access paper: https://www.mdpi.com/2076-3921/11/8/1449

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An In Vitro Experimental System for 5G 3.5 GHz Exposures

Y. S. Lee, S. B. Jeon, J. -K. Pack, N. Kim and H. -D. Choi. An In Vitro Experimental System for 5G 3.5 GHz Exposures. *IEEE Access*, 2022, doi: 10.1109/ACCESS.2022.3204055.

Abstract

In this study, an in vitro experimental system is developed for fifth-generation (5G) 3.5 GHz exposures. A radial transmission line (RTL) housed in an incubator can support the single-mode propagation at a 3.5 GHz band. A conical antenna is also placed at the center of an RTL to ensure field symmetries. A 5G signal generator along with a customized power amplifier can create 5G new radio time division duplex (TDD) waveforms. Additionally, a feedback scheme implemented by employing a directional coupler and power meter allows power control to ensure a steady output power. The system is evaluated based on temperature measurements using the initial temperature slope and nonlinear curve fitting to determine the specific absorption rate (SAR) values. Comparing SARs obtained from a “worst-case” signal of a maximum power condition with the values obtained from a “TDD” signal of an actual 5G TDD transmission gives the initial slope ratio of 0.741, which is very similar to the theoretical duty cycle of 0.743. It is also shown that the average output power, water temperature, incubator air temperature, and CO2 density are adequately controlled for appropriate in vitro experiments.

https://ieeexplore.ieee.org/document/9875270

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Pilot Study of a New Methodology to Study the Development of the Blue Bottle Fly Under Exposure to Radio-Frequency Fields at 5.4 GHz

My note: The SAR for the 19.4 V/m exposure condition was estimated to be 0.028 W/kg. At this SAR, the median delay in pupal emergence was twice as long as in the sham condition. Yet, this full-body SAR is less than the so-called 50-fold safety limit of 0.08 W/kg of full body exposure adopted by the FCC and ICNIRP. Thus, along with numerous other biological studies, this pilot study suggests that current safety limits are not adequate across different species.

De Paepe S, De Borre E, Toribio Carvajal D, Bell D, Thielens A. Pilot Study of a New Methodology to Study the Development of the Blue Bottle Fly (*Calliphora vomitoria*) Under Exposure to Radio-Frequency Electromagnetic Fields at 5.4 GHz. Int J Radiat Biol. 2022 Aug 17:1-49. doi: 10.1080/09553002.2022.2113838.

Abstract

Purpose – Exposure of insects to radio-frequency electromagnetic fields (RF-EMFs) can have developmental effects. However, there is currently no clear understanding of the exposure level that can lead to such effects. Therefore, the goal of this study was to, for the first time, study the development of the Blue Bottle Fly (Calliphora vomitoria, CV) under exposure to RF-EMFs at 5.4 GHz, using both numerical RF-EMF dosimetry with anatomically accurate 3D models of insects and an RF-EMF exposure experiment.

Materials and Methods - CV was chosen as a model organism in this study because CV's development can be influenced thermally and CV's pupal stage presents a window of several days in which immobile pupae can be exposed to RF-EMFs. The 5.4 GHz frequency was used because it allowed us licence-free operation of the exposure setup. Numerical, EM simulations with 3D anatomically accurate models of CV, obtained using micro-CT scanning, were used in this study. These simulations enable the estimation of the absorbed power and the whole-body averaged specific absorption rate in CV during RF exposure experiments. An experiment with three exposure conditions was designed and executed in which 400 pupae were split into an exposed group that was placed inside the TEM cell for 48 h and a concurrent control. Two exposure conditions used RF-EMF input power into the TEM cell at 5.4 GHz on two different levels. One exposure condition was a sham exposure. Electric field strength measurements were used to validate the proper functioning of the exposure setups and to quantify the RF-EMF exposure of the control groups.

Results and Conclusions - All studied groups of pupae – exposed to RF-EMFs, sham, and control groups- showed similar (evolutions of) masses, lengths and diameters during their development. The total rate of pupal emergence was reduced in one of the studied RF-EMF exposures in comparison to its concurrent control, while the other RF-EMF exposure and the sham exposure did not alter the total rate of pupal emergence. The sham exposure and the lowest of the two studied RF-EMF exposure conditions (19.4 V/m) caused a median delay in pupal emergence of 4 and 8 hours, respectively, in comparison to concurrent control groups. The higher studied exposure of 55 V/m caused a median relative acceleration in development of 8 h.

https://pubmed.ncbi.nlm.nih.gov/35976063/

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Effect of RFEMR on NSE and MDA levels in Sprague Dawley rats

Pagadala, P; Shankar, V and Sumathi, ME. Effect of RFEMR on NSE and MDA levels in Sprague Dawley rats. Jun 2022. Bioinformation.18 (6): 501-505.

Abstract

Radiofrequency emitted radiations (RFEMR) from mobile phones are known to produce a stress response because of its effect on hypothalamus. Mobile phones have become an integral part of our lives with increasing usage not only in terms of number of users but also increase in talk time. Therefore, it is of interest to study the effect of mobile phone radiofrequency electromagnetic radiations on NSE and MDA levels in SD rats. Twelve male SD rats of 10-12weeks old, weighing 180-220 grams, were purchased from registered laboratory breeders & housed in a room with 12:12hour's light-dark cycle with adlibitum amount of food and RO water. Present study showed significant increase in NSE and MDA levels in rats exposed to RFEMR. This study proves that mobile RFEMR causes oxidative stress and oxidative damage in SD rats.

http://www.bioinformation.net/018/97320630018501.htm

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Assessment of combined exposure to intermediate-frequency electromagnetic fields and pulsed electromagnetic fields among library workers in Japan

Yamaguchi-Sekino S, Taki M, Ikuyo M, Esaki K, Aimoto A, Wake K, Kojimahara N. Assessment of combined exposure to intermediate-frequency electromagnetic fields and pulsed electromagnetic fields among library workers in Japan. Front Public Health. 2022 Jul 28;10:870784. doi: 10.3389/fpubh.2022.870784.

Abstract

Objective: To assess exposure levels to electromagnetic fields (EMFs) among library workers in Japan, focusing on co-exposure to intermediate-frequency EMF (IF-EMF) and pulsed EMF, to propose a new epidemiological research methodology.

Methods: The evaluated exposure sources were an electromagnetic type-electronic article surveillance gate (EM-EAS, IF-EMF (operating frequency 220 Hz-14 kHz)) and an activator/deactivator of anti-theft tags termed as "book check unit" (BCU, pulsed EMF). Short-term exposures were: (E1) whole-body exposure from the EAS gate when sitting within 3 m; (E2) local exposure to transient IF-EMF while passing through or beside the EAS gate; and (E3) local exposure to a pulsed magnetic field on BCU use. E1-E3 were evaluated based on exposure levels relative to magnetic flux density at the occupational reference level (RL; E1) or as per occupational basic restrictions (BR; E2 and E3) delineated by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) 2010 guidelines. Exposure indices based on mid-term exposure (D1-D3), assuming exposure according to employment on a weekly basis, were used to assess exposure in actual working conditions. D1 represents continuous exposure from an EAS gate when sitting within 3 m of the gate. D2 and D3 represent repeated transient exposures occurring during gate pass or on the operation of a BCU. A link to a web-based

questionnaire was distributed to librarians working at all libraries where the authors had mailed institutional questionnaires (4,073 libraries). Four exposure patterns were defined according to various exposure scenarios.

Results: We obtained information on exposure parameters and working conditions from the 548 completed questionnaires. The ICNIRP guideline levels were not exceeded in any of the E1-E3 scenarios. Median of the D1 (% ICNIRP RL × hour/week) was 1, and >85% respondents had values <10. However, the maximum value was 513. Altogether, these results indicate that continuous exposure was low in most cases. The same tendency was observed regarding repeated transient exposure from EM-EAS gates (i.e., the median value for D2 (% ICNIRP BR × gate pass) was 5). However, there were several cases in which D1 and D2 values were >10 times the median. The median of D3 (% ICNIRP BR × BCU operation) was 10, and most respondents' D3 values were greater than their D2 values, although the derived results depended on the assumptions made for the estimation.

Conclusion: We conducted an assessment of combined exposures to IF-EMF and pulsed EMF among library workers in Japan by evaluating both short-term exposures (E1-E3) and exposure indices based on mid-term exposures (D1-D3) assuming actual working conditions per questionnaire results. These results provide useful information for future epidemiological studies.

Open access paper: https://www.frontiersin.org/articles/10.3389/fpubh.2022.870784/full

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Effect of Occupational Extremely Low-Frequency Electromagnetic Field Exposure on the Thyroid Gland of Workers: A Prospective Study

Fang YY, Tu Q, Zhang YT, Liu J, Liu HG, Zhao ZH, Wu H, Yin TJ. Effect of Occupational Extremely Low-Frequency Electromagnetic Field Exposure on the Thyroid Gland of Workers: A Prospective Study. Curr Med Sci. 2022 Aug;42(4):817-823. doi: 10.1007/s11596-022-2610-8.

Abstract

Objective: The aim of this study was to investigate the biological effects of occupational extremely low-frequency electromagnetic field (ELF-EMF) exposure on the thyroid gland.

Methods: We conducted a prospective analysis of 85 workers (exposure group) exposed to an ELF-EMF (100 μT, 10-100 Hz) produced by the electromagnetic aircraft launch system and followed up on thyroid function indices, immunological indices, and color Doppler images for 3 years. Additionally, 116 healthy volunteers were randomly selected as controls (control group), the thyroid function of whom was compared to the exposure group.

Results: No significant difference was observed in thyroid function between the exposure and control groups. During the follow-up of the exposure group, the serum free triiodothyronine (FT3) level was found to slowly decrease and free thyroxine (FT4) level slowly increase with increasing exposure time. However, no significant difference was found in thyroid-stimulating hormone (TSH) over the three years, and no significant difference

was observed in the FT3, FT4 and TSH levels between different exposure subgroups. Furthermore, no significant changes were observed in thyroid autoantibody levels and ultrasound images between subgroups or over time.

Conclusion: Long-term exposure to ELF-EMF may promote thyroid secretion of T4 and inhibit deiodination of T4 to T3. ELF-EMF has no significant effect on thyroid immune function and morphology.

https://pubmed.ncbi.nlm.nih.gov/35963949/

Excerpt

One of the currently popular research topics is whether thyroid cancer can be induced by long-term ELF-EMF exposure. As we know, cancer is caused by DNA damage, but it is generally believed that ELF-EMF is too weak to directly damage DNA. Nevertheless, a recent study shows that long-term occupational exposure to ELF-EMF may cause a genetically toxic effect. The researchers believe that DNA damage is caused by the magnetic field due to the oxidative stress that the magnetic field induced [32]. Another meta-analysis on the relation between ELF-EMF and the risk of cancer suggests that ELF-EMF increases the risk of cancer [33].

32 Bagheri Hosseinabadi M, Khanjani N, Mirzaii M, et al. DNA damage from long-term occupational exposure to extremely low frequency electromagnetic fields among power plant workers. Mutat Res, 2019,846:403079

33 Zhang Y, Lai J, Ruan G, et al. Meta-analysis of extremely low frequency electromagnetic fields and cancer risk: a pooled analysis of epidemiologic studies. Environ Int, 2016,88:36-43

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Magnetic field effects in biology from the perspective of the radical pair mechanism

Zadeh-Haghighi Hadi, Simon Christoph. Magnetic field effects in biology from the perspective of the radical pair mechanism. J. R. Soc. Interface. Aug 3, 2022. 192022032520220325. doi: 10.1098/rsif.2022.0325.

Abstract

Hundreds of studies have found that weak magnetic fields can significantly influence various biological systems. However, the underlying mechanisms behind these phenomena remain elusive. Remarkably, the magnetic energies implicated in these effects are much smaller than thermal energies. Here, we review these observations, and we suggest an explanation based on the radical pair mechanism, which involves the quantum dynamics of the electron and nuclear spins of transient radical molecules. While the radical pair mechanism has been studied in detail in the context of avian magnetoreception, the studies reviewed here show that magnetosensitivity is widespread throughout biology. We review magnetic field effects on various physiological functions, discussing static, hypomagnetic and oscillating magnetic fields, as well as isotope effects. We then review the radical pair mechanism as a potential unifying model for the described magnetic field effects, and we discuss plausible candidate molecules for the radical pairs. We review recent studies proposing that the radical pair mechanism provides explanations for isotope effects in xenon anaesthesia and lithium treatment of hyperactivity, magnetic field effects on the circadian clock, and hypomagnetic field effects on neurogenesis and

microtubule assembly. We conclude by discussing future lines of investigation in this exciting new area of quantum biology.

Open access paper: https://royalsocietypublishing.org/doi/10.1098/rsif.2022.0325

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Measurement and Estimation of the Magnetic Fields in Electric Vehicles

M. Garvanova, I. Garvanov, V. Ivanov, D. Borissova. Measurement and Estimation of the Magnetic Fields in Electric Vehicles. *2022 22nd International Symposium on Electrical Apparatus and Technologies (SIELA)*, 2022, pp. 1-4, doi: 10.1109/SIELA54794.2022.9845773.

Abstract

To solve the problem of harmful emissions emitted by internal combustion vehicles such as carbon dioxide, nitrogen oxides, soot and others, the use of electric cars is proposed. These devices operate on electricity that induces “electromagnetic pollution” in or near them. The effects of electromagnetic fields on living organisms are undeniable, but it is not yet clear how harmful they are to humans. In electric car, passengers sit very close to an electrical system that operates at considerable power and for a long period of time. This means that consumers are exposed to artificial magnetic fields. Electric car manufacturers are very familiar with these problems and offer various technological solutions in their design and production. In the present article, experimental measurements of the magnetic fields generated by an electric car operating in different operating modes will be performed and recommendations for its proper operation will be given.

Excerpts

The levels of MF when driving in urban conditions are constantly changing in the range of about 100–200 nT. When starting and stopping, the levels are relatively high in the range of 170–230 nT. When the car is stopped at a traffic light, the level of the MF is in the range of 165–200 nT.

When driving the electric car on the highway at speeds of 50, 80 and 100 km/h, MF levels of the order of 100–300 nT are obtained. The measurement results are shown in Table 2

The obtained results show that in the passenger compartment of a car operating in different operating modes, the MF levels are normal. This is achieved thanks to the engineering solutions used in the production of the electric car. It is noteworthy that when accelerating and stopping the car, relatively high values of MF are observed, but this is for very short periods of time. More worrying is the fact of prolonged exposure and relatively high values of MF at high speeds of the electric car. The power, weight, acceleration and speed of the car affect the power of the MF generated in the car body. When charging the electric car, it is recommended that people are outside the car and as far away from it as possible. The three factors that have the strongest impact on human health are: high levels of electromagnetic fields, small distances between the generators of these fields and passengers, as well as relatively long exposure.

https://ieeexplore.ieee.org/document/9845773

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Comparison of EMF Exposure Limits and Assessment for Electric Vehicle Wireless Power Transfer

N. Li, Y. Wang, J. Zhang, Z. Gan. Comparison of EMF Exposure Limits and Assessment for Electric Vehicle Wireless Power Transfer. *2022 IEEE 5th International Electrical and Energy Conference (CIEEC)*, 2022, pp. 3944-3948, doi: 10.1109/CIEEC54735.2022.9846400.

Abstract

The electric and magnetic fields (EMF) generated by electric vehicle wireless power transfer might have health effects on the human inside and around the electric vehicle, including persons with active implantable medical devices. The comparative analysis on the EMF limits, measurement methods and assessment methods in the relevant EMF exposure standards were conducted, and the similarities and differences between domestic and foreign EMF standards and the international mainstream view were obtained. These provide the reference for the measurement and environmental impact assessment of electric vehicle wireless power transfer, as well as for revising Chinese national standard. The simulation and test research will be required with respect to the issues in the future, including assessment method of basic restrictions.

https://ieeexplore.ieee.org/document/9846400

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The effects of operating frequency on wireless power transfer system design and human health in electric vehicles

A. Ağçal, T. H. Doğan, G. Aksu. The effects of operating frequency on wireless power transfer system design and human health in electric vehicles. Electrica. 22(2): 188-197, 2022.

Abstract

Wireless power transfer (WPT) continues to be popular in today's world because it is used in situations where the use of cables is difficult, dangerous, or restrictive. In WPT, electrical energy is transmitted over the air by magnetic connections instead of cables. In this paper, WPT system designs were made with 10 kHz and 20 kHz operating frequencies, 3.3 kW output power, and 50 cm × 50 cm size. The effects of the frequency on the WPT system were analyzed with the designs made for two separate frequencies. The WPT circuits were established in the MATLAB/Simulink program. The coil design of the WPT systems was made in ANSYS® Maxwell 3D. The critical air gap values of the 10 kHz and 20 kHz designs were determined as 15 cm and 17 cm, respectively. In this study, the efficiency of the WPT system was obtained as 88.79% at 15 cm air gap for 10 kHz and 92.74% at 17 cm air gap for 20 kHz. Wireless power transfer systems in different frequency bands at the same power were compared in terms of efficiency, loss, cost, and electromagnetic field distribution. In addition, the effects of WPT systems on human health were examined according to IEEE and ICNIRP standards.

Excerpt

In which regions the magnetic field emitted by the coils is safe and unsafe for human health has been determined according to IEEE and ICNIRP standards. In this study, it has been observed that scattering can pose a danger to human health when one is between or very close to the receiver and transmitter coil. When one moves away from the coils as much as approximately the coil diameter, a safe area for public exposure is reached in 20 kHz systems. On the other hand, in 10 kHz systems, it is necessary to move further away from the boundaries of the 20 kHz system for a safe area. In this case, it is shown that WPT systems need living and object detection systems to shut down the system when a living being or an object is between or near the receiver and transmitter. In addition, it has been observed that the magnetic field created by the 20 kHz design is less than the 10 kHz design. High-frequency designs have lower inductance values, lower number of turns, and correspondingly lower magnetic flux density.

Open access paper: https://electricajournal.org/en/the-effects-of-operating-frequency-on-wireless-power-transfer-system-design-and-human-health-in-electric-vehicles-161797

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Differential biological responses of adherent and non-adherent (cancer and non-cancerous) cells to variable extremely low frequency magnetic fields

Nezamtaheri MS, Goliaei B, Shariatpanahi SP, Ansari AM. Differential biological responses of adherent and non-adherent (cancer and non-cancerous) cells to variable extremely low frequency magnetic fields. Sci Rep. 2022 Aug 20;12(1):14225. doi: 10.1038/s41598-022-18210-y.

Abstract

Extremely low-frequency electromagnetic field (ELF-EMF) induces biological effects on different cells through various signaling pathways. To study the impact of the ELF-EMF on living cells under an optimal physiological condition, we have designed and constructed a novel system that eliminates several limitations of other ELF-EMF systems. Apoptosis and cell number were assessed by flow cytometry and the Trypan Blue dye exclusion method, respectively. In vitro cell survival was evaluated by colony formation assay. The distribution of cells in the cell cycle, intracellular ROS level, and autophagy were analyzed by flow cytometer. Suspended cell differentiation was assessed by phagocytosis of latex particles and NBT reduction assay. Our results showed that response to the exposure to ELF-EMF is specific and depends on the biological state of the cell. For DU145, HUVEC, and K562 cell lines the optimum results were obtained at the frequency of 0.01 Hz, while for MDA-MB-231, the optimum response was obtained at 1 Hz. Long-term exposure to ELF-EMF in adherent cells effectively inhibited proliferation by arresting the cell population at the cell cycle G2/M phase and increased intracellular ROS level, leading to morphological changes and cell death. The K562 cells exposed to the ELF-EMF differentiate via induction of autophagy and decreasing the cell number. Our novel ELF-EMF instrument could change morphological and cell behaviors, including proliferation, differentiation, and cell death.

Open access paper: https://www.nature.com/articles/s41598-022-18210-y

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Maternal stress induced anxiety-like behavior exacerbated by electromagnetic fields radiation in female rats offspring

Hosseini E, Farid Habibi M, Babri S, Mohaddes G, Abkhezr H, Heydari H. Maternal stress induced anxiety-like behavior exacerbated by electromagnetic fields radiation in female rats offspring. PLoS One. 2022 Aug 23;17(8):e0273206. doi: 10.1371/journal.pone.0273206.

Abstract

There is a disagreement on whether extremely low frequency electromagnetic fields (ELF-EMF) have a beneficial or harmful effect on anxiety-like behavior. Prenatal stress induces frequent disturbances in offspring physiology such as anxiety-like behavior extending to adulthood. This study was designed to evaluate the effects of prenatal stress and ELF-EMF exposure before and during pregnancy on anxiety-like behavior and some anxiety-related pathways in the hippocampus of female rat offspring. A total of 24 female rats 40 days of age were distributed into four groups of 6 rats each: control, Stress (rats whose mothers underwent chronic stress), EMF (rats whose mothers were exposed to electromagnetic fields) and EMF/S (rats whose mothers were simultaneously exposed to chronic stress and ELF-EMF). The rats were given elevated plus-maze and open field tests and then their brains were dissected and their hippocampus were subjected to analysis. ELISA was used to measure 24(S)-hydroxy cholesterol, corticosterone, and serotonin levels. Cryptochrome2, steroidogenic acute regulatory protein, 3B-Hydroxy steroid dehydrogenase, N-methyl-D-aspartate receptor 2(NMDAr2) and phosphorylated N-methyl-D-aspartate receptor 2(PNMDAr2) were assayed by immunoblotting. Anxiety-like behavior increased in all treatment groups at the same time EMF increased anxiety induced by maternal stress in the EMF/S group. The stress group showed decreased serotonin and increased corticosterone levels. ELF-EMF elevated the PNMDAr2/NMDAr2 ratio and 24(S)-hydroxy cholesterol compared to the control group but did not change corticosterone. EMF did not restore changes induced by stress in behavioral and molecular tests. The results of the current study, clarified that ELF-EMF can induce anxiety-like behavior which may be attributed to an increase in the PNMDAr2/NMDAr2 ratio and 24(S)-OHC in the hippocampus, and prenatal stress may contribute to anxiety via a decrease in serotonin and an increase in corticosterone in the hippocampus. We also found that anxiety-like behavior induced by maternal stress exposure is exacerbated by electromagnetic field radiation.

Open access paper: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0273206

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Chronic blue light leads to accelerated aging in Drosophila by impairing energy metabolism and neurotransmitter levels

Jun Yang, Song Yujuan, Law Alexander D., Rogan Conno J., Shimoda Kelsey, Djukovic Danijel, Anderson Jeffrey C., Kretzschmar Doris, Hendrix David A., Giebultowicz Jadwiga M. Chronic blue light leads to accelerated aging in Drosophila by impairing energy metabolism and neurotransmitter levels. Frontiers in Aging. Vol. 3, 2022, doi: 10.3389/fragi.2022.983373.

Abstract

Blue light (BL) is becoming increasingly prevalent in artificial illumination, raising concerns about its potential health hazard to humans. In fact, there is evidence suggesting that acute BL exposure may lead to oxidative stress and death of retinal cells specialized for photoreception. On the other hand, recent studies in Drosophila melanogaster demonstrated that chronic BL exposure across lifespan leads to accelerated aging manifested in reduced lifespan and brain neurodegeneration even in flies with genetically ablated eyes, suggesting that BL can damage cells and tissues not specialized for light perception. At the physiological level, BL exposure impairs mitochondria function in flies, but the metabolic underpinnings of these effects have not been studied. Here, we investigated effects of chronic BL on metabolic pathways in heads of eyes absent (eya²) mutant flies in order to focus on extra-retinal tissues. We compared metabolomic profiles in flies kept for 10 or 14 days in constant BL or constant darkness, using LC-MS and GC-MS. Data analysis revealed significant alterations in the levels of several metabolites suggesting that critical cellular pathways are impacted in BL-exposed flies. In particular, dramatic metabolic rearrangements are observed in heads of flies kept in BL for 14 days, including highly elevated levels of succinate but reduced levels of pyruvate and citrate, suggesting impairments in energy production. These flies also show onset of neurodegeneration and our analysis detected significantly reduced levels of several neurotransmitters including glutamate and Gamma-aminobutyric acid (GABA), suggesting that BL disrupts brain homeostasis. Taken together, these data provide novel insights into the mechanisms by which BL interferes with vital metabolic pathways that are conserved between fly and human cells.

Open access paper: https://www.frontiersin.org/articles/10.3389/fragi.2022.983373

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Genetic analysis of cryptochrome in insect magnetosensitivity

Kyriacou CP, Rosato E. Genetic analysis of cryptochrome in insect magnetosensitivity. Front Physiol. 2022 Aug 10;13:928416. doi: 10.3389/fphys.2022.928416.

Abstract

The earth's magnetic field plays an important role in the spectacular migrations and navigational abilities of many higher animals, particularly birds. However, these organisms are not amenable to genetic analysis, unlike the model fruitfly, *Drosophila melanogaster,* which can respond to magnetic fields under laboratory conditions. We therefore review the field of insect magnetosensitivity focusing on the role of the Cryptochromes (CRYs) that were first identified in *Arabidopsis* and *Drosophila* as key molecular components of circadian photo-entrainment pathways. Physico-chemical studies suggest that photo-activation of flavin adenine dinucleotide (FAD) bound to CRY generates a FAD^{o-} Trp^{o+} radical pair as electrons skip along a chain of specific Trp residues and that the quantum spin chemistry of these radicals is sensitive to magnetic fields. The manipulation of CRY in several insect species has been performed using gene editing, replacement/rescue and knockdown methods. The effects of these various mutations on magnetosensitivity have revealed a number of surprises that are discussed in the light of recent developments from both *in vivo* and *in vitro* studies.

Open access paper: https://www.frontiersin.org/articles/10.3389/fphys.2022.928416/full

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High-Power Electromagnetic Pulse Exposure (EMP) of Healthy Mice: Effects on Cognition, Neuronal Activity, and Hippocampal Structures

Hao Y, Liu W, Xu Z, Jin X, Ye Y, Yu C, Hu C, Zuo H, Li Y. High-Power Electromagnetic Pulse Exposure of Healthy Mice: Assessment of Effects on Mice Cognitions, Neuronal Activities, and Hippocampal Structures. Front Cell Neurosci. 2022 Jun 29;16:898164. doi: 10.3389/fncel.2022.898164.

Abstract

Electromagnetic pulse (EMP) is a high-energy pulse with an extremely rapid rise time and a broad bandwidth. The brain is a target organ sensitive to electromagnetic radiation (EMR), the biological effects and related mechanisms of EMPs on the brain remain unclear. The objectives of the study were to assess the effects of EMP exposure on mouse cognitions, and the neuronal calcium activities *in vivo* under different cases of real-time exposure and post exposure. EMP-treated animal model was established by exposing male adult C57BL/6N mice to 300 kV/m EMPs. First, the effects of EMPs on the cognitions, including the spatial learning and memory, avoidance learning and memory, novelty-seeking behavior, and anxiety, were assessed by multiple behavioral experiments. Then, the changes in the neuronal activities of the hippocampal CA1 area *in vivo* were detected by fiber photometry in both cases of during real-time EMP radiation and post-exposure. Finally, the structures of neurons in hippocampi were observed by optical microscope and transmission electron microscope. We found that EMPs under this condition caused a decline in the spatial learning and memory ability in mice, but no effects on the avoidance learning and memory, novelty-seeking behavior, and anxiety. The neuron activities of hippocampal CA1 were disturbed by EMP exposure, which were inhibited during EMP exposure, but activated immediately after exposure end. Additionally, the CA1 neuron activities, when mice entered the central area in an Open field (OF) test or explored the novelty in a Novel object exploration (NOE) test, were inhibited on day 1 and day 7 after radiation. Besides, damaged structures in hippocampal neurons were observed after EMP radiation. In conclusion, EMP radiation impaired the spatial learning and memory ability and disturbed the neuronal activities in hippocampal CA1 in mice.

Open access paper: https://www.frontiersin.org/articles/10.3389/fncel.2022.898164/ful

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Evidence for a health risk by RF on humans living around mobile phone base stations

Balmori, A. Evidence for a health risk by RF on humans living around mobile phone base stations: From radiofrequency sickness to cancer. Environmental Research (2022), doi: 10.1016/j.envres.2022.113851.

Abstract

The objective of this work was to perform a complete review of the existing scientific literature to update the knowledge on the effects of base station antennas on humans. Studies performed in real urban conditions, with mobile phone base stations situated close to apartments, were selected. Overall results of this review show three types of effects by base station antennas on the health of people: radiofrequency sickness (RS), cancer (C) and changes in biochemical parameters (CBP). Considering all the studies reviewed globally (n=38), 73.6% (28/38) showed effects: 73.9% (17/23) for radiofrequency sickness, 76.9% (10/13) for cancer and 75.0% (6/8) for

changes in biochemical parameters. Furthermore, studies that did not meet the strict conditions to be included in this review provided important supplementary evidence. The existence of similar effects from studies by different sources (but with RF [radio frequency radiation] of similar characteristics), such as radar, radio and television antennas, wireless smart meters and laboratory studies, reinforce the conclusions of this review. Of special importance are the studies performed on animals or trees near base station antennas that cannot be aware of their proximity and to which psychosomatic effects can never be attributed.

Excerpts

Introduction: During the last few decades, hundreds of thousands of mobile phone base stations and other types of wireless communications antennas have been installed around the world, in cities and in nature, including protected natural areas, in addition to pre-existing antennas (television, radio broadcasting, radar, etc.). Only the aesthetic aspects or urban regulations have been generally considered in this deployment, while the biological, environmental and health impacts of the associated non-ionizing electromagnetic radiation emissions have not been assessed so far. Therefore, the effects on humans living around these anthropogenic electromagnetic field sources (antennas) have not been considered.

In France, there is a significant contribution of mobile phone base stations in the exposure to radiofrequency electromagnetic fields (RF-EMF) of urban citizens living nearby (De Giudici et al., 2021). Some studies from India indicate that more than 15% of people have levels of EMF strength above 12 V/m due to their proximity to antennas (Premlal and Eldhose, 2017). Exposure estimates have shown that RF-EMF from mobile telephone systems is stronger in urban than in rural areas. For instance, in Sweden the levels of RF radiation have increased considerably in recent years, both outdoor and indoor, due to new telecommunication technologies, and the median power density measured for RF fields between 30 MHz and 3 GHz was 16 $\mu W/m^2$ in rural areas, 270 $\mu W/m^2$ in urban areas and 2400 $\mu W/m^2$ in city areas (Hardell et al., 2018). Total exposure varies not only between urban and rural areas but also, depending on residential characteristics, between different floors of a building, with a tendency for building exposure to increase at higher floors (Breckenkamp et al., 2012).

Over the past five decades, and more intensively since the beginning of this century, many studies and several reviews have been published on the effects of anthropogenic electromagnetic radiation on humans living around the antennas. The first studies were carried out with radio and television antennas, investigating increases in cancer and leukaemia (Milham, 1988; Maskarinec et al., 1994; Hocking et al., 1996; Dolk et al., 1997a, 1997b; Michelozzi et al., 1998; Altpeter et al., 2000), as well as around radars (Kolodynski and Kolodynska, 1996; Goldsmith, 1997).

Regarding base station antennas, there are scientific discrepancies in their effects: some studies concluded that there are no health-related effects (e.g. Augner and Hacker, 2009; Blettner et al., 2009; Röösli et al., 2010; Baliatsas et al., 2016) whereas others found increases in cancer and other health problems in humans living around antennas (e.g. Santini et al., 2002; Navarro et al., 2003; Bortkiewicz et al., 2004; Eger et al., 2004; Wolf and Wolf, 2004; Abdel-Rassoul et al., 2007; Khurana et al., 2010; Dode et al., 2011; Shinjyo and Shinjyo, 2014; Gandhi et al., 2015; López et al., 2021; Rodrigues et al., 2021). There is a specific symptomatology linked to radar and RF exposure at low levels, characterized by functional disturbances of the central nervous system (headache, sleep disturbance, discomfort, irritability, depression, memory loss, dizziness, fatigue, nausea, appetite loss, difficulty in concentration, dizziness, etc.), that has been termed ‘RF sickness’ (Lilienfeld et al., 1978; Johnson Lyakouris, 1998; Navarro et al., 2003).

Methods: Only studies performed in real urban conditions, with mobile phone base stations situated close to apartments, were selected. Studies conducted in larger regions with numerous antennas, based on surveys and geographic data, were also included.

Results: The studies that met the selected criteria are presented in chronological order in Table 1, catalogued as Y/N depending on whether or not they found effects. The selected studies cover three types of effects: radiofrequency sickness (RS) (according to Lilienfeld et al., 1978; Johnson Lyakouris, 1998), cancer (C) and changes in biochemical parameters (CBP). Table 1 also includes the authors, year and country, antenna type, study design, diseases and symptoms found/not found and the main conclusions of each study.

Discussion: Considering all the selected studies (n=38), 73.6% (28/38) showed effects: 73.9% (17/23) for radiofrequency sickness, 76.9% (10/13) for cancer and 75.0% (6/8) for changes in biochemical parameters (Figure 1). Therefore, most of the studies carried by research groups from twenty different countries reach the same conclusions.

For the reasons previously explained, the following studies (n=85) were not considered in this review, even though the conclusions of some of these studies will be discussed later due
to their importance regarding the similarities of the electromagnetic radiation types involved and the effects found in many cases....

The results of this review show three types of effects by base station antennas on the health of humans: radiofrequency sickness, cancer and changes in biochemical parameters (Fig. 1). From among all these studies, most of them found effects (73.6%). Thus, despite some limitations and differences in study design, statistical measures, risk estimates and exposure categories (Khurana et al., 2010), together they provide a consistent view of the effects on the health of people living in the vicinity of base station antennas.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) is a private organization that issues exposure guidelines that are then adopted by governments, but it has been accused of having conflicts of interest (Hardell and Carlberg, 2020; Hardell et al., 2021). The ICNIRP (2010, 2020) limits are thousands of times above the levels where effects are recorded for both extremely low frequency and RF man-made EMF and account only for thermal effects, whereas the vast majority of recorded effects are non-thermal. These existing guidelines for public health protection only consider the effects of acute intense (thermal) exposures and do not protect from lower level long-term exposures (Israel et al., 2011; Yakimenko et al., 2011; Blank et al., 2015; Starkey, 2016; Belpomme and Irigaray, 2022). The exposure duration is crucial to assess the induced effects.

Conclusion: In the current circumstances, it seems that the scientific experts in the field are very clear about the serious problems we are facing and have expressed this through important appeals (Blank et al., 2015; Hardell and Nyberg, 2020). However, the media, the responsible organizations (World Health Organization, 2015) and the governments are not transmitting this crucial information to the population, who remain uninformed. For these reasons, the current situation will probably end in a crisis not only for health but also for the technology itself, as it is unsustainable and harmful to the environment and the people.

https://www.sciencedirect.com/science/article/abs/pii/S0013935122011781

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Immunotoxicity of radiofrequency radiation (Review)

Himanshi Yadav, Radhey Shyam Sharma, Rajeev Singh. Immunotoxicity of radiofrequency radiation. Environmental Pollution. 2022. doi: 10.1016/j.envpol.2022.119793.

Highlights

• Drastic growth in communication technologies increased RFR exposure in environment

• Recent evidences show close relation among radiation sensitivity and immune effects

• An intracellular signaling cascade responsible for RFR action on immune system is suggested

• A better understanding of RFR linked cell effects might help radiation protection

• Urgent need to recognize probable hazards of using RFR emitting devices in excess

Abstract

Growing evidence recommends that radiofrequency radiations might be a new type of environmental pollutant. The consequences of RFR on the human immune system have gained considerable interest in recent years, not only to examine probable negative effects on health but also to understand if RFR can modulate the immune response positively. Although several studies have been published on the immune effects of RFR but no satisfactory agreement has been reached. Hence this review aims to evaluate the RFR modulating impacts on particular immune cells contributing to various innate or adaptive immune responses. In view of existing pieces of evidence, we have suggested an intracellular signaling cascade responsible for RFR action. The bio-effects of RFR on immune cell morphology, viability, proliferation, genome integrity, and immune functions such as ROS, cytokine secretion, phagocytosis, apoptosis, etc. are discussed. The majority of existing evidence point toward the possible shifts in the activity, number, and/or function of immunocompetent cells, but the outcome of several studies is still contradictory and needs further studies to reach a conclusion. Also, the direct association of experimental studies to human risks might not be helpful as exposure parameters vary in real life. On the basis of recent available literature, we suggest that special experiments should be designed to test each particular signal utilized in communication technologies to rule out the hypothesis that longer exposure to RFR emitting devices would affect the immunity by inducing genotoxic effects in human immune cells.

Concluding remarks

I. Till date, the bulk of available research articles remarkably indicated the RFR-induced changes in innate and adaptive immune responses. The morphological and physiological modulations in the immune cells were reported such as variation in viability, gene and protein expression, generation of ROS, induction of DNA damage, stimulation of inflammatory markers, altered normal immune functions and eventually provoking inflammatory reactions, chronic allergic reactions, autoimmune responses leading to damaged tissues and organs.

II. The oxidative stress via causing free radical damage to DNA appears to be the main mechanism for RFR action.

III. Many RFR studies showed conflicting conclusions because of the scarcity of subjects, variations in distance from the radiation source, exposure time, RFR frequency, mode of modulation, SAR, or power density used in various studies. Furthermore, studies even with the same experimental design showed varied responses in different types of cells.

IV. On the other hand, the findings from in vitro and in vivo studies on RFR should not be directly linked to human mobile phone usage as the duration and level of exposure to radiofrequency radiation were much higher in experimental studies as compared to what people experience with even high cell phone usage.

V. Collectively, in view of discussed limitations, the available research studies might not be enough to understand the RFR effect on the immune system.

VI. Since, the controversies exist in the recent literature on the effects of RFR on immune cell physiology, substantially more coordinated and detailed studies are needed to set up a definitive trend in RFR effects on immune cells. Such studies are also required to address the important issues of safety for the usage of technologies like cell phones and wireless equipment that are used increasingly in our everyday lives and to revise the current EMF public safety limits.

https://pubmed.ncbi.nlm.nih.gov/35863710/

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Use of mobile phones and progression of glioma incidence since 1979

My notes: Although the title of this IARC report is in German, the report is available in English. The report's summary, "no indications of a detectable effect of mobile phones have been found," seems misleading because it is inconsistent with the report's final conclusion, namely "An increased risk in the 10% heaviest mobile phone users was an exception to this general situation, as it remained plausible."

The report's bottom line: "This ecological data is not sufficient to dismiss every potential mobile phone related risk scenario, but suggests that the risk – if it exists - would be very small, only occur after very long latency periods of several decades, or only affect small subgroups within glioma patients."

If only a portion of the population has a genetic susceptibility to brain cancer in the presence of microwave radiation as appears to be the case with thyroid cancer (Luo et al., 2020), that could explain why the odds ratios obtained for brain cancer risk from case-control studies of heavy, long-term mobile phone users over-predict glioma incidence in the overall population based upon tumor registry data.

* Luo J, Li H, Deziel NC, Huang H, Zhao N, Ma S, Nie X, Udelsman R, Zhang Y. Genetic susceptibility may modify the association between cell phone use and thyroid cancer: A population-based case-control study in Connecticut. Environmental Research. 2020 Mar;182:109013. doi: 10.1016/j.envres.2019.109013.

Deltour I, Schuz J. Nutzung von Mobiltelefonen und Verlauf der Gliom-Inzidenz seit 1979: Vorhaben 3618S00000 (FM 8867). International Agency for Research on Cancer. Jun 2022.

Summary

1.1 Introduction

In the Nordic countries, the sharp increase in the use of mobile phone occurred in the mid-1990s among adults; thus, time trends in glioma incidence rates (IR) may provide information about possible risks associated with mobile phone use. We investigated time trends in IR of glioma, and compared IR and observed number of cases to those that would be expected under a range of hypothetical mobile phone risk scenarios, encompassing risk levels reported in published case-control studies.

1.2 Methods

We analyzed age standardised IR of glioma in Denmark, Finland, Norway, and Sweden among adults 20-84 years old, using data from national cancer registries and population data covering the period 1979-2016, using a log linear joinpoint analysis. Exposure distribution of use and of high level of use were obtained from self-reported information in the Nordic Interphone, the Cosmos-Denmark and the Cosmos-France datasets. Based on analytical epidemiological studies, we considered various scenarios according to which mobile phone use would hypothetically increase the glioma risk. We quantified compatibility, or absence of compatibility between the observed data and the risk scenarios by projecting incidence rates of glioma of men aged 40-69 years old under these scenarios and comparing them with the observed incidence rates in the Nordic countries.

1.3 Results

Glioma IR increased regularly with annual percent change (APC) of 0.6 (95% confidence interval (CI) 0.4-0.7) in men and 0.3 (95%CI 0.2-0.5) in women in the period 1979-2016. There were hardly any changes in IR among men and women below age 59. In men and women in their sixties, IR increased by 0.6 (95%CI 0.4-0.9) in men and 0.4 (95%CI 0.2-0.7) in women, regularly for the whole period of observation, while IR among 70-84 years old increased very markedly, with APC of 3.1 (95%CI 2.6-3.5) among men and 2.8 (95%CI 2.3-3.3) among women over at least the last 2 decades of observation. Very few risk scenarios appeared compatible with the observed data using standardised incidence ratios analyses. The risk scenarios that appeared compatible involved either long latencies (20 years), or very low risks (RR = 1.08); in these projections, risks that would be limited to mobile phone heavy users were not compatible with the observed number of cases.

1.4 Discussion

IR time trends did not demonstrate breakpoints in their secular evolution in the last 20 years. Virtually all the reported results from the case-control studies with a positive association between mobile phone use and glioma risk were shown to be implausible in our simulations comparing them with the observed incidence rates, implying that biases and errors have likely distorted their findings; very low risks at the population level, and risks after very long latencies remained plausible. Simulations were based on high quality case registration,

which is a strength, while the uncertainties in the exposure information and the limited information about some of the model's assumptions were limitations. Altogether, this study confirms and reinforces conclusions made previously, that no indications of a detectable effect of mobile phones have been found.

Excerpts

... We analyzed the time trends in the incidence rates of glioma among adults aged 20 to 84 years of the Nordic countries from 1979 to 2016 (step 1 of the work description). Then, we addressed the question whether the observed time trends and observed number of cases were statistically different from the one we would observe if we assumed that the use of mobile phones caused glioma, so if we assumed that there was a true causal association (step 2 and step 3 of the work description). Within this, we delineated the levels of risks and the duration of induction periods that would not be compatible with the observed time trends and numbers of cases in this population (step 3 of the work description). We also discussed these findings in light of some of the elevated OR found in the literature. The study tested the consistency between risks that have been reported and the effect they would have had at the level of the population, had they been true. Noteworthy, the study was not meant to dismiss every single hypothetical association, as it would most likely always be possible to devise a pattern of risk that would fit the data....

This study was based on 28,015 male and 20,630 female glioma cases diagnosed from 1979 to 2016 in Denmark, Finland, Norway and Sweden (called "the Nordic countries" in the following). In 2016, the number of glioma cases was 1,724 in a population of 19.7 million adults aged 20–84 years. Over the last 10 years of data, Sweden accounted for 38% of the population and of the cases; of the remainder, Denmark, Finland, and Norway had populations of similar size. The age-standardized incidence rates were higher in men (9.1 per 100000 person years) than in women (6.1 per 100 000 person years), and higher with increasing age. All countries had comparable rates; Norway had slightly higher rates, while Finland had slightly lower rates in both sexes (Table 2 and Table 3).

Joinpoint analyses described in paragraph 6.1 showed that overall, the trends were smooth: glioma rates increased by 0.6% (95% CI 0.4%-0.7%) per year in men and 0.3% (95% CI 0.2%-0.5%) per year in women over the period 1979-2016 in the Nordic countries combined (Table 4 and Table 5), and in each country separately except for a marked increase in 1979-1984 in Swedish men (APC about 6%). For the younger age groups (20-39 and 40-59 years old), the time trends were smooth and did not demonstrate strong increases at any point in time during the period 1979 to 2016 in any country among men (Table 6), and women (Table 7). Below the age of 60, incidence rates were generally stable over the whole period (Figure 1, Table 6 and Table 7). Among people aged 60-69 years old, incidence rates increased gradually by 0.6% in men and 0.4% in women per year, and these regular increases with no joinpoint were observed in every country and at a very similar rate in both sexes, except among Swedish women, whose rates showed a slight decrease. Irregular patterns were observed among the persons aged 70-84 years old at the beginning of the observation period, while for at least the last 12 years of observation, all countries showed highly increasing rates. Exceptions to this general pattern were noted among the Finnish males and the Norwegian females, in which an increase was seen at the beginning of the observation period that lasted at least 21 years.

The analysis by subgroups of tumour types could be performed only for the period 1990-2016 for reasons of data availability: in Sweden, a separate code for glioblastoma did not exist prior to 1993, and very few of the tumours which had been diagnosed during the period 1990-1992 were retrospectively coded into this code. Indeed, cancer registries are continuously updated when additional information becomes available on an earlier diagnosis, for example.

Among men and women, the rates of glioblastomas increased in the last years of observations, while the rate of other high-grade gliomas decreased (Table 8 and Table 9). Rates of low grade gliomas were relatively stable in all countries since the mid 1990's except in Denmark, where substantial increases were noted towards the end of the period of observation, albeit non-significant....

When examining the trends by subtypes, glioblastoma generally increased while other high grade gliomas decreased, and low grade glioma were stable in the most recent period, except in Denmark where low grade glioma rates increased among men and women in the last 3 years of observation. In Sweden, the rates of glioblastoma underwent most changes, namely the increase in glioblastoma rates in Sweden in the years after the introduction of that code by the cancer registry, since a new code is not mandatorily fully used immediately after it is introduced....

To sum up, our simplified and more sophisticated analyses appeared to indicate that the small increase in IR of men age 40-59 and the marked increase in RR of men aged 60-69 were generally not compatible with the same mobile phone related risks increases. When models in which the totality of the IR increases were assumed to be associated with mobile phone effects, a RR of 1.31 that would start 20 years after first using a mobile phone was borderline compatible between these 2 age groups, while all other induction periods (0, 5, 10, 15 years) or heavy users risk scenarios produced RR estimates and CI which did not overlap between the 2 age groups when the same exposure distribution was considered. When half of the IR increases were attributed to other factors, none of the mobile phone related risks scenarios were compatible with the data, in the SIR analyses (assuming the same risk in both age groups). When most (75%) of the IR increases were attributed to other factors, then small excess risks (RR= 1.08 applying to all users after 10 years) or risks after long latencies (RR = 1.3 applying to all users after 20 years) were compatible with the observed incidence rates and exposure distributions that we assumed. Further work on these scenarios could shed more light on the remaining uncertainties. Of note, scenarios of risks limited to heavy users groups did not appear compatible with the observed number of cases in these analyses....

Our simulation study is not free of assumptions. The induction period relating mobile phone use and glioma risk, if such an association exists, is unknown, so is the magnitude of the risk, and the real patterns may be more complex than the scenarios that we simulated. In addition, there are several factors that we did not account for. The coverage of the Nordic cancer registries was not complete, but some 1.5% to 10% of the malignant tumours were missed in this age group. In Sweden, it has been estimated that completeness would not have changed over the period 1998-2014, while completeness might have improved in other countries. We modelled that other, yet to be discovered, risk factors of the disease as well as improvement in its detection and reporting had a smooth, gradual impact, over the period 1979–2016, which is consistent with the gradually increasing IR. We used 3 sources of information on the use of mobile phones, all self-reported, to evaluate the prevalence of use and heavy use up to 2002, 2008 or 2016 and extrapolated the prevalences for the periods and age groups for

which no data was available, based on the trends observed in the other age groups. The use of hands-free devices was not accounted for, although this was not frequent in these populations (data not shown).

In conclusion, it is difficult to demonstrate the absence of risk, in real life condition, and assumptions about the impact of the improvement of diagnosis tools, treatment and registration changes over time were used in our simulations. However, based both on the observed IR and the simulations, we reiterate and strengthen our previous conclusion that, the risk, should one exist, ought to be lower or occur after a longer induction period or act on a smaller population, or a combination of these, than most of the level of risk that have been reported in previously published case-control studies.

Conclusions

In this project we projected incidence rates of glioma under various scenarios of mobile phone-associated increased glioma risks, and compared them with the observed incidence rates in the Nordic countries. The comparison was carried out on the data of men aged 40 to 69 years. The modelled scenarios included risk increases reported from analytical epidemiological studies, which were all of case-control design. Most of those results were shown to be implausible in our simulations, implying that biases and errors in the self-reported use of mobile phones have likely distorted their findings. An increased risk in the 10% heaviest mobile phone users was an exception to this general situation, as it remained plausible. Results of cohort studies showing no association were compatible with observed incidence rates. We also studied what hypothetical mobile phone-related risks were conceivable if the changes in incidence rates in 40-59 year old and 60-69 year old men were fully attributable to mobile phone use. The fact that we observed different hypothetical risks in these two age groups while research at present has not suggested that older men should have higher risk related to mobile phone use than younger men, does not align with the assumption that mobile phone exposures caused the incidence rate trends. This ecological data is not sufficient to dismiss every potential mobile phone related risk scenario, but suggests that the risk – if it exists - would be very small, only occur after very long latency periods of several decades, or only affect small subgroups within glioma patients.

Open access report: https://doris.bfs.de/jspui/bitstream/urn:nbn:de:0221-2022063033222/4/BfS_2022_3618S00000.pdf

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Improvement of several stress response and sleep quality hormones in men and women after sleeping in a bed that protects against electromagnetic fields

Díaz-Del Cerro E, Félix J, Tresguerres J, De la Fuente M. Improvement of several stress response and sleep quality hormones in men and women after sleeping in a bed that protects against electromagnetic fields. Environ Health. 2022 Jul 22;21(1):72. doi: 10.1186/s12940-022-00882-8.

Abstract

Background: The electromagnetic fields (EMFs) emitted by the technologies affect the homeostatic systems (nervous, endocrine, and immune systems) and consequently the health. In a previous work, we observed that

men and women, after 2 months of using a bed with a registered HOGO system, that prevents and drain EMFs, improved their immunity, redox and inflammatory states and rejuvenated their rate of aging or biological age. Since, EMFs can act as a chronic stressor stimulus, and affect the sleep quality. The objective of this work was to study in men and women (23-73 years old) the effect of sleeping for 2 months on that bed in the blood concentrations of several hormones related to stress response and sleep quality as well as to corroborate the rejuvenation of their biological age.

Methods: In 18 men and women, plasma concentration of cortisol, dehydroepiandrosterone (DHEA), catecholamines (epinephrine, norepinephrine and dopamine), serotonin, oxytocin and melatonin were analyzed before and after 2 months of using the HOGO beds. A group of 10 people was used as placebo control. In another cohort of 25 men (20 experimental and 5 placebo), the effects of rest on the HOGO system on the concentration of cortisol and testosterone in plasma were studied. In all these volunteers, the biological age was analyzed using the Immunity Clock model.

Results: There is a significant increase in plasma concentration of DHEA, norepinephrine, serotonin, oxytocin, and melatonin as well as in testosterone, after resting for 2 months in that bed with the EMFs avoiding system. In addition, decreases in Cortisol/DHEA and Testosterone/cortisol ratio and plasma dopamine concentration were observed. No differences were found in placebo groups. In all participants that slept on HOGO beds, the biological age was reduced.

Conclusions: Sleeping in a bed that isolates from EMFs and drain them can be a possible strategy to improve the secretion of hormones related to a better response to stress and sleep quality, which means a better endocrine system, and consequently better homeostasis and maintenance of health. This fact was confirmed with the slowdown in the rate of aging checked with a rejuvenation of the biological age.

Open access paper: https://ehjournal.biomedcentral.com/articles/10.1186/s12940-022-00882-8

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Empirical Study of the Stochastic Nature of Electromagnetic Field Exposure in Massive MIMO Systems (5G)

F. Héliot, T. H. Loh, D. Cheadle, Y. Gui, M. Dieudonne. An Empirical Study of the Stochastic Nature of Electromagnetic Field Exposure in Massive MIMO Systems. *IEEE Access*, vol. 10, pp. 63100-63112, 2022, doi: 10.1109/ACCESS.2022.3182236.

Abstract

Base stations (BSs) rely on the massive multiple-input multiple-output (mMIMO) technology in the fifth generation of mobile networks (5G). A technology having a major impact on the nature of the electromagnetic field (EMF) exposure in such systems. This work has used a fully reconfigurable mMIMO testbed (operating at 2.63 GHz), capable of mimicking realistic 5G new radio (NR) BS beamforming performance, to first gather experimental-based evidence of 5G BS EMF exposure within a real-world outdoor environment, to then analyze its stochastic behaviour, and to finally understand its impact on the definition of exclusion boundaries for 5G BSs. The exposure data of our testbed have been complemented by exposure data collected from a typical

commercial 5G BS (operating at 3.65 GHz) to confirm the result trends and findings of our analysis. A robust metrology has been followed to obtain all the EMF exposure data. Our data and analysis indicate that significant exposure variations can be noticed according to the beam directions, i.e. the relative position of the exposure measurement location to the beam directions as well as the environment, confirming the stochastic nature of 5G BS exposure. The variance of the exposure tends to decrease as the number of users increase for a constant traffic load. Whereas the exposure grows sub-linearly with the traffic load, regardless of the number of users. As far as the exclusion boundary of 5G BS is concerned, its revised definition based on 95-th percentile seems still not flexible enough to accommodate the deployment of 5G BS in countries/places with stringent EMF exposure limits, as for instance in Belgium.

Conclusion

This paper has studied the stochastic nature of the EMF exposure and how it can impact the de finition of the exclusion boundary, especially under the constraint of stringent exposure limits, by relying on two different approaches for gathering experimental-based evidences. First we have used a fully reconfi gurable mMIMO testbed for evaluating the spatial and temporal variations of the RF-EMF exposure in a controlled outdoor scenario. Then, we have used a typical commercial 5G BS to complement/confirm some of the results/trends obtained via the mMIMO testbed. Several important insights can be inferred from our measurement campaign results:

EMF exposure due to 5G BS grows linearly with the number of utilized RF chains at the BS.

Significant exposure variations can result from the beam directionality, i.e. the relative position of the exposure measurement location to the beam direction has a significant impact on the measured exposure. This suggests a very dynamic/changing exposure environment driven by active UEs in 5G, in clear contrast with previous cellular technologies.

Environmental effects, such as indirect propagation paths (e.g. re flecting off objects) or blocked paths can also create further variations.

The variance of the exposure tends to decrease as the number of active UEs increases when the traffic remains constant, or in other words it becomes more deterministic. Whereas the exposure grows sub-linearly with the traffi c, regardless of the number of active UEs.

The statistical distribution of EMF exposure for 5G BSs should be better understood and probably taken into account for defi ning the exclusion boundary. The results of our two measurement campaigns indicate that the statistics of different 5G BSs are not necessarily the same, i.e., the exposure of our mMIMO testbed BS follows a Poisson distribution while the commercial 5G BS exposure is closer to a normal distribution. In turn, this can impact the exclusion boundary size when it is defi ned as a particular percentile of the exposure cdf.

Defining the BS exclusion boundary based on the 95-th percentile seems to not be a exible enough approach to accommodate the deployment of 5G BS in countries/places with stringent EMF exposure limits. Our measurement results correspond to a boundary size in the order of several tens of meters for an exposure limit of 6 V/m based on the 95-th percentile. The quality and quantity of field strength data collection need to be

carefully considered to properly tune the extrapolation parameters in the SSB method as well as to accurately model the EMF exposure distribution of a particular 5G BS site.

In the future, we would like to extend this work to mm-wave frequencies and build an empirical statistical model of the EMF exposure based on the same metrology approach.

https://ieeexplore.ieee.org/document/9794655

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Computational Assessment of RF Exposure Levels due to 5G Mobile Phones

M. Bonato *et al*. Computational Assessment of RF Exposure Levels due to 5G Mobile Phones*. 2022 Microwave Mediterranean Symposium (MMS)*, 2022, pp. 1-4, doi: 10.1109/MMS55062.2022.9825603.

Abstract

The present work was performed to expand the knowledge on human RF-EMF exposure, considering the use of mm-wave spectrum in mobile communication applications, due to the deployment of 5th generation (5G) networks. The mobile antenna was modelled based on the 5G innovation technologies (i.e., mm-Wave bands, beamforming capability and high gain), resulting in a phased array antenna with 8 elements at the working frequency of 27 GHz. Three different skin layers models were simulated, to spot differences in the peaks of absorbed power density averaged over 4 cm^2, following the ICNIRP guidelines. The simulations were implemented using the Sim4Life platform, simulating not only the presence of a mobile phone user, but also of a person passing nearby, who could be hit by the phased array antenna main beam. This work underlined that the absorbed power density peaks were greatly underestimated using the homogeneous skin model, respect to the multi-layers skin models. Moreover, for the person passing nearby, we found slightly higher exposure levels than those assessed for the mobile phone user. Lastly, in all the examined cases, the limits indicated by the ICNIRP guidelines were well respected.

Excerpt

These findings are also confirmed evaluating the three different configurations for the other two multi-layers models and analyzing the peak values of Sab in the most superficial tissue (i.e., the dermis in the homogeneous model and the stratum corneum in the two multi-layers models). Indeed, as we can see from Fig. 3, where the peak values of Sab are illustrated, the highest exposure levels are obtained for the person passing nearby. The highest peak value for the person passing nearby is obtained for the three-layers skin model, in the configuration where both the user and the person nearby are considered, with values equal to 6.97 W/m2 > whereas the highest peak value for the user is obtained in the same configuration, but for the four-layers model, with value equal to 5.80 W/m2.

Interestingly, the results showed that the use of a homogenous skin model could led to underestimate the exposure peak levels from 18% to 55% respect to the use of multi-layer models. This is probably due to the

multiple reflections of the mm-waves that occur at the boundaries of the different tissue layers, and it is in line with other literature studies, where it was underlined the need to use multi-layers models for assessing the exposure levels when the mm-wave spectrum is considered [13], [16].

Lastly, all the peak values obtained greatly respected the basic restrictions of 20 W/m2, indicated in the ICNIRP guidelines [7].

https://ieeexplore.ieee.org/document/9825603

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A meta-analysis of the risk of salivary gland tumors associated with mobile phone use: the importance of correct exposure assessment

Vijayan K, Eslick GD. A meta-analysis of the risk of salivary gland tumors associated with mobile phone use: the importance of correct exposure assessment. Rev Environ Health. 2022 Jul 11. doi: 10.1515/reveh-2022-0055.

Abstract

Objectives: To investigate the risk of developing salivary gland tumors associated with the use of mobile phones.

Content: There have been a number of epidemiological studies conducted to assess for a possible association between mobile phone usage and the development of intracranial tumours, however results have been conflicting. We conducted an extensive literature search across four different databases. After selecting the articles relevant to the area of study, a total of seven studies were included in this meta-analysis, with no restrictions set on publication date or language. Studies were qualitatively assessed using the Newcastle-Ottawa scale. No significant association between the use of mobile phones and salivary gland tumors was observed (OR=1.06, 95% CI=0.86-1.32). No evidence for publication bias was detected.

Summary and outlook: Our findings indicate no significant association between mobile phone usage and salivary gland tumours. However, there were many limitations encountered in these studies, suggesting that the observed result may not be an accurate estimate of the true carcinogenic risk of mobile phones, especially for heavy long-term users. In fact, the studies included in this meta-analysis highlight the need to correctly define exposure assessment in order to ascertain the risk of a certain variable.

https://pubmed.ncbi.nlm.nih.gov/35822706/

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The Protective Effects of EMF-LTE against DNA Double-Strand Break Damage In Vitro and In Vivo

Hee Jin, Kyuri Kim, Ga-Young Park, Minjeong Kim, Hae-June Lee, Sangbong Jeon, Ju Hwan Kim, Hak Rim Kim, Kyung-Min Lim, Yun-Sil Lee. 2021. The Protective Effects of EMF-LTE against DNA Double-Strand Break Damage In Vitro and In Vivo. *International Journal of Molecular Sciences* 22, 10: 5134. doi: 10.3390/ijms22105134.

Abstract

With the rapid growth of the wireless communication industry, humans are extensively exposed to electromagnetic fields (EMF) comprised of radiofrequency (RF). The skin is considered the primary target of EMFs given its outermost location. Recent evidence suggests that extremely low frequency (ELF)-EMF can improve the efficacy of DNA repair in human cell-lines. However, the effects of EMF-RF on DNA damage remain unknown. Here, we investigated the impact of EMF-long term evolution (LTE, 1.762 GHz, 8 W/kg) irradiation on DNA double-strand break (DSB) using the murine melanoma cell line B16 and the human keratinocyte cell line HaCaT. EMF-LTE exposure alone did not affect cell viability or induce apoptosis or necrosis. In addition, DNA DSB damage, as determined by the neutral comet assay, was not induced by EMF-LTE irradiation. Of note, EMF-LTE exposure can attenuate the DNA DSB damage induced by physical and chemical DNA damaging agents (such as ionizing radiation (IR, 10 Gy) in HaCaT and B16 cells and bleomycin (BLM, 3 μM) in HaCaT cells and a human melanoma cell line MNT-1), suggesting that EMF-LTE promotes the repair of DNA DSB damage. The protective effect of EMF-LTE against DNA damage was further confirmed by attenuation of the DNA damage marker γ-H2AX after exposure to EMF-LTE in HaCaT and B16 cells. Most importantly, irradiation of EMF-LTE (1.76 GHz, 6 W/kg, 8 h/day) on mice in vivo for 4 weeks reduced the γ-H2AX level in the skin tissue, further supporting the protective effects of EMF-LTE against DNA DSB damage. Furthermore, p53, the master tumor-suppressor gene, was commonly upregulated by EMF-LTE irradiation in B16 and HaCaT cells. This finding suggests that p53 plays a role in the protective effect of EMF-LTE against DNA DSBs. Collectively, these results demonstrated that EMF-LTE might have a protective effect against DNA DSB damage in the skin, although further studies are necessary to understand its impact on human health.

Open access paper: https://www.mdpi.com/1422-0067/22/10/5134

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Idiographic approach to idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF) part I. Environmental, psychosocial & clinical assessment of 3 individuals with severe IEI-EMF

Dömötör Z, Szabolcs Z, Bérdi M, Witthöft M, Köteles F, Szemerszky R. An idiographic approach to idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF) part I. Environmental, psychosocial and clinical assessment of three individuals with severe IEI-EMF. Heliyon. 2022 Jul 16;8(7):e09987. doi: 10.1016/j.heliyon.2022.e09987.

Abstract

IEI-EMF refers to an environmental illness whose primary feature is the occurrence of symptoms that are attributed to exposure to weak electromagnetic fields (EMFs). There is a growing evidence that this condition is characterized by marked individual differences thus a within-subject approach might add important information beyond the widely used nomothetic method. A mixed qualitative/quantitative idiographic protocol with a threefold diagnostic approach was tested with the participation of three individuals with severe IEI-EMF. In this qualitative paper, the environmental, psychosocial, and clinical aspects are presented and discussed (results of ecological momentary assessment are discussed in Part II of this study). For two participants, psychopathological factors appeared to be strongly related to the condition. Psychological assessment indicated a severe pre-

psychotic state with paranoid tendencies, supplemented with a strong attentional focus on bodily sensations and health status. The psychological profile of the third individual showed no obvious pathology. Overall, the findings suggest that the condition might have uniformly been triggered by serious psychosocial stress for all participants. Substantial aetiological differences among participants with severe IEI-EMF were revealed. The substantial heterogeneity in the psychological and psychopathological profiles associated with IEI-EMF warrants the use of idiographic multimodal assessments in order to better understand the different ways of aetiology and to facilitate person-taylored treatments.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9305360/

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Short-term exposure to radiofrequency radiation and metabolic enzymes' activities during pregnancy and prenatal development

Tomruk A, Ozgur-Buyukatalay E, Ozturk GG, Ulusu NN. Short-term exposure to radiofrequency radiation and metabolic enzymes' activities during pregnancy and prenatal development. Electromagn Biol Med. 2022 Jul 29:1-9. doi: 10.1080/15368378.2022.2104309.

Abstract

Radiofrequency radiation (RFR) as an environmental and physical pollutant may induce vulnerability to toxicity and disturb fetal development. Therefore, the potential health effects of short-term mobile phone like RFR exposure (GSM 1800 MHz; 14 V/m, 2 mW/kg specific absorption rate (SAR) during 15 min/day for a week) during pregnancy and also the development of fetuses were investigated. Hepatic glucose regulation and glutathione-dependent enzymes' capacities were biochemically analyzed in adult (female) and pregnant New Zealand White rabbits. Pregnant rabbits' two-day-old offspring were included to understand their developmental stages under short-term maternal RFR exposure. We analyzed two regulatory enzymes in the oxidative phase of phosphogluconate pathways to interpret the cytosolic NADPH's biosynthesis for maintaining mitochondrial energy metabolism. Moreover, the efficiencies of maternal glutathione-dependent enzymes on both the removal of metabolic disturbances during pregnancy and fetus development were examined. Whole-body RFR exposures were applied to pregnant animals from the 15th to the 22nd day of their gestations, i.e., the maturation periods of tissues and organs for rabbit fetuses. There were significant differences in hepatic glucose regulation and GSH-dependent enzymes' capacities with pregnancy and short-term RFR exposure. Consequently, we observed that intrauterine exposure to RFR might lead to cellular ROS- dependent disturbances in metabolic activity and any deficiency in the intracellular antioxidant (ROS-scavenging) system. This study might be a novel insight into further studies on the possible effects of short-term RF exposure and prenatal development.

https://pubmed.ncbi.nlm.nih.gov/35904122/

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Immune Responses to Multi-Frequencies of 1.5 GHz and 4.3 GHz Microwave Exposure in Rats: Transcriptomic and Proteomic Analysis

Zhao L, Yao C, Wang H, Dong J, Zhang J, Xu X, Wang H, Yao B, Ren K, Sun L, Peng R. Immune Responses to Multi-Frequencies of 1.5 GHz and 4.3 GHz Microwave Exposure in Rats: Transcriptomic and Proteomic Analysis. Int J Mol Sci. 2022 Jun 22;23(13):6949. doi: 10.3390/ijms23136949.

Abstract

With the rapidly increasing application of microwave technologies, the anxiety and speculation about microwave induced potential health hazards has been attracting more and more attention. In our daily life, people are exposed to complex environments with multi-frequency microwaves, especially L band and C band microwaves, which are commonly used in communications. In this study, we exposed rats to 1.5 GHz (L10), 4.3 GHz (C10) or multi-frequency (LC10) microwaves at an average power density of 10 mW/cm^2. Both single and multi-frequency microwaves induced slight pathological changes in the thymus and spleen. Additionally, the white blood cells (WBCs) and lymphocytes in peripheral blood were decreased at 6 h and 7 d after exposure, suggesting immune suppressive responses were induced. Among lymphocytes, the B lymphocytes were increased while the T lymphocytes were decreased at 7 d after exposure in the C10 and LC10 groups, but not in the L10 group. Moreover, multi-frequency microwaves regulated the B and T lymphocytes more strongly than the C band microwave. The results of transcriptomics and proteomics showed that both single and multi-frequency microwaves regulated numerous genes associated with immune regulation and cellular metabolism in peripheral blood and in the spleen. However, multi-frequency microwaves altered the expression of many more genes and proteins. Moreover, multi-frequency microwaves down-regulated T lymphocytes' development, differentiation and activation-associated genes, while they up-regulated B lymphocytes' activation-related genes. In conclusion, multi-frequency microwaves of 1.5 GHz and 4.3 GHz produced immune suppressive responses via regulating immune regulation and cellular metabolism-associated genes. Our findings provide meaningful information for exploring potential mechanisms underlying multi-frequency induced immune suppression.

Open access paper: https://www.mdpi.com/1422-0067/23/13/6949

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Estimation of some antioxidants for people exposed to electromagnetic waves for Internet towers in Samarra

Methaq Nazhan Mahmood, Asmaa Hashim Shaker, Humam E. Mohammed. Estimation of some antioxidants for people exposed to electromagnetic waves for Internet towers in Samarra. e79J Popul Ther Clin Pharmacol Vol 29(2):e79–e87; 16 June 2022. doi: 10.47750/jptcp.2022.934.

Abstract

The current study was conducted in Samarra city, as a preliminary study to explore the impact of the presence of Internet network towers inside cities and on residential homes and its impact on people exposed directly and indirectly. The study included collecting samples from people exposed to the radioactive frequencies of Internet towers for periods ranging from (1-5) years and from (5- 10) years. The number of samples was 43 samples of females and males exposed (present in the places where the constellations are located), and 20 samples not exposed (in places far from the towers) as a control group, and the ages ranged between (20-35) years. Analysis and measurements were made for some antioxidants because it is one of the most essential lines of defense

against free radicals that cause many diseases and premature aging, which included the concentration of the enzyme glutathione peroxidase PGx, the enzyme superoxide dismutase SOD, glutathione GSH, dimalondhyde MDA, and ONOO. The results showed a significant increase in the level of glutathione peroxidase enzyme concentration and the concentration of superoxide dismutase in the blood serum for people exposed to electromagnetic waves from the Internet towers compared to the control group. The results also showed a significant decrease in the level of GSH in the blood serums of people exposed to electromagnetic waves of the Internet towers compared to the control group. The results also showed a significant increase in the concentration of both MDA and peroxynitrite ONOO compared to the non-exposed subjects in the control group.

Open access paper: https://www.jptcp.com/index.php/jptcp/article/view/934/895

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Measurement and image-based estimation of dielectric properties of biological tissues -past, present, and future

Sasaki K, Porter E, Rashed EA, Farrugia L, Schmid G. Measurement and image-based estimation of dielectric properties of biological tissues -past, present, and future. Phys Med Biol. 2022;67(14):10.1088/1361-6560/ac7b64. Published 2022 Jul 8. doi:10.1088/1361-6560/ac7b64.

Abstract

The dielectric properties of biological tissues are fundamental pararmeters that are essential for electromagnetic modeling of the human body. The primary database of dielectric properties compiled in 1996 on the basis of dielectric measurements at frequencies from 10 Hz to 20 GHz has attracted considerable attention in the research field of human protection from non-ionizing radiation. This review summarizes findings on the dielectric properties of biological tissues at frequencies up to 1 THz since the database was developed. Although the 1996 database covered general (normal) tissues, this review also covers malignant tissues that are of interest in the research field of medical applications. An intercomparison of dielectric properties based on reported data is presented for several tissue types. Dielectric properties derived from image-based estimation techniques developed as a result of recent advances in dielectric measurement are also included. Finally, research essential for future advances in human body modeling is discussed.

Open access paper: https://iopscience.iop.org/article/10.1088/1361-6560/ac7b64

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Effects of phone mast-generated electromagnetic radiation gradient on the distribution of terrestrial birds and insects in a savanna protected area

Nyirenda, V.R., Namukonde, N., Lungu, E.B. *et al.* Effects of phone mast-generated electromagnetic radiation gradient on the distribution of terrestrial birds and insects in a savanna protected area. *Biologia* (2022). https://doi.org/10.1007/s11756-022-01113-8

Abstract

Inappropriate deployment of linear physical infrastructures, such as game fences, roads, electric power-lines, buildings, and phone masts can be detrimental to wild fauna. Fatalities arising from wildlife collisions with such infrastructure have been widely documented. However, there are non-physical and less studied effects, such as the 'hidden' negative ecological effects of electromagnetic radiation (EMR) on terrestrial fauna. In this study, the effects of phone mast-generated EMR on abundance, richness and distribution of terrestrial birds and insects in the Kafue National Park were studied. Ten (10) sample plots of 100 m × 100 m each were set at three (3) radial locations, based on the phone mast generated EMR strengths. For birds, point counts, while hand collection, cryptic searching, vegetation beating, sweep netting, pitfall trapping, sorting and identification for insects were employed for data collection. Data were analysed using biological indices (i.e., Shannon-Wiener and Simpson's) and Analysis of Variance (ANOVA). The wildlife diversity significantly reduced with increasing EMR strengths, especially in areas (<12 km from phone mast) with greater than 250 ± 20 µA/m EMR levels. We suggest that deployment of wireless telecommunication infrastructure should take into account EMR levels, safe zones and avoid or minimize biological loss in hotspots.

https://link.springer.com/article/10.1007/s11756-022-01113-8

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Locomotor Activity of *Ixodes ricinus* Females in 900 MHz Electromagnetic Field

Vargová B, Majláth I, Kurimský J, Cimbala R, Zbojovský J, Tryjanowski P, Majláthová V. Locomotor Activity of *Ixodes ricinus* Females in 900 MHz Electromagnetic Field. Life (Basel). 2022 Jun 13;12(6):884. doi: 10.3390/life12060884.

Abstract

Mobile telecommunications technologies have become an indispensable part of people's lives of all ages around the world. They affect personal life and social interactions and are a work tool in the work routine. Network availability requirements and the quality of the Internet connection are constantly increasing, to which telecommunications providers are responding. Humans and wildlife live in the permanent presence of electromagnetic radiation with just a minor knowledge of the impact this radiation has. The aim of our study was to investigate the effect of a 900 MHz electromagnetic field (EMF) on the locomotor behavior of female *Ixodes ricinus* ticks under laboratory conditions. Experiments were performed in the radiation-shielded tube (RST) test and radiation-shielded circular open-field arena placed in an anechoic chamber. Altogether, 480 female *I. ricinus* ticks were tested. In the RST arena, no differences in preference for irradiated and shielded parts of experimental modules were observed; in the open-field arena, the time spent and the trajectory passed was significantly longer in the part exposed to the EMF.

Conclusions

Cell phone use, an exponentially expanding phenomenon introducing electromagnetic load in the environment, inevitably has a biological effect on all living organisms. This does not exclude ticks, epidemiologically very important parasites. EMFs emit a very weak signal to animals (vertebrate and invertebrates), and the evidence of animal response to this signal may be diminished by the plethora of other, stronger signals. To provide evidence unequivocally showing the response to the presence of an EMF is difficult and needs different approaches, such as behavioral tests, and possibly evidence on molecular levels. The number of publications in this field is rising very slowly. In our pilot study, we determined that ticks reacted to the presence of a man-made EMF and a change in the *I. ricinus* female tick locomotor behavior occurred when exposed to 900 MHz frequency. In future studies, it is crucial to test other frequencies, other EMF sources, other tick species, and possibly use the results of behavioral tests as a starting point leading to studying the impact and the changes triggered by EMF exposure at the cellular or molecular level.

Open access paper: https://www.mdpi.com/2075-1729/12/6/884

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Uptake of nanoparticles from sunscreen physical filters into cells from increased environmental microwave radiation: increased potential risk of use of sunscreens to human health

Horikoshi, S., Iwabuchi, M., Kawaguchi, M. *et al.* Uptake of nanoparticles from sunscreen physical filters into cells arising from increased environmental microwave radiation: increased potential risk of the use of sunscreens to human health. *Photochem Photobiol Sci* (2022). https://doi.org/10.1007/s43630-022-00259-3.

Abstract

This study examines the microwave chemical risks posed by photocatalysts present in sunscreens (physical filters) against the increasing use of microwaves (radio waves) in the environment, sometimes referred to as electronic smog. Specifically, the study assesses the damage caused by silica-coated physical filters (photocatalysts, TiO_2, and/or ZnO) contained in commercially available sunscreens and fresh silica-coated ZnO for sunscreens to mouse skin fibroblasts cells (NIH/3T3) evaluated in vitro by the life/death of cells using two types of electromagnetic waves: UV light and microwave radiation, and under simultaneous irradiation with both UV light and microwaves. Conditions of the electromagnetic waves were such as to be of lower light irradiance than that of UVA/UVB radiation from incident sunlight, and with microwaves near the threshold power levels that affect human health. The photocatalytic activity of the physical filters was investigated by examining the degradation of the rhodamine B (RhB) dye in aqueous media and by the damage caused to DNA plasmids from *E. coli*. Compared to the photocatalytic activity of ZnO and TiO_2 when irradiated with UV light alone, a clear enhanced photocatalytic activity was confirmed upon irradiating these physical filters concurrently with UV and microwaves. Moreover, the uptake of these metal oxides into the NIH/3T3 cells led to the death of these cells as a result of the enhanced photocatalytic activity of the metal oxides on exposure to microwave radiation.

Concluding Remarks

This study has demonstrated that the degradation of RhB and the degradation of DNA plasmids were promoted by two types of metal-oxide physical filters (ZnO and/or TiO2) in sunscreens when exposed to both UV and

microwave radiations, with the irradiation output of the microwaves adjusted to a value close to the legal regulations. The effect of these photoactive filters on NIH/3T3 cells was also examined. In addition to the decomposition of the dye and the damage caused to the DNA plasmids by these photocatalytically active metal oxides, the study has also shown that nanoparticles of these physical filters are taken up by the cells under concurrent irradiation with ultraviolet rays and microwaves.

Although we did not discuss the risks to people on using sunscreens (however, see ref. [6]) and the effects of microwaves to human health, we hasten to point out that various catalytic reactions have been shown to be accelerated in Microwave Chemistry [29] as a result of the electromagnetic wave effects. The issue raised in this study is that if ZnO and/or TiO2 contained in cosmetics acted as photocatalysts under UV and UV/MW irradiation, in addition to scattering UV light (as suggested by many), any increase of the microwave intensity in the environment would certainly pose an increased risk to human health as evidenced by the damage caused to DNA plasmids. In addition, to the extent that the presence of metal oxides used as physical filters in sunscreens are activated by the UVA/UVB radiation (320–400 nm/290–320 nm), their simultaneous exposure to microwave radiation can also lead to or otherwise increase their uptake by the cells, a consequence of which can also pose potential risks to human health.

https://link.springer.com/article/10.1007/s43630-022-00259-3

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Electromagnetic field effects of marine radar systems on the ship crew

Ünal Özdemir. Electromagnetic field effects of marine radar systems on the ship crew. Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for the Maritime Environment. July 2022. doi:10.1177/14750902221107733.

Abstract

Marine radars become the sources of electromagnetic pollution during navigation and anchor watchkeeping. In several scientific studies, it was reported that electromagnetic fields could lead to several serious diseases, especially in the nervous system. In the current study, electromagnetic pollution is measured at different points on ships of various tonnage and types to identify electromagnetic pollution induced by marine radars. During these measurements, SRM 3006 compact spectrum analyzer (Narda Safety Test Solutions GmbH, Germany) that was operated within the 400 MHz–6 GHz frequency range was employed with a triaxial antenna. Then, the measurement results were compared with the benchmark published by ICNIRP (International Committee on Non-Ionizing Radiation Protection), and electromagnetic pollution levels induced by marine radar antennas and possible negative consequences for the crew were analyzed.

Conclusion

The study findings revealed that the radar-induced EMF generally exceeded the ICNIRP limits in the ships. This increased the possibility of adverse health outcomes due to the exposure of the crew to magnetic field pollution

for long periods of time. In future studies, it would be better to consider the problem from this perspective, especially that of the medical professional. Furthermore, future studies could conduct measurements during navigation or anchor watch to avoid external pollution in port environment to reach more accurate findings if the required financial resources could be provided. It could also be suggested that it would be beneficial to increase the sample size and develop various groups. Furthermore, since the measurements were conducted for 6 min, namely the limit specified in the ICNIRP guide, these were short-term spot measurements. However, continuous 24-h measurements over several days in a robust sample of ships would provide more realistic findings.

It could be suggested that the present study findings would provide a foundation for future IMO regulations, maritime industry policy makers, WMO and related institutions. It would be a correct approach to revise the mandatory MARPOL (International Convention for the Prevention of Pollution from Ships) and MLC (Maritime Labor Convention) conventions for IMO member nations, and to keep the issue of electromagnetic pollution in the maritime agenda. It was estimated that the topic will raise the interest of the maritime transportation industry in the future after certain number of studies are published on the topic, which is currently quite limited.

https://journals.sagepub.com/doi/10.1177/14750902221107733

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Is extremely low frequency pulsed electromagnetic fields (EMF) applicable to gliomas? A literature review of underlying mechanisms and application of extremely low frequency pulsed EMF

Huang M, Li P, Chen F, Cai Z, Yang S, Zheng X, Li W. Is extremely low frequency pulsed electromagnetic fields applicable to gliomas? A literature review of the underlying mechanisms and application of extremely low frequency pulsed electromagnetic fields. Cancer Med. 2022 Aug 5. doi: 10.1002/cam4.5112.

Abstract

Gliomas refer to a group of complicated human brain tumors with a low 5-year survival rate and limited therapeutic options. Extremely low-frequency pulsed electromagnetic field (ELF-PEMF) is a specific magnetic field featuring almost no side effects. However, the application of ELF-PEMF in the treatment of gliomas is rare. This review summarizes five significant underlying mechanisms including calcium ions, autophagy, apoptosis, angiogenesis, and reactive oxygen species, and applications of ELF-PEMF in glioma treatment from a clinical practice perspective. In addition, the prospects of ELF-PEMF in combination with conventional therapy for the treatment of gliomas are reviewed. This review benefits any specialists, especially oncologists, interested in this new therapy because it can help treat patients with gliomas properly.

Open access paper: https://onlinelibrary.wiley.com/doi/10.1002/cam4.5112

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Vestibular Extremely Low-Frequency Magnetic and Electric Stimulation Effects on Human Subjective Visual Vertical Perception

Bouisset N, Villard S, Legros A. Vestibular Extremely Low-Frequency Magnetic and Electric Stimulation Effects on Human Subjective Visual Vertical Perception. Bioelectromagnetics. 2022 Jul 8. doi: 10.1002/bem.22417.

Abstract

Electric fields from both extremely low-frequency magnetic fields (ELF-MF) and alternating current (AC) stimulations impact human neurophysiology. As the retinal photoreceptors, vestibular hair cells are graded potential cells and are sensitive to electric fields. Electrophosphene and magnetophosphene literature suggests different impacts of AC and ELF-MF on the vestibular hair cells. Furthermore, while AC modulates the vestibular system more globally, lateral ELF-MF stimulations could be more utricular specific. Therefore, to further address the impact of ELF-MF-induced electric fields on the human vestibular system and the potential differences with AC stimulations, we investigated the effects of both stimulation modalities on the perception of verticality using a subjective visual vertical (SVV) paradigm. For similar levels of SVV precision, the ELF-MF condition required more time to adjust SVV, and SVV variability was higher with ELF-MF than with AC vestibular-specific stimulations. Yet, the differences between AC and ELF-MF stimulations were small. Overall, this study highlights small differences between AC and ELF-MF vestibular stimulations, underlines a potential utricular contribution, and has implications for international exposure guidelines and standards.

https://pubmed.ncbi.nlm.nih.gov/35801487/

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The Subjective and Objective Improvement of Non-Invasive Treatment of Schumann Resonance in Insomnia-A Randomized and Double-Blinded Study

Huang YS, Tang I, Chin WC, Jang LS, Lee CP, Lin C, Yang CP, Cho SL. The Subjective and Objective Improvement of Non-Invasive Treatment of Schumann Resonance in Insomnia-A Randomized and Double-Blinded Study. Nat Sci Sleep. 2022 Jun 8;14:1113-1124. doi: 10.2147/NSS.S346941.

Abstract

Purpose: Accumulated studies revealed that electromagnetic field can affect human brain and sleep, and the extremely low-frequency electromagnetic field, Schumann resonance, may have the potential to reduce insomnia symptoms. The purpose of this study was to investigate the responses of patients with insomnia to a non-invasive treatment, Schumann resonance (SR), and to evaluate its effectiveness by subjective and objective sleep assessments.

Patients and methods: We adopted a double-blinded and randomized design and 40 participants (70% female; 50.00 ± 13.38 year) with insomnia completed the entire study. These participants were divided into the SR-sleep-device group and the placebo-device group and were followed up for four weeks. The study used polysomnography (PSG) to measure objective sleep and used sleep diaries, Pittsburgh Sleep Quality Inventory (PSQI), Epworth Sleepiness Scale (ESS), and visual analogy of sleep satisfaction to measure subjective sleep. The 36-Item Short-Form Health Survey (SF-36) was used to evaluate quality of life. Chi-square test, Mann-Whitney U-test, and Wilcoxon test were used to analyze the data.

Results: About 70% of the subjects were women, with an average age of 50±13.38 years and an average history of insomnia of 9.68±8.86 years. We found that in the SR-sleep-device group, objective sleep measurements (sleep-onset-latency, SOL, and total-sleep-time, TST) and subjective sleep questionnaires (SOL, TST, sleep-efficiency, sleep-quality, daytime-sleepiness, and sleep-satisfaction) were significantly improved after using the SR-sleep-device; in the placebo-device group, only such subjective sleep improvements as PSQI and sleep-satisfaction were observed.

Conclusion: This study demonstrates that the SR-sleep-device can reduce the insomnia symptoms through both objective and subjective tests, with minimal adverse effects. Future studies can explore the possible mechanism of SR and health effects and, with a longer tracking time, verify the effectiveness and side effects.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9189153/

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Static magnetic fields from earphones: Detailed measurements plus some open questions

L. Makinistian, L. Zastko, A. Tvarožná, L.E. Días, I. Belyaev. Static magnetic fields from earphones: Detailed measurements plus some open questions. Environmental Research, 2022. doi: 10.1016/j.envres.2022.113907.

Highlights

• Experimental mapping of the static magnetic fields near 6 earphones.

• Physical modeling of the measured fields allows extrapolation and simulation.

• 3D simulations allow for visualization of field distribution in the ear.

• Field intensity and gradients, plus their combination with RF/ELF should be studied.

Abstract

Earphones (EP) are a worldwide, massively adopted product, assumed to be innocuous provided the recommendations on sound doses limits are followed. Nevertheless, sound is not the only physical stimulus that derives from EP use, since they include a built-in permanent magnet from which a static magnetic field (SMF) originates. We performed 2D maps of the SMF at several distances from 6 models of in-ear EP, showing that they produce an exposure that spans from ca. 20 mT on their surface down to tens of μT in the inner ear. The numerous reports of bioeffects elicited by SMF in that range of intensities (applied both acutely and chronically), together with the fact that there is no scientific consensus over the possible mechanisms of interaction with living tissues, suggest that caution could be recommendable. In addition, more research is warranted on the possible effects of the combination of SMF with extremely low frequency and radiofrequency fields, which has so far been scarcely studied. Overall, while several open questions about bioeffects of SMF remain to be

addressed by the scientific community, we find sensible to suggest that the use of air-tube earphones is probably the more conservative, cautious choice.

Excerpt

The International Commission on Non-Ionizing Radiation Protection recommends a 400 mT exposure limit for the general public (ICNIRP, 2009), which are way above the SMF reported here. It must be noted that the recommendation is based on the effects of nausea, vertigo, photo phosphenes and nerve stimulation, well associated to high and ultra-high magnetic fields (typical of MRI facilities). All the other reported biological effects, which are not directly proven to be a health hazard (but could be, such being the case of the increase of reactive oxygen species (Wang and Zhang, 2017)) are disregarded by the recommendation.

https://www.sciencedirect.com/science/article/pii/S0013935122012348

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Do magnetic fields related to submarine power cables affect the functioning of a common bivalve?

Jakubowska-Lehrmann M, Białowąs M, Otremba Z, Hallmann A, Śliwińska-Wilczewska S, Urban-Malinga B. Do magnetic fields related to submarine power cables affect the functioning of a common bivalve? Mar Environ Res. 2022 Jul 11;179:105700. doi: 10.1016/j.marenvres.2022.105700.

Abstract

The aim of the study was to determine the effect of static magnetic field (SMF) and electromagnetic field (EMF), of values usually recorded near submarine cables, on the bioenergetics, oxidative stress, and neurotoxicity in the cockle Cerastoderma glaucum. Bivalves maintained a positive energy balance, but the filtration rate and energy available for individual production were significantly lower in SMF-exposed animals compared to the control treatment. No changes in the respiration were noted but ammonia excretion rate was significantly lower after exposure to EMF. Changes in the activities of antioxidant enzymes and the lipid peroxidation were not observed; however, exposure to both fields resulted in increased protein carbonylation. After exposure to EMF a significant inhibition of acetylcholinesterase activity was observed. As the present study for the first time revealed the oxidative damage and neurotoxicity in marine invertebrate after exposure to artificial magnetic fields, the need for further research is highlighted.

https://www.sciencedirect.com/science/article/pii/S0141113622001453?via%3Dihub

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The Impact of Magnetic Field on Insecticide Toxicity Measured by Biological and Biochemical Parameters of Earias insulana (Bollworm)

Hisham M El-Bassouiny, Warda A Z El-Medany, Mervat A A Kandil. The Impact of Magnetic Field on Insecticide

Toxicity Measured by Biological and Biochemical Parameters of Earias insulana (Boisd). Bioelectromagnetics. 2022 Aug 5. doi: 10.1002/bem.22418.

Abstract

This study illustrates the effect of magnetic field (MF) on the toxicity of two insecticides, emamectin benzoate (Emazoate 2.15% EC) and spinosad (SpinTor 24% SC), and determines their adverse effects on the bollworm (Earias insulana) through various biological and biochemical assays. The investigation indicated that exposure to the insecticides in a MF of 180 mT resulted in stronger toxicity, with LC50 values of 0.162, 1.211, and 1.770 ppm, respectively. In addition, the results showed that magnetized insecticides significantly increased in the duration of the total immature stages (larvae and/or pupae) 32.1 and 36.6 days, compared with 27.9 and 30.5 days, respectively, in the nonmagnetized insecticides, while untreated check was 21 days. Also, the magnetized insecticides reduced the percentage of adult emergence, and increased deformations in the larval and pupal stages. Furthermore, sex ratio was greatly affected by exposure to both insecticides in conjunction with the MF. Exposure of the larvae of E insulana to magnetized insecticides can bring about malfunction in some biochemical process and significantly decreased the invertase activity, and decreased the total protein and carbohydrates. In contrast, it can increase amylase compared with nonmagnetized insecticides and untreated controls. Results concluded that the two insecticides' MF affected growth, survival time, and biological and biochemical parameters of E. insulana.

https://pubmed.ncbi.nlm.nih.gov/35930550/

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Self-referencing authorships behind the ICNIRP 2020 radiation protection guidelines

Else K Nordhagen, Einar Flydal. Self-referencing authorships behind the ICNIRP 2020 radiation protection guidelines. Rev Environ Health. 2022 Jun 27. doi: 10.1515/reveh-2022-0037.

Abstract

In March 2020, ICNIRP (the International Commission for Non-Ionizing Radiation Protection) published a set of guidelines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz). ICNIRP claims this publication's view on EMF and health, a view usually termed "the thermal-only paradigm", is consistent with current scientific understanding. We investigated the literature referenced in ICNIRP 2020 to assess if the variation in authors and research groups behind it meets the fundamental requirement of constituting a broad scientific base and thus a view consistent with current scientific understanding, a requirement that such an important set of guidelines is expected to satisfy. To assess if this requirement has been met, we investigated the span of authors and research groups of the referenced literature of the ICNIRP 2020 Guidelines and annexes. Our analysis shows that ICNIRP 2020 itself, and in practice all its referenced supporting literature stem from a network of co-authors with just 17 researchers at its core, most of them affiliated with ICNIRP and/or the IEEE, and some of them being ICNIRP 2020 authors themselves. Moreover, literature reviews presented by ICNIRP 2020 as being from independent committees, are in fact products of this same informal network of collaborating authors, all committees having ICNIRP 2020 authors as members. This shows that the ICNIRP 2020 Guidelines fail to meet

fundamental scientific quality requirements and are therefore not suited as the basis on which to set RF EMF exposure limits for the protection of human health. With its thermal-only view, ICNIRP contrasts with the majority of research findings, and would therefore need a particularly solid scientific foundation. Our analysis demonstrates the contrary to be the case. Hence, the ICNIRP 2020 Guidelines cannot offer a basis for good governance.

Excerpts

... ICNIRP members are found to have conflicts of interest, as pointed out by e.g., [3]: “the Ethical Board at the Karolinska Institute in Stockholm, Sweden concluded already in 2008 that being a member of ICNIRP may be a conflict of interest that should be stated officially whenever a member from ICNIRP makes opinions on health risks from EMF (Karolinska Institute diary number: 3753-2008-609)”. An EU report [4] concluded in June 2020 that “for really independent scientific advice we cannot rely on ICNIRP”....

As is apparent from the debate on this issue, a majority of peer-reviewed papers support the opposing view, i.e., that sub-thermal RF EMFs have health effects [5]. Several athermal mechanisms have been identified [6], [7], [8], [9], [10] and accepted as evidenced, if not proven....

All in all, ICNIRP 2020 has 158 unique references. Not all have been authored by the ICNIRP co-authorship network found in Pattern 1. We found that the network co-authored 78 of the referenced peer reviewed papers, seven of the literature reviews, and six ICNIRP publications, in total 91 documents. In addition to these 91 documents, there are 67 references to other documents.

Of these 67 documents, only 15 are peer reviewed papers on RF EMF and health. The remaining 52 are documents with no direct relation to this topic. We termed these 52 “technical documents”, as they address topics such as WHO’s definition of “health” and other general terms used (three documents), thermal regulation (20 documents), contact currents and pain (five documents), technical documentation (three documents) and SAR-modelling and calculations (21 documents). We excluded these technical documents from further analyses (see Figure 1) ....

Conclusions

In the introduction we raised five questions relating to the authorship behind the referenced literature used to underpin the ICNIRP 2020 thermal-only view. Below we repeat the patterns found, answering these questions whilst adding some overarching conclusions.

> Pattern 1: *ICNIRP affiliates and ICNIRP 2020 authors are heavily involved in literature referenced in ICNIRP 2020 to underpin it*. Figure 2 shows the graph of the complete network of co-authorship relations found in the referenced literature in ICNIRP 2020 originating from the ICNIRP affiliates, displaying that ICNIRP affiliates are the most central nodes of the network, and seven of the most central nodes being ICNIRP 2020 authors.
>
> Pattern 4: *a small and tight network of just 17 authors is behind all the literature used to underpin ICNIRP 2020*. Of these 17, 10 were ICNIRP affiliates, of whom six were also authors of ICNIRP 2020. Five of these 17 were IEEE C95.1 2019 authors, two of whom were also ICNIRP 2020 authors.

Pattern 2: *ICNIRP 2020 authors are involved in all the literature reviews referenced in ICNIRP 2020 to underpin it*. In addition to the ICNIRP 2020 authors, these committees are manned by several other ICNIRP affiliates.

Pattern 3: *All scientific papers used to underpin ICNIRP 2020 are from the same co-author network centered around ICNIRP affiliates.*

Only four papers were found to be used to underpin ICNIRP 2020 that were not linked to the ICNIRP co-authorship network. Of these four, a simple internet search revealed that two of them have authors who have co-authored several papers with ICNIRP affiliates and thus cannot be seen as independent from ICNIRP. The two last were misinterpreted to underpin ICNIRP 2020 or offered no scientifically sound support.

Pattern 5: *The spread of first authors gives a false impression of broad support*. While there is a high variation of first authors, most of them not affiliated with ICNIRP/IEEE, a tight network of just 16 key authors, dominated by ICNIRP and IEEE affiliates, is involved in *all the papers* used to underpin ICNIRP 2020 (Pattern 4). Moreover, in the co-authorship network (Pattern 1) ICNIRP affiliates are found as central nodes, while most first authors are peripheral in the network.

Intentionally or not, the domination of ICNIRP affiliated authorship is blurred by the practice of having many different non-affiliates as first authors. This conceals the fact that effectively all referenced papers used to support ICNIRP 2020 originate from a network of researchers completely dominated by ICNIRP affiliates and a few who are closely related.

Pattern 6: *All referenced papers not authored by the ICNIRP co-authorship network are either rejected, misinterpreted to underpin ICNIRP 2020, or offer no scientifically sound support.*

Our analysis shows that ICNIRP 2020 itself and, in practice, all its referenced supportive literature stem from a network of co-authors with just 17 researchers at its core, most of them affiliated with ICNIRP and/or the IEEE and with ICNIRP 2020 authors in prominent positions, where those who are not are still closely related.

The overlaps between ICNIRP and the committees authoring the referenced literature reviews have been documented multiple times [4, 19, 20]. However, it was not anticipated that these ties would be so strong, that they include all committees behind the literature reviews, as well as the authorships of all the peer reviewed papers used to underpin ICNIRP 2020. Indeed, we would never have expected to find as few as 17 key authors as the smallest set of authors involved in all the literature used to underpin the ICNIRP 2020, and that they constitute a network heavily overlapping with the ICNIRP 2020 authors themselves. It was also not anticipated that the ICNIRP 2020 authors themselves would be represented in all committees. This means that the authors of ICNIRP 2020 are exclusively referring to themselves and their fellow network members as the basis for their own scientifically highly controversial recommendations.

As well, it was highly unexpected to find that the WHO report [11] described in ICNIRP 2020 as "*an in-depth review from the World Health Organization on radiofrequency EMF exposure and health*" [2 p. 486] and presented in these words: "*This independent review is the most comprehensive and thorough appraisal of the adverse effects of radiofrequency EMFs on health*" [2 p. 517], is in fact a retracted draft where five out of six WHO core group members were ICNIRP affiliates, of whom three are among the authors of ICNIRP 2020. Such a claim and circularity of authorship is encroaching upon something very similar to fraud.

From our findings we draw the conclusion that the referenced literature used in ICNIRP 2020 to underpin its guidelines is neither varied, nor independent or balanced, and is by no means "*consistent with current scientific knowledge*", as claimed by ICNIRP 2020 [2 p. 484]. ICNIRP 2020 bases this claim within this small network only, a claim that runs contrary to the majority of biology-oriented researchers and publications within this research field. Hence, our review shows that the ICNIRP 2020 guidelines fail to meet fundamental scientific quality requirements as to being built on a broad, solid and established knowledge base, uphold a view contrary to well established knowledge within the field, and therefore cannot offer a basis for good governance when setting RF exposure limits for the protection of human health.

Open access paper: **https://www.degruyter.com/document/doi/10.1515/reveh-2022-0037/html**

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Protection of Workers Exposed to Radiofrequency Electromagnetic Fields: A Perspective on Open Questions in the Context of the New ICNIRP 2020 Guidelines

Jeschke P, Alteköster C, Hansson Mild K, Israel M, Ivanova M, Schiessl K, Shalamanova T, Soyka F, Stam R, Wilén J. Protection of Workers Exposed to Radiofrequency Electromagnetic Fields: A Perspective on Open Questions in the Context of the New ICNIRP 2020 Guidelines. Front Public Health. 2022 Jun 2;10:875946. doi: 10.3389/fpubh.2022.875946.

Abstract

Workers in occupational settings are usually exposed to numerous sources of electromagnetic fields (EMF) and to different physical agents. Risk assessment for industrial workplaces concerning EMF is not only relevant to operators of devices or machinery emitting EMF, but also to support-workers, bystanders, service and maintenance personnel, and even visitors. Radiofrequency EMF guidelines published in 2020 by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) may also be indirectly applied to assess risks emerging from EMF sources at workplaces by technical standards or legislation. To review the applicability and adequacy to assess exposure to EMF in occupational settings in the European Union, the most current ICNIRP guidelines on radiofrequency EMF are reviewed. Relevant ICNIRP fundamentals and principles are introduced, followed by practical aspects of exposure assessment. To conclude, open questions are formulated pointing out gaps between the guidelines' principles and occupational practice, such as the impact of hot and humid environments and physical activity or controversies around ICNIRP's reduction factors in view of assessment uncertainty in general. Thus, the article aims to provide scientific policy advisors, labor inspectors, or experts developing standards with a profound understanding about ICNIRP guidelines' applicability to assess hazards related to radiofrequency EMF in occupational settings.

Concluding Remarks

We highly acknowledge the effort and scientific quality that is shown by ICNIRP 2020 (1). This review aims to foster a constructive dialogue aimed at future improvements. Based on previous experiences with the implementation of ICNIRP guidelines in OSH [occupational safety and health] risk assessment, it became necessary to reflect the 2020 ICNIRP RF EMF guidelines (1) in the light of OSH risk assessment practice. Occupational exposure settings differ significantly to those of the general public, with the latter ones focussing

more or less on the application of mobile communication with limited frequency ranges and exposure levels. In contrast, occupational exposure is permitted at levels 5 times larger than the general public, across the whole frequency range from 100 kHz to 300 GHz with unlimited exposure durations. ICNIRP did not provide practical details relevant to OSH exposure assessment and occupational exposure durations during working hours over decades as well as its effects. Some of these details could be addressed in an updated version of the non-binding guide for the EMF Directive (8, 9) or could be provided in relevant technical standards. Other, more fundamental choices that are necessary to provide legal clarity could be addressed in a possible revision of the EMF directive.

The removal of non-adverse health effects, e.g., the microwave hearing effect, is questionable for OSH purposes. In consequence, a solid anchor in OSH legislation is required to provide a reliable basis to evaluate distracting effects, even if they are not adverse to health, in OSH risk assessments.

In addition, several open questions regarding ICNIRP's (1) practical implementation were identified and discussed in the present review. It is acknowledged that ICNIRP itself has no intention nor obligation to consider the practical application of its guidelines in OSH tasks, such as workplace risk assessment. As challenging as it might be, such considerations are clearly needed for a reliable OSH risk assessment practice. Those considerations are yet to be developed, along with appropriate measurement devices. To facilitate a holistic understanding and application of ICNIRP 2020 (1), a set of BR and RL [Basic Restrictions and Reference Levels] which are easy to comprehend is desirable for OSH practitioners. Furthermore, any doubt on conservativeness, for all possible occupational scenarios is disadvantageous, and should be avoided by an appropriate selection of BR and RL. Considering policy makers at a European and member states level, OSH EMF-legislation would benefit greatly from an adopted safety concept, comprising a comprehensible set BR and RL for all substantiated RF EMF effects, regardless of whether they are adverse to health or distracting.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9215329/

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Systematic review of the physiological and health-related effects of radiofrequency electromagnetic field exposure from wireless communication devices on children and adolescents in experimental and epidemiological human studies

Bodewein L, Dechent D, Graefrath D, Kraus T, Krause T, Driessen S (2022) Systematic review of the physiological and health-related effects of radiofrequency electromagnetic field exposure from wireless communication devices on children and adolescents in experimental and epidemiological human studies. PLoS ONE 17(6): e0268641. doi: 10.1371/journal.pone.0268641.

Abstract

Background For more than 20 years, the potential health risks of radiofrequency electromagnetic field (RF EMF) exposure from mobile communication devices on children and adolescents have been examined because they are considered sensitive population groups; however, it remains unclear whether such exposure poses any particular risk to them.

Objectives The aim of this review was to systematically analyze and evaluate the physiological and health-related effects of RF EMF exposures from wireless communication devices (mobile phones, cordless phones, Bluetooth, etc.) on children and adolescents.

Methods This review was prepared according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Methodological limitations in individual studies were assessed using the Office of Health Assessment and Translation (OHAT) Risk-of-Bias Rating Tool for Human and Animal Studies.

Results A total of 42 epidemiological and 11 experimental studies were eligible for this review. Most of the studies displayed several methodological weaknesses that limited the internal validity of the results. Due to a lack of consistency regarding the outcomes as well as the lack of scientific rigor in most reviewed studies, the body of evidence for the effects of RF EMF of mobile communication devices on subjective symptoms, cognition, and behavior in children and adolescents was low to inadequate. Evidence from the studies investigating early childhood development, brain activity, cancer, and physiological parameters was considered inadequate for drawing conclusions about possible effects.

Discussion Overall, the body of evidence allows no final conclusion on the question whether exposure to RF EMF from mobile communication devices poses a particular risk to children and adolescents. There has been rapid development in technologies generating RF EMF, which are extensively used by children and adolescents. Therefore, we strongly recommend high-quality systematic research on children and adolescents, since they are generally considered as sensitive age groups.

Excerpts

"From a total of 42 epidemiological studies, 10 studies found consistent associations between mobile phone exposure and health effects on children and adolescents, 23 studies found limited associations, and 9 studies did not find any consistent associations (Fig 4).... In summary, the evidence for physiological and health-related effects of mobile communication RF EMF (mobile phones, wireless phones, WLAN, Bluetooth, etc.) on children and adolescents was rated as low to inadequate overall, based on the included epidemiological studies in this review."

"Out of a total of 11 experimental studies, 3 of them including a total of 116 children and adolescents found an effect of mobile phone exposure on brain activity and cognition, whereas the remaining 8 studies, with a total of 222 children and adolescents, could not identify any effects (Fig 4).... As the experimental studies included in this review only investigated acute and short-term effects, no conclusion can be drawn regarding potential long-term effects. In summary, the evidence from the included experimental studies is inadequate to draw a conclusion regarding mobile phone-related exposure and its effects on cognition, brain activity, and physiological changes in children and adolescents."

"As the OHAT risk-of-bias tool was used to assess the risk of bias in each study as a whole, the assessment utilizing the “confidence in the exposure” criterion might not represent the true risk of bias in every individual exposure assessment method in epidemiological studies with different exposure sources and assessment methods (e.g., mobile phone use assessed by questionnaire, mobile phone base station exposure assessed by

measurements). This may have led to an over- or underestimation in the risk of bias in single epidemiological studies."

Conclusion

"In this review, 42 epidemiological and 11 experimental studies on children and adolescents were systematically researched, analyzed, and assessed in view of the health-related effects of RF EMF from wireless communication devices (mobile phones, cordless phones, WLAN, Bluetooth, etc.). A total of 50 studies investigated mobile phone usage, 3 studies examined the exposure to mobile phone base stations, and 22 studies investigated both mobile phone usage and exposure to cordless phones, mobile phone base stations, etc.

Of a total of 53 included studies, 35 studies had several methodological weaknesses, which limited the internal validity of the results. Overall, evidence for the effects of RF EMF of mobile communication devices on subjective symptoms, cognition, and behavior in children and adolescents was considered to be low to inadequate. Furthermore, the studies investigating early childhood development, brain activity, cancer, and physiological parameters were considered inadequate to draw conclusions concerning possible effects. Based on the studies included in this review, it remains unclear whether children and adolescents are particularly sensitive to mobile communication exposure.

In summary, we could not identify a high evidence for any significant detrimental health effects of RF EMF of mobile communications on children and adolescents. Nevertheless, we do not conclude that such exposure would be safe for this particular age group, since the evidence base for this conclusion is too weak.

There has been rapid development in technologies generating RF EMF, which are extensively used by children and adolescents. Therefore, we strongly recommend high-quality systematic research on children and adolescents, since they are generally considered as sensitive age groups [13]. For example, cohort studies with improved exposure assessments and experimental studies investigating the nervous systems, including larger study populations and different age groups, should be conducted. Moreover, children and adolescents should be considered separately in future trend studies.

The conclusions of this review are largely in line with the evaluation of the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) [28] and the conclusions of other authors of earlier studies [7, 26, 27, 118]."

Open access paper: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0268641

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Protection of Workers Exposed to Radiofrequency Electromagnetic Fields: A Perspective on Open Questions in the Context of the New ICNIRP 2020 Guidelines

Jeschke Peter, Alteköster Carsten, Hansson Mild Kjell, Israel Michel, Ivanova Mihaela, Schiessl Klaus, Shalamanova Tsvetelina, Soyka Florian, Stam Rianne, Wilén Jonna. Protection of Workers Exposed to Radiofrequency Electromagnetic Fields: A Perspective on Open Questions in the Context of the New ICNIRP 2020 Guidelines. Frontiers in Public Health, 10, 2022, doi: 10.3389/fpubh.2022.875946

Abstract

Workers in occupational settings are usually exposed to numerous sources of electromagnetic fields (EMF) and to different physical agents. Risk assessment for industrial workplaces concerning EMF is not only relevant to operators of devices or machinery emitting EMF, but also to support-workers, bystanders, service and maintenance personnel, and even visitors. Radiofrequency EMF guidelines published in 2020 by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) may also be indirectly applied to assess risks emerging from EMF sources at workplaces by technical standards or legislation. To review the applicability and adequacy to assess exposure to EMF in occupational settings in the European Union, the most current ICNIRP guidelines on radiofrequency EMF are reviewed. Relevant ICNIRP fundamentals and principles are introduced, followed by practical aspects of exposure assessment. To conclude, open questions are formulated pointing out gaps between the guidelines' principles and occupational practice, such as the impact of hot and humid environments and physical activity or controversies around ICNIRPS's reduction factors in view of assessment uncertainty in general. Thus, the article aims to provide scientific policy advisors, labor inspectors, or experts developing standards with a profound understanding about ICNIRP guidelines' applicability to assess hazards related to radiofrequency EMF in occupational settings.

Concluding Remarks

We highly acknowledge the effort and scientific quality that is shown by ICNIRP 2020 (1). This review aims to foster a constructive dialogue aimed at future improvements. Based on previous experiences with the implementation of ICNIRP guidelines in OSH [occupational safety and health] risk assessment, it became necessary to reflect the 2020 ICNIRP RF EMF guidelines (1) in the light of OSH risk assessment practice. Occupational exposure settings differ significantly to those of the general public, with the latter ones focussing more or less on the application of mobile communication with limited frequency ranges and exposure levels. In contrast, occupational exposure is permitted at levels 5 times larger than the general public, across the whole frequency range from 100 kHz to 300 GHz with unlimited exposure durations. ICNIRP did not provide practical details relevant to OSH exposure assessment and occupational exposure durations during working hours over decades as well as its effects. Some of these details could be addressed in an updated version of the non-binding guide for the EMF Directive (8, 9) or could be provided in relevant technical standards. Other, more fundamental choices that are necessary to provide legal clarity could be addressed in a possible revision of the EMF directive.

The removal of non-adverse health effects, e.g., the microwave hearing effect, is questionable for OSH purposes. In consequence, a solid anchor in OSH legislation is required to provide a reliable basis to evaluate distracting effects, even if they are not adverse to health, in OSH risk assessments.

In addition, several open questions regarding ICNIRP's (1) practical implementation were identified and discussed in the present review. It is acknowledged that ICNIRP itself has no intention nor obligation to consider the practical application of its guidelines in OSH tasks, such as workplace risk assessment. As challenging as it might be, such considerations are clearly needed for a reliable OSH risk assessment practice. Those considerations are yet to be developed, along with appropriate measurement devices. To facilitate a holistic understanding and application of ICNIRP 2020 (1), a set of BR and RL [Basic Restrictions and Reference Levels]

which are easy to comprehend is desirable for OSH practitioners. Furthermore, any doubt on conservativeness, for all possible occupational scenarios is disadvantageous, and should be avoided by an appropriate selection of BR and RL. Considering policy makers at a European and member states level, OSH EMF-legislation would benefit greatly from an adopted safety concept, comprising a comprehensible set BR and RL for all substantiated RF EMF effects, regardless of whether they are adverse to health or distracting.

Open access paper: https://www.frontiersin.org/article/10.3389/fpubh.2022.875946

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IEC/IEEE Draft Standard for Determining the SAR from Wireless Devices, 30 MHz to 6 GHz. Part 1: General Requirements for using the Finite Difference Time Domain (FDTD) Method

International Electrotechnical Commission (IEC), Institute of Electrical and Electronics Engineers (IEEE). IEC/IEEE Draft Standard for Determining the Peak Spatial Average Specific Absorption Rate (SAR) in the Human Body from Wireless Communications Devices, 30 MHz to 6 GHz. Part 1: General Requirements for using the Finite Difference Time Domain (FDTD) Method for SAR Calculations. 2022, IEEE/IEC P62704-1: 1-82.

Abstract

This standard defines the methodology for the application of the finite difference time domain (FDTD) technique when used for determining the peak spatial-average specific absorption rate (SAR) in the human body exposed to wireless communication devices with known uncertainty. It defines methods to validate the numerical model of the device under test (DUT) and to assess its uncertainty when used in SAR simulations. Moreover, it defines procedures to determine the peak spatial average SAR in a cubical volume and to validate the correct implementation of the FDTD simulation software. This document does not recommend specific SAR limits since these are found elsewhere, e.g., in the guidelines published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) or in IEEE C95.1

https://standards.ieee.org/ieee/62704-1/10440/

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Biological and Medical Disturbances Due to Exposure to Fields Emitted by Electromagnetic Energy Devices—A Review

Adel Razek. Biological and Medical Disturbances Due to Exposure to Fields Emitted by Electromagnetic Energy Devices—A Review. *Energies*. 2022; 15(12):4455. doi:10.3390/en15124455.

Abstract

The use of electromagnetic systems in daily life is on the rise. The immediate environment, of these electromagnetic energy devices, is exposed to their emitted fields. Environmental disturbances from such exposure could be severe in many ways; one of the most important is health. This could be directly related to the human body or to healthcare sensing and interventional devices. The review of the biological effects and

disturbances of medical instruments due to electromagnetic field exposure is the subject of this article. The analysis of the different types of exposure as well as their control to meet safety requirements are investigated involving energy devices covering wide ranges of power and frequency. Thus, biological effects of both wireless telecommunications tools and inductive charging systems are reviewed. Next, we survey electromagnetic disturbances in sensing and stimulation instruments joint to the human body as well as devices used in medical interventions. Means of evaluating and controlling the effects of electromagnetic fields, through electromagnetic compatibility analysis, experimentally and by numerical modeling are conferred and assessed.

https://www.mdpi.com/1996-1073/15/12/4455

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A co-polarization-insensitive metamaterial absorber for 5G n78 mobile devices at 3.5 GHz to reduce the specific absorption rate

Hannan S, Islam MT, Soliman MS, Faruque MRI, Misran N, Islam MS. A co-polarization-insensitive metamaterial absorber for 5G n78 mobile devices at 3.5 GHz to reduce the specific absorption rate. *Sci Rep* **12,** 11193 (2022). doi:10.1038/s41598-022-15221-7.

Abstract

Specific absorption rate (SAR) by next-generation 5G mobile devices has become a burning question among engineers worldwide. 5G communication devices will be famous worldwide due to high-speed data transceiving, IoT-based mass applications, etc. Many antenna systems are being proposed for such mobile devices, but SAR is found at a higher rate that requires reduced for human health. This paper presents a metamaterial absorber (MMA) for SAR reduction from 5G n78 mobile devices at 3.5 GHz. The MMA is co-polarization insensitive at all possible incident angles to ensure absorption of unnecessary EM energies obeying the Poynting theorem for energy conservation and thus ensuring smooth communication by the devices. The unit cell size of the absorber is 0.114 λ making it design efficient for array implementation into mobile devices. This absorber has achieved a minimum of 33% reduction of SAR by applying it to the 5G n78 mobile phone model, equivalent to SAR by GSM/LTE/UMTS band mobile phones and making it suitable for SAR reduction from next-generation 5G mobile devices.

Conclusion

In this study, we numerically studied the SAR reduction from next-generation 5G n78 mobile devices by applying a novel co-polarization-insensitive metamaterial absorber (MMA) and experimentally verified the absorptivity of the MMA at the resonance frequency. The MMA was designed to aim the resonance frequency at 3.5 GHz with metamaterial characteristics by the necessary engineering of L-C-R transmission lines as per the equivalent circuit. However, it is essential to mention that the metamaterial was designed with a modified circular split-ring resonator so that it cannot be rotationally symmetric [13, 29] and thus be able to absorb the co-polarized portion of the applied EM wave only. This property made it appropriate to be used inside 5G mobile phones for both smooth communication and SAR reduction. However, as perfect MMA can absorb entire applied EM waves of both the co-polar and the cross-polar elements, they will not be suitable for applying to mobile phones or other

similar devices due to the entire signal absorption capability that can hamper EM signal, even if they can reduce SAR effectively. Furthermore, the proposed MMA has shown at least a 33% reduction of SAR from n78 5G mobile phones and maintained the SAR value equivalent to GSM/ LTE/ UMTS bands for the 5G band, a benchmark set by the proposed absorber.

https://www.nature.com/articles/s41598-022-15221-7

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Instruments to measure environmental and personal radiofrequency-electromagnetic field exposures: an update

Bhatt, C.R., Henderson, S., Brzozek, C., Benke, G. Instruments to measure environmental and personal radiofrequency-electromagnetic field exposures: an update. *Phys Eng Sci Med* (2022). doi: 10.1007/s13246-022-01146-y.

Abstract

Modern human populations are exposed to anthropogenic sources of radiofrequency-electromagnetic fields (RF-EMFs), primarily to telecommunication and broadcasting technologies. As a result, ongoing concerns from some members of the public have arisen regarding potential health effects following RF-EMF exposures. In order to monitor human RF-EMF exposures and investigate potential health effects, an objective assessment of RF-EMF exposures is necessary. Accurate dosimetry is essential for any investigation of potential associations between RF-EMF exposure and health effects in human populations. This review updates state-of-the-art knowledge of currently available RF-EMF exposure assessment tools applicable in human epidemiological studies. These tools cater for assessing RF-EMF exposures in human environments; through mobile phone-based tools or other standalone tools. RF-EMF exposure assessment has been significantly improved through the application of some of these tools in recent years.

Conclusion

This updated review includes most currently used tools for environmental and personal RF-EMF assessment. These tools, involving both mobile phone-based and standalone RF-EMF exposure assessment instruments, provide useful objective measurements of RF-EMF exposures associated with broadcast and telecommunication technologies. Most of these instruments have been validated through recent epidemiological studies conducted internationally. These tools have demonstrated capabilities in providing RF-EMF exposure data for current and future human epidemiological studies. The future research and development in the science of RF-EMF exposure assessment could consider tools that would enable exposure assessment in relation to a wide range of currently available RF-EMF emitting sources, such as cordless and mobile phones, tablet devices and laptop computers. The need for further development of exposimeters or radiation meters that could measure mmWave frequencies is also necessary.

Open access paper: https://link.springer.com/article/10.1007/s13246-022-01146-y

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Assessment of Radiofrequency Exposure in the Vicinity of School Environments in Crete Island, South Greece

Theodore N. Kapetanakis, Melina P. Ioannidou, Anargyros T. Baklezos, Christos D. Nikolopoulos, Eleftheria S. Sergaki, Antonios J. Konstantaras, Ioannis O. Vardiambasis. 2022. Assessment of Radiofrequency Exposure in the Vicinity of School Environments in Crete Island, South Greece. *Applied Sciences* 12(9):4701. doi: org/10.3390/app12094701

Abstract

This study aimed to estimate the radiofrequency exposure levels in the vicinity of nursery and primary schools at the northwest part of Crete island in Greece. Moreover, the compliance with the exposure limits, according to Greek legislation, was investigated. A total of 396 in situ frequency-selective and broadband measurements were conducted around 69 schools, classified in urban and suburban environments, in the range of 27–3000 MHz (subdivided in seven frequency bands). The measured value of the electric field strength (V/m) was recorded and, subsequently, the exposure ratio was calculated. Statistical analysis was performed in order to analyze and evaluate the data. In addition, a worst-case scenario was examined by considering the highest measured exposure level around each school. The statistical tests indicated that the mean and median values of the exposure ratio, even in the worst-case scenario, were found well below 1 for all frequency bands. The calculated distributions of the electric field measurements demonstrated that almost 90% of the latter were below 1 V/m, with the majority of values lying in the range of 0.5–1 V/m. The main contributors to the total exposure were the mobile communication frequencies and broadcasting, while the exposure was greater in urban than in suburban environments.

Conclusions

In conclusion, our results indicate that, in the vast majority of cases, we observed compliance with the Greek established reference levels for RF exposure. The median values of the exposure ratio were found less than 0.035 in all cases examined, whereas the maximum values of the exposure ratio lay below 0.28 except for a very few cases, where the maximum value of the E-field strength exceeded the reference level. Most recordings of the electric field strength (i.e., 90%) were found lower than 1 V/m, while the majority of the total exposure ratio values (i.e., almost 94%) were below 0.2. The median values of the E-field strength were found to be statistically significantly different in urban and suburban environments, except for the 27–879 MHz band where broadcast applications dominate. Readings were slightly higher in urban areas than in the suburbs and the latter exhibited a narrower interquartile range than the former due to their more uniform construction. We also found that mobile communication frequencies and broadcast were the sources that contributed most to the total exposure.

Our future plans include EMF measurements not only around but also inside schools and classrooms, in the frequency range of 27 MHz–6 GHz, especially with the prospect of the rapidly upcoming 5G mobile services everywhere. A comparison of the electric field strength at the same measurement locations, before and after the advent of 5G, will be interesting and revealing.

Open access paper: https://www.mdpi.com/2076-3417/12/9/4701/htm

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Impact of Small-Cell Deployment on Combined Uplink and Downlink RF Exposure Compared to the Status Quo in Mobile Networks

L. M. Schilling, C. Bornkessel and M. A. Hein. Impact of Small-Cell Deployment on Combined Uplink and Downlink RF Exposure Compared to the Status Quo in Mobile Networks*. 2021 51st European Microwave Conference (EuMC)*, 2022, pp. 618-621, doi: 10.23919/EuMC50147.2022.9784284.

Abstract

As new cellular technologies are introduced in mobile networks nowadays, more and more small cells and mobile road side units are being deployed to upgrade the performance of the wireless communication network. With regard to the overall human RF exposure, the question arises to what extent the exposure is affected by the deployment of such small cells compared to macro cells as the status quo. In an attempt to answer this important question, this paper proposes a method to measure and evaluate the combined uplink and downlink exposure in terms of the specific absorption rate of a mobile phone user at recently installed small cell locations. The comparison between the small cell and macro cell scenarios revealed a reduction of the total exposure when the user equipment was logged into the investigated LTE small cells, although the downlink exposure increased. The main reason for this encouraging result is the reduction of the uplink transmission power due to the improved link conditions across the small cell. In contrast, the total exposure in a macro cell scenario is dominated by the uplink exposure. In order to minimise the total exposure, a balance must be sought between downlink and uplink exposure.

Conclusion

With the proposed method of combined UL [uplink] and DL [downlink] exposure assessment, a comparison was made between macro cell and small cell scenarios, with the latter tending to lower the total user exposure. Therefore, not only the demands for improved data rates, capacities and coverage of the mobile network, but also a reduction of the total exposure could be achieved with the small cell deployment. The proposed method could be extended to the evaluation of the dose with different exposure durations due to the link connections. In a next step, the data can be evaluated in relation to measurement distances, in order to make a general statement about total exposure independent of specific measurement scenarios. Furthermore, the method should be extended towards 5G and indoor small cells.

https://ieeexplore.ieee.org/document/9784284

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Mobile phone carrying locations and risk perception of men: A cross-sectional study

Zeleke BM, Brzozek C, Bhatt CR, Abramson MJ, Freudenstein F, Croft RJ, Wiedemann PM, Benke G. Mobile phone carrying locations and risk perception of men: A cross-sectional study. PLoS One. 2022 Jun 7;17(6):e0269457. doi: 10.1371/journal.pone.0269457.

Abstract

Little was known about the relationship between carrying mobile phone handsets by men and their risk perception of radiofrequency-electromagnetic field (RF-EMF) exposure due to carrying handsets close to the body. This study aimed to determine where men usually carried their handsets and to assess the relationship to risk perception of RF-EMF. Participants completed a self-administered questionnaire about mobile phone use, handset carrying locations, and levels of risk perception to RF-EMF. Data were analysed using linear regression models to examine if risk perception differed by mobile phone carrying location. The participants were 356 men, aged 18-72 years. They owned a mobile phone for 2-29 years, with over three quarters (78.7%) having a mobile phone for over 20 years. The most common locations that men kept their handsets when they were 'indoors' were: on a table/desk (54.0%) or in close contact with the body (34.7%). When outside, 54.0% of men kept the handset in the front trouser pocket. While making or receiving calls, 85.0% of men held their mobile phone handset against the head and 15.0% either used earphones or loudspeaker. Men who carried their handset in close contact with the body perceived higher risks from RF-EMF exposure compared to those who kept it away from the body ($p<0.01$). A substantial proportion of men carried their mobile phone handsets in close proximity to reproductive organs i.e. front pocket of trousers (46.5%). Men who kept their handset with the hand ($p < .05$), and those who placed it in the T-shirt pocket ($p < .05$), while the phone was not in use, were more likely to perceive health risks from their behaviour, compared to those who kept it away from the body. However, whether this indicates a causal relationship, remains open.

Excerpt

In the current study, one in every six men believed that carrying mobile phones would cause infertility. This may not be surprising since a third of the participants also reported feeling heating on body parts near where the mobile phone was carried. This may be worrisome in modern days since smartphones are more prone to heating human tissues in contact as there is a trend in moving toward lower specific absorption rate (SAR) and higher battery capacity smartphones due to their increased uses other than making/receiving calls [6]....

Given the ubiquity of mobile phone use and that the majority of men carried their mobile phones in close proximity to reproductive organs (e.g. testes), the relationship between resulting perceived RF-EMF exposures and associated health risks warrants further research.

Open access paper: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0269457

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Bluetooth versus non-Bluetooth earphones and their potential harmful effect on hearing: a cross-sectional study conducted among undergraduate medical students, Saudi Arabia

Zeinab A. Abd-El.haleem, Madania M N. Idrees, Waqas Sami, Shamshad B.A. Loni, Hemmat H.G.Hareedy. Bluetooth versus non- Bluetooth earphones and their potential harmful effect on hearing: a cross-sectional study conducted among undergraduate medical students, Saudi Arabia. International Journal of Early Childhood Special Education (INT-JECSE). 2022. 14(03): 3115.

Abstract

Background The use of Bluetooth and non- Bluetooth earphones is increasing worldwide. Improper use of these devices is associated with a higher risk for hearing loss. The objective of this study was to determine the effect of use of Bluetooth and non -Bluetooth earphones on hearing function and to determine whether the combined use of both types have more negative impact on hearing or not.

Methods A cross-sectional study was conducted on 42 adult female students in medical college, Majmaah University. It included a questionnaire to evaluate earphone listening habits and pure-tone audiometry to assess hearing function. The data was analyzed using ANOVA and Chi-square tests to fulfill the objectives of the study.

Results Around 85.7% of the students had hearing threshold ≥20 dB HL at one or more frequencies. Left ears were more affected than right ears. Hearing threshold > 40dB HL was observed in left ear. A significant higher difference was only observed between combined group and Bluetooth group at frequency of 250 Hz in left ear. No significant difference was observed between studied groups at other frequencies. Poorer hearing thresholds was observed in those who frequently used earphones.

Conclusion Main hearing thresholds were poor in earphone users which could be interpreted as earphones use may have negative impact on hearing. The combined use of both types of earphones did not show more negative impact on hearing threshold. It is essential to implement education programs in order to raise young people's awareness of proper earphone use and change their attitudes toward them.

Conclusion

Pure-tone audiometry showed poor hearing thresholds in those using earphones for more than 1 year. 85.7% of the students had hearing thresholds >20 dB HL at one or more frequencies. Mild hearing loss was observed in both right and left ears. Moderate hearing loss was observed in left ear only. On comparing the mean hearing thresholds of the three studied group, a higher hearing threshold was only observed between the combined and Bluetooth groups at frequency of 250 Hz in left ear. In right ear no difference was observed between the three studied groups at all frequencies. Thus, combined use of Bluetooth and non-Bluetooth earphones did not show more risk on hearing function in relation to either Bluetooth or non-Bluetooth alone.

Open access paper: https://www.int-jecse.net/data-cms/articles/20220524061918pm380.pdf

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Evidence of the radiofrequency exposure on the antioxidant status potentially contributing to the inflammatory response and demyelination in rat brain

Sharma A, Shrivastava S, Singh A, Gupte SS, Rathore A, Reshi MS, Shukla S. Evidence of the radiofrequency exposure on the antioxidant status potentially contributing to the inflammatory response and demyelination in rat brain. Environ Toxicol Pharmacol. 2022 Jun 11:103903. doi: 10.1016/j.etap.2022.103903.

Highlights

• MWR produces a significant rise in lipid peroxidation and depletion of total antioxidant status.
• Chronic exposure of MWR alters the heme synthetic pathway.

• MWR exposure induces inflammatory response in the rats that may cause neural injury.
• Prolonged MWR exposure degenerated hippocampus, cerebellum and corpus callosum.
• Long term MWR exposure showed mitochondrial damage and demyelination.

Abstract

Present study exhibited the oxidative potential of microwave radiation (MWR) leading to the neurodegeneration in rats. Wistar rats were exposed at 2100MHz frequency for 4hours/day, 5days/week/3 months. Animals were exposed at an estimated specific absorption rate (0.453W/kg) and power density (8.237μW/m^2). After exposure, the irradiated group was compared with control group. Results indicated that microwave exposure significantly increased the levels of serological triglycerides and cholesterol. Oxidative stress is observed through alteration of Glutathione homeostasis followed by Activated inflammatory response further confirmed by pro and anti-inflammatory cytokines in the exposed group. Histopathological assessments and electron microscopic observation confirmed a significant change in the myelination pattern and cellular organelles in the brain of exposed animals. Taking everything into account it can be concluded that chronic exposure of 2100-MHz frequency caused oxidative stress, which leads to neural damage and demyelination and may affect neural communication.

https://pubmed.ncbi.nlm.nih.gov/35700956/

Conclusion

In conclusion, our findings suggested that 2100 MHz frequency exposure (0.433, W/kg SAR) leads to an increase in free radicals due to compromised GSH homeostasis. It contributes to the poor defense capacity of the brain against reactive oxygen species that leads to a condition of oxidative stress. The oxidative stress modulates immune responses that further elicit neuronal cell death and demyelination. Thus, strengthening the statement that microwave radiation exposure is a "multi-hit" process of pathogenesis, including, oxidative stress, inflammatory activation, and demyelination contributed to the prevalence of neurodegenerative diseases.

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Effects of 5.8 GHz Microwaves on Testicular Structure and Function in Rats

Xue Y, Guo L, Lin J, Lai P, Rui G, Liu L, Huang R, Jing Y, Wang F, Ding G. Effects of 5.8 GHz Microwaves on Testicular Structure and Function in Rats. Biomed Res Int. 2022 Jun 6;2022:5182172. doi: 10.1155/2022/5182172.

Abstract

Objective: To investigate the effects of exposure to 5.8 GHz microwaves on testicular structure and function of male adult rats.

Methods: After 30 days of exposure, we evaluated sperm quality by determining sperm concentration and quantifying the number of abnormal sperm. Testicular morphology was investigated by hematoxylin-eosin (HE) staining. The levels of testosterone (T), follicle-stimulating hormone (FSH), luteinizing hormone (LH), glial cell line-derived neurotrophic factor (GDNF), stem cell factor (SCF), and transferrin (TRF) were determined by

enzyme-linked immunosorbent assays (ELISAs). We also used western blotting to determine the levels of GDNF and SCF and apoptosis-related protein (caspase-3) in the testis.

Results: Compared with the sham group, there were no significant differences in terms of sperm count, sperm abnormality, and the levels of T, FSH, LH, GDNF, SCF, and caspase-3 in the microwave group.

Conclusion: Under the experimental conditions, 5.8 GHz microwave exposure has no obvious effect on testicular structure and function of rats.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9192205/

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Transgenerational changes in *Daphnia magna* under radio frequency radiation in the juvenile and puberty period

Sarapultseva EI, Uskalova DV, Ustenko KV, Tikhonov VN, Ivanov IA, Tikhonov AV. Transgenerational changes in *Daphnia magna* under radio frequency radiation in the juvenile and puberty period. Int J Radiat Biol. 2022 Jun 8:1-31. doi: 10.1080/09553002.2022.2087928.

Abstract

Purpose To analyze the results of direct and transgenerational effects of radio frequency electromagnetic fields (RF-EMF) on the model organism of crustaceans *Daphnia magna*.

Materials and Methods *D. magna* were chronically exposed at 900 GHz EMF with an energy flux density (EFD) of about 1 mW/cm^2 in the juvenile and pubertal periods of their ontogenesis. The cytotoxicity of exposure as well as survival, fertility and teratogenic effect of directly exposed daphnids and their progeny across three generations were analyzed.

Results and Conclusions The results of our study show that exposure of RF-EMF at juvenile period can significantly affect the fertility and size of irradiated daphnids and their offspring of the first generation. The decrease in fertility may be associated with a cytotoxic effect on the cells of irradiated animals. The reduction in the size of the spike and the body of individuals is an indicator of the negative impact of radiation on the protective strategy of the crustacean population. The reproductive process is restored by the second generation. The results of our study provide further insights into the possible mechanisms underlying the *in vivo* effects of RF-EMF.

https://pubmed.ncbi.nlm.nih.gov/35675553/

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The Effect of Electromagnetic Radiation Transmitted from Routers on Antibiotic Susceptibility of Bacterial Pathogens

Pegios, A., Kavvadas, D., Zarras, K., Mpani, K., Soukiouroglou, P., Charalampidou, S., Vagdatli, E., Papamitsou, T. (2022). 'The Effect of Electromagnetic Radiation Transmitted from Routers on Antibiotic Susceptibility of Bacterial Pathogens', *Journal of Biomedical Physics and Engineering*. Available Online from 22 June 2022.

Abstract

Background: Electromagnetic non-ionizing radiation has both thermal and non-thermal outcomes on biological systems, such as humans, animals, and bacteria.

Objective: This study aimed to investigate the effect of non-ionizing radiofrequency radiation, emitted by Wi-Fi routers, on bacterial strains and the modification of their susceptibility to modern antibiotics.

Material and Methods: In this case-control paired study, four bacteria were selected, and one colony from each bacterial strain was exposed to Wi-Fi radiation forming the exposure group. Another set of colonies was not exposed to Wi-Fi radiation, forming the control group. Eight different antibiotic disks were set on the bacterial plates, and the inhibition zone was measured every 3 h for each colony.

Results: Electromagnetic radiation affects bacterial colonies and their susceptibility to antibiotics. Analysis revealed statistically significant differences, correlated with the bacterial strain, the antibiotic agent, and the time of the exposure, in the inhibition zones, mostly after 6 and 24 h (p-value < 0.05).

Conclusion: A correlation was observed between antibiotic susceptibility and non-ionizing radiofrequency exposure. Studying the effects of radiofrequency radiation on prokaryotic organisms could clarify more complicated cell structures and organisms, such as eukaryotic. Further experiments, in vitro and in vivo, could provide more information about these outcomes and cause experts to discuss the current guidelines of exposure limits.

Open access paper: https://jbpe.sums.ac.ir/article_48472.html

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Label-Free Study of the Global Cell Behavior during Exposure to Environmental Radiofrequency Fields in the Presence or Absence of Pro-Apoptotic or Pro-Autophagic Treatments

Joushomme A, Garenne A, Dufossée M, Renom R, Ruigrok HJ, Chappe YL, Canovi A, Patrignoni L, Hurtier A, Poulletier de Gannes F, Lagroye I, Lévêque P, Lewis N, Priault M, Arnaud-Cormos D, Percherancier Y. Label-Free Study of the Global Cell Behavior during Exposure to Environmental Radiofrequency Fields in the Presence or Absence of Pro-Apoptotic or Pro-Autophagic Treatments. Int J Mol Sci. 2022 Jan 8;23(2):658. doi: 10.3390/ijms23020658.

Abstract

It remains controversial whether exposure to environmental radiofrequency signals (RF) impacts cell status or response to cellular stress such as apoptosis or autophagy. We used two label-free techniques, cellular impedancemetry and Digital Holographic Microscopy (DHM), to assess the overall cellular response during RF exposure alone, or during co-exposure to RF and chemical treatments known to induce either apoptosis or

autophagy. Two human cell lines (SH-SY5Y and HCT116) and two cultures of primary rat cortex cells (astrocytes and co-culture of neurons and glial cells) were exposed to RF using an 1800 MHz carrier wave modulated with various environmental signals (GSM: Global System for Mobile Communications, 2G signal), UMTS (Universal Mobile Telecommunications System, 3G signal), LTE (Long-Term Evolution, 4G signal, and Wi-Fi) or unmodulated RF (continuous wave, CW). The specific absorption rates (S.A.R.) used were 1.5 and 6 W/kg during DHM experiments and ranged from 5 to 24 W/kg during the recording of cellular impedance. Cells were continuously exposed for three to five consecutive days while the temporal phenotypic signature of cells behavior was recorded at constant temperature. Statistical analysis of the results does not indicate that RF-EMF exposure impacted the global behavior of healthy, apoptotic, or autophagic cells, even at S.A.R. levels higher than the guidelines, provided that the temperature was kept constant.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8776001/

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Millimeter waves alter DNA secondary structures and modulate the transcriptome in human fibroblasts

Lawler NB, Evans CW, Romanenko S, Chaudhari N, Fear M, Wood F, Smith NM, Wallace VP, Swaminathan Iyer K. Millimeter waves alter DNA secondary structures and modulate the transcriptome in human fibroblasts. Biomed Opt Express. 2022 Apr 28;13(5):3131-3144. doi: 10.1364/BOE.458478.

Abstract

As millimetre wave (MMW) frequencies of the electromagnetic spectrum are increasingly adopted in modern technologies such as mobile communications and networking, characterising the biological effects is critical in determining safe exposure levels. We study the exposure of primary human dermal fibroblasts to MMWs, finding MMWs trigger genomic and transcriptomic alterations. In particular, repeated 60 GHz, 2.6 mW cm^{-2}, 46.8 J cm^{-2} d^{-1} MMW doses induce a unique physiological response after 2 and 4 days exposure. We show that high dose MMWs induce simultaneous non-thermal alterations to the transcriptome and DNA structural dynamics, including formation of G-quadruplex and i-motif secondary structures, but not DNA damage.

Excerpt

In conclusion, our findings demonstrate that high dose MMWs can induce characteristic transcriptomic and genomic modifications in primary human fibroblasts that are not associated with a typical cellular thermal response. We show that MMW-induced changes at the transcriptome level are distinct from a traditional cytokine-induced transition, and that they may be associated with alterations in DNA structural dynamics. These changes represent unique interactions of MMWs with biological material and illustrate the importance of both power density and dose when determining safety margins for longer periods.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9203081/

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Effects of intermediate frequency electromagnetic fields: a review of animal studies

Lee Hae-June, Jin Hee, Ahn Young Hwan, Kim Nam, Pack Jeong Ki, Choi Hyung-Do, Lee Yun-Sil. Effects of intermediate frequency electromagnetic fields: a review of animal studies. International Journal of Radiation Biology. 2022. doi: 10.1080/09553002.2022.2094016

Abstract

Many novel devices such as induction cookers or wireless power transfer produce electromagnetic fields (EMFs) in the intermediate frequency (IF) range (300 Hz to 10 MHz) and it is very meaningful for summarizing the bioeffects of IF-EMF research, particularly animal studies. This review takes into account experimental studies that used murine models to study the health effects of exposure to IF-EMF. The analyses included here use data available in the literature published from January 1988 to August 2021 including the animal studies about general adverse effects, tumorigenic effects, and effects on developmental stages. The studies that linked IF-EMF exposure during pregnancy or neonatal stage to behavioral and cognition changes were included. Additionally, this review also covers the effects of IF-EMF on gene expression patterns in the brain, behavior patterns associated with learning and memory, and immune function.

Excerpt

The main sources of IF-EMF can be divided into the following areas.

> Industry: dielectric heater sealers, induction and plasma heaters, broadcast and telecommunication transmitters
> General public: induction cookers, proximity readers, electronic article surveillance systems and other anti-theft devices, computer monitors, and TV sets
> Hospitals: MRI systems, electromagnetic nerve stimulators, electrosurgical instruments, and other medical devices
> Defense: submarine communication transmitters and high frequency (HF) transmitters.

Conclusion

As the use of IF-EMF-based devices such as induction cookers and wireless power transfer increases, it is meaningful to comprehensively summarize the biological effects of IF-EMF studies conducted so far, especially animal studies. We reviewed a total of 38 experimental studies published from databases EMF Portal and PubMed between January 1988 to August 2021 that used rats or mice to investigate the effects of IF-EMF on prolonged exposure, developmental stages, tumorigenicity, effects on sperm fertility, and other effects that linked IF-EMF exposure during pregnancy or neonatal stage to behavioral and cognition changes. In addition, studies on gene expression in the brain, learning and memory behaviors, and immune functions by IF-EMFs have also been evaluated. Even though most studies have reported that IF-EMFs do not induce any adverse effects, some studies have linked harmful effects on early development in mice. The adverse effects on neutrophil count, cytokines, and the concentrations of testosterone and progesterone, and the alteration of mRNA or protein expression levels in the brain, were also reported. However, the health effects of IF-EMF exposure were not independently reproduced and were not dependent on the degree of IF-EMF exposure. Therefore, we concluded that IF-EMF exposure within ICNRP limits (ICNRP reference levels: 27 μT for the general public and 100 μT for occupational exposure) did not produce any harmful effects on animals. Of course, more research

needs to be done using the latest biomedical tools, however, a comprehensive review of IF-EMF studies, especially animal studies, will provide a valuable basis for further risk analysis of IF-EMF in humans.

https://www.tandfonline.com/doi/full/10.1080/09553002.2022.2094016

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Geomagnetic disturbances reduce heart rate variability in the Normative Aging Study

Carolina L. Zilli Vieira, Kelly Chen, Eric Garshick, Man Liu, Pantel Vokonas, Petter Ljungman, Joel Schwartz, Petros Koutrakis. Geomagnetic disturbances reduce heart rate variability in the Normative Aging Study. *Science of The Total Environment.* Volume 839. 15 September 2022. 156235. doi: 10.1016/j.scitotenv.2022.156235.

Highlights

- Intense geomagnetic activity up to 24 h reduced heart rate variability (HRV).
- Patients with coronary heart diseases presented higher risk.
- The associations remained similar after the adjustments for air pollutant exposures.
- Geomagnetic activity may account for temporal HRV-related cardiovascular outcomes.

Abstract

Background Solar and geomagnetic activity (GA) have been linked to increased cardiovascular (CVD) events. We hypothesize that heart rate variability (HRV) may be the biological mechanism between increased CVD risk and intense geomagnetic disturbances (GMD).

Methods To evaluate the impact of GA and intense GMD on HRV in 809 elderly men [age mean 74.5 (SD = 6.8)] enrolled in the Normative Aging Study (Greater Boston Area), we performed repeated-measures using mixed-effects regression models. We evaluated two HRV outcomes: the square root of the mean squared differences of successive normal-to-normal intervals (r-MSSD) and the standard deviation of normal-to-normal heartbeat intervals (SDNN) in milliseconds (ms). We also compared the associations between Kp and HRV in patients with and without comorbidities such as diabetes and coronary heart diseases (CHD). We used data on global planetary K-Index (Kp) from middle latitudes as a GA and GMD (>75th Kp) parameters from the National Oceanic and Atmospheric Agency's Space Weather Prediction Center.

Results We found a near immediate effect of continuous and higher Kp on reduced HRV for exposures up to 24 h prior to electrocardiogram recording. A 75th percentile increase in 15-hour Kp prior the examination was associated with a −14.7 ms change in r-MSSD (95 CI: −23.1, −6.3, p-value = 0.0007) and a −8.2 ms change in SDNN (95 CI: −13.9, −2.5, p-value = 0.006). The associations remained similar after adjusting the models for air pollutants over the exposure window prior to the event. In periods of intense GMD, the associations were stronger in patients with CHD and non-diabetes.

Conclusions This is the first study to demonstrate the potential adverse effects of geomagnetic activity on reduced heart rate variability in a large epidemiologic cohort over an extended period, which may have important clinical implications among different populations.

Conclusions

Our findings showed a significant impact of GA and intense GMD on the reduction in HRV up to 24 h prior to the electrocardiogram in elderly individuals. The associations remained even after adjusting for air pollutants. In periods of intense GMD, the reduction of HRV was even stronger in patients with CHD and no diabetes. This exposure nexus could have important clinical implications for cardiac health and preventative strategies, as HRV is a predictor of CVD morbidity and mortality caused by the dysregulation of sympathetic and/or parasympathetic activity. Future studies may investigate differential susceptibility and related biological mechanisms based on location, age, and other pre-existing comorbidities in different populations.

Open access paper (until July 21, 2022): https://bit.ly/GMDhrv

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Solar and geomagnetic activity reduces pulmonary function and enhances particulate pollution effects

Kritika Anand, Carolina L.Z. Vieira, Eric Garshick, Veronica Wang, Annelise Blomberg, Diane R. Gold, Joel Schwartz, Pantel Vokonas, Petros Koutrakis. Solar and geomagnetic activity reduces pulmonary function and enhances particulate pollution effects. Science of The Total Environment. 2022. 156434. doi: 10.1016/j.scitotenv.2022.156434.

Abstract

Background Increased solar and geomagnetic activity (SGA) may alter sympathetic nervous system activity, reduce antioxidant activity, and modulate physiochemical processes that contribute to atmospheric aerosols, all which may reduce pulmonary function.
Objectives Investigate associations between forced expiratory volume at 1 s (FEV1) and forced vital capacity (FVC) with SGA, and assess whether SGA enhances adverse effects of particulate pollution, black carbon (BC) and particulate matter ≤2.5 μm in diameter (PM2.5).

Methods We conducted a repeated measures analysis in 726 Normative Aging Study participants (Boston, Massachusetts, USA) between 2000 and 2017, using interplanetary magnetic field (IMF), planetary K index (Kp), and sunspot number (SSN) as SGA measures. Linear mixed effects models were used to assess exposure moving averages up to 28 days for both SGA and pollution.

Results Increases in IMF, Kp Index and SSN from the day of the pulmonary function test averaged through day 28 of were associated with a significant decrement in FEV1 and FVC, after adjusting for potential confounders. There were greater effects for longer moving averages and enhanced effects of PM2.5 and BC on FEV1 and FVC with increased SGA. For example, for each inter-quartile increase (4.55 μg/m3) in average PM2.5 28 days before testing, low IMF (10th percentile: 3.2 nT) was associated with a −21.4 ml (95 % CI: −60.8, 18.1) and −7.1 ml (95 % CI: −37.7, 23·4) decrease in FVC and FEV1, respectively; high IMF (90th percentile: 9.0 nT) was associated with a −120.7 ml (95 % CI:-166.5, −74.9) and −78.6 ml (95 % CI: −114.3, −42·8) decrease in FVC and FEV1, respectively.

Discussion Increased periods of solar and geomagnetic activity may directly contribute to impaired lung function and also enhance effects of PM2.5 and BC. Since exposure to solar activity is ubiquitous, stricter measures in reducing air pollution exposures are warranted, particularly in elderly populations.

Open access paper (until July 30, 2022): https://authors.elsevier.com/c/1fDlOB8cculns

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Recurrent ancient geomagnetic field anomalies shed light on future evolution of the South Atlantic Anomaly

Andreas Nilsson, Neil Suttie, Joseph S. Stoner, Raimund Muscheler. Recurrent ancient geomagnetic field anomalies shed light on future evolution of the South Atlantic Anomaly. PNAS. 2022. 119 (24) e2200749119. doi: 10.1073/pnas.2200749119.

Significance

Earth's magnetic field, which is generated through convection in the liquid iron–rich outer core, acts as a shield against harmful particle radiation. During the past two centuries, the field strength has decreased rapidly as an area of weak field has expanded over the South Atlantic Ocean. The decreased shielding effect of the magnetic field in this area has important implications for low Earth-orbiting satellites and space travel. Using archeological and geological records, we have reconstructed the variations of Earth's magnetic field over the past 9,000 y. We find evidence for recurrent magnetic field anomalies, similar to the present-day South Atlantic Anomaly, which provides insights into underlying geodynamo processes that may help predict the future development of Earth's magnetic field.

Abstract

The strength of the geomagnetic field has decreased rapidly over the past two centuries, coinciding with an increasing field asymmetry due to the growth of the South Atlantic Anomaly. The underlying processes causing the decrease are debated, which has led to speculation that the field is about to reverse. Here, we present a geomagnetic field model based on indirect observations over the past 9,000 y and identify potential ancient analogs. The model is constructed using a probabilistic approach that addresses problems with age uncertainties and smoothing of sedimentary data that have hampered previous attempts. We find evidence for recurrent hemispherical field asymmetries, related to quasiperiodic millennial-scale variations in the dipole moment. Our reconstruction indicates that minima in the dipole moment tend to coincide with geomagnetic field anomalies, similar to the South Atlantic Anomaly. We propose that the period around 600 BCE, characterized by a strongly asymmetric field, could provide an analog to the present-day field. The analogy implies that the South Atlantic Anomaly will likely disappear in next few hundred years, accompanied by a return to a more symmetric field configuration and possibly, a strengthening of the axial dipole field.

https://www.pnas.org/doi/full/10.1073/pnas.2200749119

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Myths in Magnetosensation

Simon Nimpf, David A. Keays. Myths in magnetosensation. 25(6); 104454. May 23, 2022. doi: 10.1016/j.isci.2022.104454.

Summary

The ability to detect magnetic fields is a sensory modality that is used by many animals to navigate. While first postulated in the 1800s, for decades, it was considered a biological myth. A series of elegant behavioral experiments in the 1960s and 1970s showed conclusively that the sense is real; however, the underlying mechanism(s) remained unresolved. Consequently, this has given rise to a series of beliefs that are critically analyzed in this manuscript. We address six assertions: (1) Magnetoreception does not exist; (2) It has to be magnetite; (3) Birds have a conserved six loci magnetic sense system in their upper beak; (4) It has to be cryptochrome; (5) MagR is a protein biocompass; and (6) The electromagnetic induction hypothesis is dead. In advancing counter-arguments for these beliefs, we hope to stimulate debate, new ideas, and the design of well-controlled experiments that can aid our understanding of this fascinating biological phenomenon.

Open access paper: https://www.cell.com/iscience/fulltext/S2589-0042(22)00725-8

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A critical analysis of the MOBI-Kids study of wireless phone use in childhood and adolescence and brain tumor risk

Lennart Hardell, Joel M. Moskowitz. A critical analysis of the MOBI-Kids study of wireless phone use in childhood and adolescence and brain tumor risk. *Reviews on Environmental Health*, May 5, 2022. https://doi.org/10.1515/reveh-2022-0040.

Abstract

The MOBI-Kids case-control study on wireless phone use and brain tumor risk in childhood and adolescence included the age group 10–24 years diagnosed between 2010 and 2015. Overall no increased risk was found although for brain tumors in the temporal region an increased risk was found in the age groups 10–14 and 20–24 years. Most odds ratios (ORs) in MOBI-Kids were <1.0, some statistically significant, suggestive of a preventive effect from RF radiation; however, this is in contrast to current knowledge about radiofrequency (RF) carcinogenesis. The MOBI-Kids results are not biologically plausible and indicate that the study was flawed due to methodological problems. For example, not all brain tumor cases were included since central localization was excluded. Instead, all brain tumor cases should have been included regardless of histopathology and anatomical localization. Only surgical controls with appendicitis were used instead of population-based controls from the same geographical area as for the cases. In fact, increased incidence of appendicitis has been postulated to be associated with RF radiation which makes selection of control group in MOBI-Kids questionable. Start of wireless phone use up to 10 years before diagnosis was in some analyses included in the unexposed group. Thus, any

important results demonstrating late carcinogenesis, a promoter effect, have been omitted from analysis and may underestimate true risks. Linear trend was in some analyses statistically significant in the calculation of RF-specific energy and extremely low frequency (ELF)-induced current in the center of gravity of the tumor. Additional case-case analysis should have been performed. The data from this study should be reanalyzed using unconditional regression analysis adjusted for potential confounding factors to increase statistical power. Then all responding cases and controls could be included in the analyses. In sum, we believe the results as reported in this paper seem uninterpretable and should be dismissed.

Summary

- In our opinion, the results as reported in the MOBI-Kids paper seem uninterpretable and should be dismissed.
- All brain tumor cases should have been included regardless of histopathology and anatomical localization.
- Only surgical controls with suspected appendicitis were used. Yet, increased incidence of appendicitis has been postulated to be associated with RF radiation.
- Start of wireless phone use up to 10 years before diagnosis was in some analyses included in the unexposed group. This would bias the ORs towards unity.
- The results indicate an increased risk for tumors in the temporal brain region in spite of methodological issues based on low numbers in several categories.
- Linear trend was in some analyses statistically significant in the calculation of RF-specific energy and ELF-induced current in the center of gravity of the tumor. Additional case-case analysis should have been performed.
- The data from this study should be reanalyzed using unconditional regression analysis adjusted for potential confounding factors to increase the statistical power.

Finally, it is unfortunate that after such a major investment of resources that little can be learned at this time from the MOBI-Kids study about the risk of brain tumors from wireless phone use in young people. Since the study addresses an issue critical to public health and the majority of the funding was from the European Commission, the MOBI-Kids data set should be publicly archived making it available to the scientific community to enable the data to be re-analyzed using different assumptions and methods.

Open access paper: https://www.degruyter.com/document/doi/10.1515/reveh-2022-0040/html

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Genotoxic effects of electromagnetic field radiations from mobile phones (Review)

Ganesh Chandra Jagetia. Genotoxic effects of electromagnetic field radiations from mobile phones. Environmental Research. 2022. 113321. doi: 10.1016/j.envres.2022.113321.

Highlights

• The exposure to electromagnetic field radiation has increased tremendously from manmade electronic gadgets in addition to natural sources.
• A few studies on mobile phone exposure indicated that it does not cause harmful effects.
• The studies indicated a positive correlation between mobile phone use and genotoxic effects that outnumber the negative effect.

• Electromagnetic field radiations increase reactive oxygen species formation that causes mutagenic and genotoxic effects leading to cancer.

Abstract

The use of wireless communication technology in mobile phones has revolutionized modern telecommunication and mobile phones have become so popular that their number exceeds the global population. Electromagnetic field radiations (EMR) are an integral part of wireless technology, which are emitted by mobile phones, mobile towers, electric power stations, transmission lines, radars, microwave ovens, television sets, refrigerators, diagnostic/therapeutic and other electronic devices. The manmade EMR sources have added to the existing burden of natural EMR human exposure arising from the Sun, cosmos, atmospheric discharges, and thunderstorms. EMR including radiofrequency waves (RF) and extremely low frequency radiation (ELF) has generated great interest as their human exposure causes headache, fatigue, tinnitus, concentration problems, depression, memory loss, skin irritation, sleep disorders, nausea, cardiovascular effects, chest pain, immunity and hormonal disorders as the short-term effects and cancer as the late effect. The review has been written by collecting the information using various search engines including google scholar, PubMed SciFinder, Science direct, EMF-portal, saferemr, and other websites on the internet and its main focus is on the mutagenic and genotoxic effects of EMR in humans and mammals. Numerous investigations revealed that exposure in the range of 0–300 GHz EMR is harmless as this did not increase micronuclei and chromosome aberrations. On the contrary, several other studies have demonstrated that exposure to EMR increases the frequency of micronuclei, chromosome aberrations, DNA adducts, DNA single and double strand breaks at the molecular level in vitro and in vivo. The EMR exposure induces reactive oxygen species and changes the fidelity of genes involved in signal transduction, cytoskeleton formation, and cellular metabolism.

Excerpts

Table 1 lists 75 (23 ELF/IF, 52 RF) studies that did not find significant genotoxic effects.

Table 2 lists 145 (47 ELF/IF, 98 RF) studies that reported significant genotoxic effects.

Conclusions

The electromagnetic radiations especially in the radiofrequency range are long wavelength radiation and they have a wide application in wireless communication. Human exposure to EMF-RF-ELF is from electrical transmission lines, mobile signal transmission towers, mobile phones, microwaves and various electronic gadgets which are in daily use. A phenomenal rise in the subscription of mobile phones which continues unabated has drastically increased the exposure to EMF-RF-ELF of children and adults equally. Various agencies worldwide have also raised concern about the ill effects of these radiations. Investigations reporting that EMF-RF-ELF exposures are are genotoxic outnumber the reports that the EMF-RF-ELF exposure are not harmful to the human population, Various preclinical models report the genotoxic effect of EMF-RF-ELF in the form of chromosome condensation, various types of chromosome aberrations, micronuclei formation, sister chromatid exchanges, DNA base damages, DNA adduct formation, DNA SSBs and DNA DSBs. The EMF-RF-ELF triggered the formation of ROS, which seem to be responsible for all the genotoxic and mutagenic effects of EMF-RF-ELF. EMF-RF-ELF also reduces antioxidant status by alleviating GSH, catalase, SOD, GST, GPx and increasing lipid peroxidation. At the molecular level EMF-RF-ELF stimulates the activation NF-κB, TNF-α, HSP 70, p53, Chk-2, p38, LC3-II, pAMPK, PARP, Bax/Bcl-2 ratio, DNA-PKcs, RAD9B, BM11, cytochrome c release and cleaved caspase-

3 and subsequently downmodulates p21, p62, p-mTOR, GADD45α, XRCC1, XRCC4, Ku80 (XRCC5), Ku70 (XRCC6), and LIG4, caspase3 and Bcl2 which are involved in numerous cellular processes. The repeated EMF-RF-ELF exposures exert a negative effect on human health and cause mutagenesis and cancer in humans. It will be prudent to follow ALARA (as low as reasonably achievable) principle to minimize the adverse effect on humans.

https://pubmed.ncbi.nlm.nih.gov/35508219/

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Analysis of ICNIRP 2020 Basic Restrictions for Localized Radiofrequency Exposure in the Frequency Range Above 6 GHz

Eric Lemay, Gregory B Gajda, Gregory W McGarr, Mykola Zhuk, Jonathan Paradis. Analysis of ICNIRP 2020 Basic Restrictions for Localized Radiofrequency Exposure in the Frequency Range Above 6 GHz. Health Phys. 2022 May 21. doi: 10.1097/HP.0000000000001581.

Abstract

ICNIRP 2020 guidelines have defined a practical temperature elevation threshold for human health effects, namely the operational adverse health effect threshold that forms the basis of the absorbed power and energy density basic restrictions. These basic restrictions for localized exposures at frequencies above 6 GHz were evaluated by comparing numerically computed temperature rise against the target temperature rise of 2.5 oC, which is the operational adverse health effect threshold divided by the occupational safety factor of 2. The numerical model employs the maximum absorbed power and energy density levels allowed by the occupational basic restriction for both pulsed and continuous wave exposures. These analyses were performed considering 3- and 4-tissue layer models and a variety of beam diameters, frequencies, and exposure durations. The smallest beam diameters were based on a study of theoretically achievable beam widths from half-wave resonant dipoles and show the impact of the averaging area on the computed temperature elevation. The results demonstrated that ICNIRP's assumed occupational safety factors in the frequency range above 6 GHz were not sufficiently maintained for all exposure scenarios and particularly for short pulse exposures at frequencies of 30 GHz or higher with small beam diameters. Worst-case tissue temperature elevations were estimated to be as much as 3.6 times higher than ICNIRP's target temperature increases. Consequently, the authors suggest a small modification in the application of the ICNIRP 2020 localized basic restrictions, thereby limiting the worst-case tissue temperature increases to 1.4 times the target value.

Conclusion

Numerical computations of the SAR distribution and resulting temperature rise in models of superficial tissue at levels allowed by the ICNIRP (2020) BRs for frequencies above 6 GHz were carried out to investigate the safety factors from the assumed OAHET thermal thresholds inherent in the BRs.

The results showed that for a range of beam sizes, pulse durations, and carrier frequencies, the safety factors are reduced from their assumed values of 2 times below an OAHET temperature rise of 5 °C for the occupationally exposed. The lowest safety factors (the worst case was 0.56, resulting in a temperature rise of 1.8

times the OAHET) occurred for single pulses with the smallest assumed spot size of FWHM = 0.005 m (or an assumed unperturbed power density beam diameter of 0.0063 m) for short durations (t_d < 1 s) at 200 GHz.

Examinations of SAR distributions from half-wave resonant dipoles (Appendix) led to the decision to set a lower value of FWHM = 0.005 m for frequencies of 30 GHz and beyond. While it may be argued that current mobile applications may not deliver such small SAR distributions, there exists the theoretical possibility that even smaller spots sizes can be generated at the higher millimeter-wave frequencies covered in the ICNIRP (2020) guideline.

Safety factors for CW exposures (t_d > 360 s) were generally higher than for a single pulse, with the worst-case (a safety factor of 1.46 as opposed to the assumed value of 2) again occurring for the smallest spot size.

Despite the low worst-case safety factors and high resulting temperature rises, CEM43 calculations suggest that even minor damage to the skin is unlikely at the current BR levels in ICNIRP (2020). The small beam diameters at which the lowest safety factors occur would suggest that maintaining the beam on the skin for a length of time necessary to induce even minor damage would be practically impossible, especially given that under such conditions, exposed individuals would likely remove the affected tissue away from the RF heat source in response to the sensation of warmth and/or heat pain before tissue damage could occur.

Mitigation of the low safety factors that occurred for the smallest beam diameters can be accomplished by changing the 1 cm^2 spatial averaging 0 cm^2 (essentially the spatial peak of the beam). If this modification to the local BRs is applied, the associated maximum (worst-case) tissue temperature rise is ≈ 3.5 °C for exposures at the occupational BR (≈ 0.7 °C for general public BR). This modification to the BR rules is easy to implement and would allow use of the ICNIRP (2020) AED formulae and APD limits for localized exposures above 6 GHz to 300 GHz to remain unchanged.

Open access paper: https://journals.lww.com/health-physics/Fulltext/9900/Analysis_of_ICNIRP_2020_Basic_Restrictions_for.15.aspx

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Why electrohypersensitivity and related symptoms are caused by non-ionizing man-made electromagnetic fields: An overview and medical assessment

Dominique Belpomme, Philippe Irigaray. Why electrohypersensitivity and related symptoms are caused by non-ionizing man-made electromagnetic fields: An overview and medical assessment. Environmental Research. May 7, 2022, 113374. doi: 10.1016/j.envres.2022.113374.

Highlights

• Electrohypersensitivity is caused by electromagnetic fields.
• Electrohypersensitivity is a neurological disorder with inflammation, oxidative stress, blood brain barrier opening and neurotransmitter abnormalities.
• Electrohypersensitivity must be defined by the decrease of brain electromagnetic fields tolerance threshold.

Abstract

Much of the controversy over the cause of electrohypersensitivity (EHS) lies in the absence of recognized clinical and biological criteria for a widely accepted diagnosis. However, there are presently sufficient data for EHS to be acknowledged as a distinctly well-defined and objectively characterized neurologic pathological disorder. Because we have shown that 1) EHS is frequently associated with multiple chemical sensitivity (MCS) in EHS patients, and 2) that both individualized disorders share a common pathophysiological mechanism for symptom occurrence; it appears that EHS and MCS can be identified as a unique neurologic syndrome, regardless its causal origin. In this overview we distinguish the etiology of EHS itself from the environmental causes that trigger pathophysiological changes and clinical symptoms after EHS has occurred. Contrary to present scientifically unfounded claims, we indubitably refute the hypothesis of a nocebo effect to explain the genesis of EHS and its presentation. We as well refute the erroneous concept that EHS could be reduced to a vague and unproven "functional impairment". To the contrary, we show here there are objective pathophysiological changes and health effects induced by electromagnetic field (EMF) exposure in EHS patients and most of all in healthy subjects, meaning that excessive non-thermal anthropogenic EMFs are strongly noxious for health. In this overview and medical assessment we focus on the effects of extremely low frequencies, wireless communications radio frequencies and microwaves EMF. We discuss how to better define and characterize EHS. Taken into consideration the WHO proposed causality criteria, we show that EHS is in fact causally associated with increased exposure to man-made EMF, and in some cases to marketed environmental chemicals. We therefore appeal to all governments and international health institutions, particularly the WHO, to urgently consider the growing EHS-associated pandemic plague, and to acknowledge EHS as a new real EMF causally-related pathology.

https://pubmed.ncbi.nlm.nih.gov/35537497/

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An idiographic approach to Idiopathic Environmental Intolerance attributed to Electromagnetic Fields (IEI-EMF) Part II. Ecological momentary assessment of three individuals with severe IEI-EMF

Zsuzsanna Dömötör, Gábor Ruzsa, György Thuróczy, Péter P Necz, Steven Nordin, Ferenc Köteles, Renáta Szemerszky. An idiographic approach to Idiopathic Environmental Intolerance attributed to Electromagnetic Fields (IEI-EMF) Part II. Ecological momentary assessment of three individuals with severe IEI-EMF. Heliyon. 2022 May 14;8(5):e09421. doi: 10.1016/j.heliyon.2022.e09421.

Abstract

IEI-EMF refers to a self-reported sensitivity characterized by attribution of non-specific physical symptoms to exposure to weak EMFs. The majority of empirical results do not support the existence of a causal relationship between EMF and IEI-EMF. However, this conclusion was drawn from environmental and experimental studies that are not without methodological limitations. In the current study, as part of a complex biopsychosocial approach, an ecological momentary assessment (EMA) protocol was applied for the investigation of the temporal relationship between actual radio frequency (RF) EMF exposure and IEI-EMF, at the individual level. Continuous measurement of autonomic variables by holter electrocardiogram (ECG) monitors and the ambient RF EMF by personal dosimeters, as well as repeated (8/day) paper-and-pencil assessments of momentary

internal states (symptoms, mood, perceived EMF intensity) and situational factors was conducted for 21 days with the participation of three individuals with severe IEI-EMF. Temporal relationships were examined by time series analyses. For two participants, the results did not support the association between the suspected EMF frequency range(s) and symptom reports. Nevertheless, the results revealed a reverse association with respect to another frequency range (GSM900 downlink), which contradicts the IEI-EMF condition. Autonomic activation related findings were inconsistent. For the third participant, the claimed association was partly supported, both for symptom reports and autonomic reactions (UMTS downlink, total RF; RMS values). The findings of this study suggest that IEI-EMF does not have a unitary aetiology. For certain individuals, a biophysical background cannot be excluded, whereas no such underlying factor appears to be at work for others. EMA is a useful method for the investigation of the aetiology of IEI-EMF.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9123209/

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Microwave Emissions and the Problem of Modern Viral Diseases

S V Avakyan, L A Baranova. Microwave Emissions and the Problem of Modern Viral Diseases. Her Russ Acad Sci. 2022;92(2):177-187. doi: 10.1134/S1019331622020058.

Abstract

The results of a study on the mechanisms of the influence of an increased level of microwave radiation on the growth of infectious, primarily viral, diseases in the environment are presented. This is the radiation of the earth's ionosphere, which reached its maximum in the late 1980s-early 2000s, following an increase in the level of solar activity since the 17th century. Over the past 30 years, the anthropogenic electromagnetic background has increased 100 times due to the development of cellular mobile communications and computerization. The predicted interaction of natural and anthropogenic sources of microwaves sharply increases their negative impact on the ecological situation. Of particular concern is the active spread in recent years of the new 5G communication standard; in the future, it is the development of the most dangerous millimeter range in our country. Energy from the environment in the microwave range can cause "unexpected behavior" in the DNA of viruses. Clarifications to the recommendations of experts on the protection of the population with the help of electromagnetic shielding, obtained in the framework of supramolecular physics of the environment, are proposed.

Excerpt

The effect of a permanent increase in microwave fluxes from the environment on the activation of viral pandemics is considered. This is not only the radiation of the earth’s ionosphere but also the anthropogenic electromagnetic background, caused by an avalanche-like increase in microwave pollution of the habitat during the operation of mobile cellular telephony, household computer equipment, and digitalization systems. The predicted interaction of natural and anthropogenic sources of microwaves sharply increases their negative impact on the ecological situation. Therefore, efforts are needed to reduce drastically the amount of time spent using mobile phones and surfing the Internet among at-risk populations, including secondary school students.

This wish of the authors is consistent with the concerns expressed recently by both teachers and parents of students, as well as with the opinion of the General Prosecutor's Office of the Russian Federation.

The proposed clarifications to the recommendations of experts on the protection of the population using electromagnetic shielding suggest the development of biophysical studies of the cumulative microwave impact both within heliobiology (at the present stage of the decline in the level of solar–geomagnetic activity) and taking into account the resonant mechanisms of increasing anthropogenic exposure at communication frequencies.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9107623/

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Symptoms reported by Canadians posted in Havana are linked with reduced white matter fibre density

Guillermo Aristi, Lyna Kamintsky, Margaux Ross, Chris Bowen, Cynthia Calkin, Alon Friedman, Javeria A. Hashmi. Symptoms reported by Canadians posted in Havana are linked with reduced white matter fibre density, *Brain Communications*. 4:2, 2022, fcac053, doi: 10.1093/braincomms/fcac053.

Abstract

Diplomats representing the USA have reported with unusual neurologic symptoms and MRI changes after being posted in Havana, Cuba between late 2016 and 2018. Here, we examined white matter microstructure and network connectivity of individuals stationed in Havana, using diffusion-weighted MRI, fixel-based analysis and structural connectomics as implemented in MRtrix3. MRI data acquisition and clinical assessments were done in a total of 24 diplomats and their family members and 40 healthy controls. The diplomat data were grouped into an exposed cohort (n = 16) and an unexposed cohort (n = 10), and among these, two individuals were assessed before and after potential exposure. Fixel-based analysis revealed a reduction in fibre density in two specific regions: the fornix and the splenium, in exposed individuals, relative to unexposed individuals and healthy controls. *Post hoc* analyses showed the effect remained present ($P < 0.05$) in both regions when comparing exposed and unexposed diplomats; and reduced fibre density was correlated with longer time period stationed in Cuba after age correction. Reduction of fibre density was also found to be linked with clinical symptoms of persistent migraine, tinnitus, sound sensitivity and fatigue. Network statistical comparisons revealed decreased structural connectivity in two distinct networks, comprising subcortical and cortical systems in exposed individuals, relative to unexposed and normative data. While the cause for the differences between the groups remains unknown, our results reveal region-specific white matter injury, that is, significantly correlated with clinical symptoms.

https://academic.oup.com/braincomms/article/4/2/fcac053/6543087

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Microwave Auditory Effects Among U.S. Government Personnel Reporting Directional Audible and Sensory Phenomena in Havana

James C. Lin. Microwave Auditory Effects Among U.S. Government Personnel Reporting Directional Audible and Sensory Phenomena in Havana. *IEEE Access*, vol. 10, pp. 44577-44582, 2022, doi: 10.1109/ACCESS.2022.3168656.

Abstract

The mysterious incidents on diplomatic and intelligence personnel began in 2016. Since then, nearly 200 incidents have been reported. The illnesses and symptoms are called Havana Syndrome, named for the city where cases were first reported. The initial accounts from Havana include hearing of loud high-pitched sounds, localizing the sources as coming from above or behind the head, experiencing a directional sound that ceases if one steps away, the covering of ears not making any difference, some hearing the sound but others in the same room not hearing it, or hearing it in one part of a room but not in other areas. Assuming the reported symptoms and accounts are consistent, the microwave auditory effect provides a scientific explanation for Havana Syndrome.

Excerpts

Although the required peak power densities are high, they are achievable with existing high-power commercial and military microwave systems operating under pulsed conditions [25]. Significantly, they also fall within the permissible “safe” limits of currently promulgated safety standards and protection guidelines, The required microwave technology is mature and in general, commercially available in many developed countries. confirming the conclusion of earlier studies.

Furthermore, the study showed that to generate tissue injuring level of high-power microwave induced acoustic pressures inside the human brain, the theoretical microwave pulse induced temperature elevation would be substantially below 1o C (see Table 2), which is again “safe” according to currently promulgated RF and microwave safety protection guidelines.

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9759429&isnumber=9668973

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Editorial: Human Exposure to New-Emerging Electric, Magnetic and Electromagnetic Fields

Wu Tongning, Peng Ruiyun, Zhang Lei, Li Kun. Editorial: Human Exposure to New-Emerging Electric, Magnetic and Electromagnetic Fields. Frontiers in Public Health, 10, 2022. doi: 10.3389/fpubh.2022.894624.

No abstract

With the advancement of wireless technologies and electronic/electrical devices, humans are exposed to more complicated electric, magnetic, and electromagnetic fields (EMF), which has raised public concerns on potential health effects. Researchers have recently conducted a series of studies on diverse exposure scenarios. In addition, international standard organizations have revised safety guidelines and standards (1). These recent results and practices can enhance our knowledge in assessing health risks from the exposure to EMF (2). This

Research Topic consists of 14 articles (one review article, two brief research report articles, and 11 original research articles) published in the Radiation and Health section of Frontiers in Public Health....

Open access paper: https://www.frontiersin.org/article/10.3389/fpubh.2022.894624

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Paternal Radiofrequency Electromagnetic Radiation Exposure Causes Sex-Specific Differences in Body Weight Trajectory and Glucose Metabolism in Offspring Mice

Yan Song, Ju Ying, Dong Jie, Lei Hui, Wang Jun, Xu Qian, Ma Yefei, Wang Jingjing, Wang Xiaohong. Paternal Radiofrequency Electromagnetic Radiation Exposure Causes Sex-Specific Differences in Body Weight Trajectory and Glucose Metabolism in Offspring Mice. Frontiers in Public Health. 10, 2022. doi: 10.3389/fpubh.2022.872198.

Abstract

Nowadays, concerns about the harmful effects of radiofrequency electromagnetic radiation (RF-EMR) on male fertility and offspring health are growing. In the present study, we investigated the effects of long-term exposure (at least 10 weeks) to the RF-EMR [2.0 GHz; power density, 2.5 W/m2; whole-body specific absorption rate (SAR), 0.125–0.5 W/kg] on male mice fertility and F1 growth and glucose metabolism. No significant injuries were observed in testis organization, sperm quality, and pregnancy rate. However, mice exposed to RF-EMR exhibited a significantly elevated apoptosis rate in testis germ cells. Interestingly, paternal RF-EMR exposure resulted in sex-specific weight trajectory differences and glucose metabolism changes in male F1 mice but not in female F1 mice. The changed glucose metabolism in F1 male may result from the altered gene expression of liver Gck. These data collectively suggested that 2.0 GHz RF-EMR whole-body exposure of male mice does not cause obvious impairment in testis, sperm quality, and pregnancy rate. Paternal RF-EMR exposure causes male-specific alterations in body weight trajectories and glucose metabolism of F1.

Open access paper: https://www.frontiersin.org/article/10.3389/fpubh.2022.872198

Measurement and Exposure Assessment of Intermediate Frequency Magnetic Fields From Electronic Article Surveillance (EAS) Gates in Libraries

Ikuyo Miwa, Esaki Kaoru, Aimoto Atsuko, Wake Kanako, Yamaguchi-Sekino Sachiko, Kojimahara Noriko, Suzuki Yukihisa, Taki Masao. Measurement and Exposure Assessment of Intermediate Frequency Magnetic Fields From Electronic Article Surveillance (EAS) Gates in Libraries. Frontiers in Public Health. 10, 2022. doi: 10.3389/fpubh.2022.871134.

Abstract

Exposure to magnetic fields from the electronic article surveillance (EAS) gate was evaluated in consideration of the application to epidemiological studies of library workers who are exposed continually to intermediate frequency magnetic fields from the EAS gate. Two types of exposures were investigated. One was transient exposure due to passing through or beside the gate and another was chronic exposure in the room. We measured magnetic fields from five EAS gate models which were commonly used in libraries in Japan. Detailed measurements were performed for two of them in consideration of the phase difference of vector components of magnetic flux density. The polarization of the magnetic field in the gate was investigated with the index of ellipticity. The induced electric field in a human body was numerically calculated for exposures to magnetic fields of the two gate models. The results provide a quantitative understanding of exposures during passing through or by the EAS gate. Magnetic field distribution was measured in a large room for one gate model to quantify the chronic exposure of library workers during the work at the desk. It was found that the magnetic field was distributed as a function of the horizontal distance to the nearest gatepost. The 45-point average value BIEC defined by the IEC standard was suggested to be a useful quantity to characterize the magnitude of the magnetic field from the EAS gate. Exposures to different EAS gates are expected to be compared through this quantity without detailed measurements. These results are expected to provide useful means for exposure assessment of epidemiological studies on the association between the IF-EMF exposure and possible health outcomes.

Open access paper: https://www.frontiersin.org/article/10.3389/fpubh.2022.871134

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Letter to the Editor "Mobile phone electromagnetic radiation and the risk of headache: a systematic review and meta-analysis"

Jalilian, H., Dongus, S., Bosch-Capblanch, X. *et al.* Letter to the Editor "Mobile phone electromagnetic radiation and the risk of headache: a systematic review and meta-analysis". *Int Arch Occup Environ Health*. 2022. doi: 10.1007/s00420-022-01890-4

No abstract

In conclusion, this review has not followed a systematic approach and should thus not be labeled as a systematic review. Calculating only an average effect estimate based on a convenient sample of studies without addressing potential risk of bias and not considering the duration and level of exposure is largely uninformative.

https://link.springer.com/article/10.1007/s00420-022-01890-4

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Investigation of the impact of electromagnetic fields emitted close to the head by smart glasses

Philipp Jungk, Matthias Wienke, Christoph Schiefer, Ulrich Hartmann, Volker Harth, Claudia Terschüren, Carsten Alteköster, Daniel Friemert. Investigation of the impact of electromagnetic fields emitted close to the head by smart glasses. Biomed Tech (Berl). 2022 May 17. doi: 10.1515/bmt-2021-0301.

Abstract

The functionality of smart glasses includes the possibility of wireless communication. For this purpose, WiFi or Bluetooth modules are integrated into the glasses. They emit electromagnetic radiation in the vicinity of the user's head. This simulation study investigates the impact of varying positions, frequencies, and antenna types of the embedded WiFi or Bluetooth modules on different tissue types in the human head. The absorption of electromagnetic energy causes the main impact on the tissue in the head. This physical process is best described by the specific absorption rate SAR. To investigate the effects of position, frequency, and antenna type on the simulated SAR values multiple simulations have been carried out considering real-world applications of smart glasses. The results show that the type of antenna has little effect on the SAR values of the different tissues. The maximum regulated output powers explain the frequencies' impact on the exposure. According to our findings, the greatest influence on the SAR values can be attributed to the placement of the antenna. Finally, our study reveals that positioning the antenna at the front side of the head is optimal for most tissues because of its maximal distance to the head tissues.

https://pubmed.ncbi.nlm.nih.gov/35580838/

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5G NR Base Station Exposure of the General Public: Comparison of Assessment Methods

Kenneth Deprez, Leen Verloock, Loek Colussi, Sam Aerts, Matthias Van den Bossche, Jos Kamer, John Bolte, Luc Martens, David Plets, Wout Joseph. In-Situ 5G NR Base Station Exposure of the General Public: Comparison of Assessment Methods. Radiat Prot Dosimetry. 2022 May 3;ncac061. doi: 10.1093/rpd/ncac061.

Abstract

New measurement methods and equipment for correct 5G New Radio (NR) electromagnetic field (EMF) in-situ exposure assessment of instantaneous time-averaged exposure (Eavg) and maximum extrapolated field exposure (Emax) are proposed. The different options are investigated with in-situ measurements around 5G NR base stations (FR1) in different countries. The maximum electric field values satisfy the ICNIRP 2020 limit (maximum 7.7%). The difference between Emax and Eavg is <3 dB for the different measurement equipment at multiple sites in case there is only self-generated traffic. However, in a more realistic scenario, Eavg cannot be used to assess the exposure correctly due to influence of other users as the spatial distribution of user equipment (UE) influences Eavg, while Emax is not affected. However, when multiple UEs are collocated, there is no influence of the number of UEs. A broadband measurement can give a first impression of the RF-EMF exposure up to 700 m, but is not enough to assess the 5G-NR exposure.

Conclusions and Future Work

This paper provides an overview of different measurement equipment and optimal settings that can be used to correctly perform in-situ 5G NR electromagnetic field exposure assessment at 3.5 GHz (FR1). Both time-averaged exposure and maximum extrapolated field exposure assessment are proposed and investigated with in-situ measurements in different countries. The maximum electric field values satisfy the ICNIRP 2020 limit (i.e.

maximum 7.7%). Furthermore, in a low-traffic environment, one UE is sufficient to attract the beam towards the measurement equipment. The difference between Emax and Eavg is <3 dB for the different measurement equipment at multiple sites. Hence, the current setups are to be recommended in 5G-NR exposure assessment in the current low-traffic scenarios. In a more realistic scenario, not all measurement methods are valid and must thus be adapted. When Eavg is used as metric, the exposure assessment drops with 6 dB when four UEs are spatially separated. However, Emax is not affected by the spatially separated UEs (difference of 0.60 dB between the various measurements) and is the recommended metric to use for exposure assessment in high-traffic environments.

A broadband measurement can give a first impression of the RF-EMF environment up to 700 m (deviations of 0.05–4.86 dB), but is limited in use (larger separations) and not enough to assess the 5G-NR field exposure.

The future work can be divided into two main parts. The first part is to test the measurement methods and equipment in more realistic, higher traffic environments. This will give a more accurate view on the impact of 5G NR on everyday RF-EMF exposure. The second part is to test the measurement methods for the *frequency range 2* of 5G-NR (FR2), i.e. mm-waves. Here, more beams, higher bandwidths and more traffic are expected.

https://pubmed.ncbi.nlm.nih.gov/35511688/

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On the Exposure Dose Minimization of Multi-antenna Multi-carrier System Users

F. Heliot, T. Brown. On the Exposure Dose Minimization of Multi-antenna Multi-carrier System Users.*IEEE Transactions on Vehicular Technology*. Apr 27, 2022. doi: 10.1109/TVT.2022.3170606.

Abstract

From the fourth generation (4G) of cellular systems onward, wireless personal devices (WPDs) support multi-input multi-output (MIMO) communication. However, the impact of MIMO communication on the electromagnetic field (EMF) of WPD users has yet to be fully understood and analyzed at the system level. In this paper, we first provide a generic model for assessing the individual exposure dose of multi-antenna WPD users in a multi-user multi-carrier communication system. An optimization framework for minimizing this exposure dose is then developed based on our exposure model. This framework helps us to identify a new criterion, i.e., the ratio between the normalized exposure dose and the channel to noise ratio (CNR), as the main system level criterion for minimizing the individual exposure dose of multi-antenna WPD users. This criterion is further integrated in the design of two novel centralized resource allocation schemes that take advantage of the multiple antennas at the WPD to minimize the per-user exposure dose, when full or limited knowledge of each user channel is available. Our new schemes can significantly reduce the individual exposure dose of WPD users (by approximately 80%) in comparison with the most relevant existing resource allocation schemes. Our results also provide insights into the logarithmic relationship between the per-user exposure dose and the number of receive antennas (or the number of time slots), and how such a parameter can be exploited to further reduce the exposure and/or provide a higher SE while maintaining a low exposure dose.

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Methodology to determine threshold distance for estimating main electromagnetic exposure in wireless local area network (WiFi)

Marta Fernández, David Guerra. Methodology for determining the threshold distance for estimating the main EM exposure contribution in WLAN. Engineering Science and Technology, an International Journal. Volume 25, 2022, 100997. doi:10.1016/j.jestch.2021.05.001.

Abstract

The location of radiation sources in wireless networks is a key factor to characterize their contribution to electromagnetic exposure levels in order to deploy future networks that account for minimizing electromagnetic field levels. In relation to wireless local area networks, considering that mobile communication devices comply with the SAR (Specific Absorption Rate) limits imposed by the international standardization organizations for preserving human health, the interest is nowadays focused on the signal levels coming from the WiFi access points. This paper presents a methodology to determine the threshold distance at which the field strength levels from the AP are negligible in comparison with the radiation generated by a user equipment. The theoretical concepts, which can be applied to other technologies, were implemented by means of simulations and experimental measurements. For the simulations, actual WiFi antennas were modelled. Experimental measurements completed the results obtained in simulations, resulting in a greater number of real situations. Results showed that the threshold distance depends on the WiFi standard employed by the devices connected to the network.

Open access paper: https://www.sciencedirect.com/science/article/pii/S2215098621001099

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Quasi-Deterministic Channel Propagation Model for 60 GHz Urban WiFi Access from Light Poles

S.Y. Jun, C. Lai, D. Caudill, J. Wang, J. Senic, N. Varshney, C. Gentile. Quasi-Deterministic Channel Propagation Model for 60 GHz Urban WiFi Access from Light Poles. IEEE Antennas and Wireless Propagation Letters. Published online Apr 29, 2022. doi: 10.1109/LAWP.2022.3171503.

Abstract

There is strong impetus by the Telecom Infra Project to exploit the 60 GHz unlicensed band for public WiFi in urban environments, by installing access points on light poles. Although many 60 GHz urban channel measurements have been recorded to date, they have resulted only in path loss models or RMS delay spreads. What is needed at millimeter-wave is a spatially consistent channel model for beamtracking that embodies the characteristics of these short wavelengths sparsity and rough surface scattering such as the Quasi-Deterministic model. In this letter, we fit the model to channel measurements we recorded in an urban environment. The measurements were recorded at 4 m, 6 m, and 9 m antenna heights to investigate the tradeoffs between light pole heights. The large-scale channel metrics between the model and the measurements were shown to match very well.

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Effects of Long-Term and Multigeneration Exposure of Caenorhabditis elegans to 9.4 GHz Microwaves

Sun A, Zhao X, Li Z, Gao Y, Liu Q, Zhou H, Dong G, Wang C. Effects of Long-Term and Multigeneration Exposure of Caenorhabditis elegans to 9.4 GHz Microwaves. Bioelectromagnetics. 2022 May 11. doi: 10.1002/bem.22409.

Abstract

A large number of studies on the biological effects of microwaves are carried out using rodents and cells, but the conditions are difficult to control, and the irradiation period is short; the results obtained have always been controversial and difficult to reproduce. In this study, we expose nematodes to an electromagnetic environment for a long-term and multigeneration period to explore the possible biological effects. Wild-type N2 strains of Caenorhabditis elegans are exposed to 9.4 GHz microwaves at a specific adsorption rate of 4 W/kg for 10 h per day from L1 larvae to adults. Then, adult worms are washed off, and the laid eggs are kept to hatch L1 larvae, which are continuously exposed to microwaves until passing through 20 generations. The worms of the 10th, 15th, and 20th generations are collected for index detection. Interestingly, we found that the fecundity of C. elegans decreased significantly in the exposed group from the 15th generation. At the same time, we found that the growth of C. elegans decreased, motility decreased, and oxidative stress occurred in the exposed group from the 10th generation, which may play roles in the decreased spawning in worms. We preliminarily believe that the microwave energy received by worms leads to oxidative stress, which causes a decrease in the spawning rate, and the underlying mechanism needs to be further studied.

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Semi-quantitative methodology to assess health and safety risks arising from exposure to electromagnetic fields up to 300 GHz at workplaces according to Italian regulations

Laura Filosa, Vanni Lopresto. Semi-quantitative methodology to assess health and safety risks arising from exposure to electromagnetic fields up to 300 GHz at workplaces according to Italian regulations. Int J Occup Saf Ergon. 2022 May 16;1-41. doi: 10.1080/10803548.2022.2077511. 3557482410803548.2022.2077511.

Abstract

This paper is focused a semi-quantitative methodology to assess and manage the health and safety risks arising from exposure to electromagnetic fields (EMF) up to 300 GHz at workplaces as well as to identify the priorities of intervention, based on the requirements of European directive 2013/35/EU and Italian regulations. The study includes a synthetic overview on the effects arising from EMF exposure and the related regulatory framework on protection. Furthermore, an in-depth analysis is carried-out on the risk assessment process as well as on the technical and organisational measures for risk mitigation and their adaptation to the specific requirements of

workers at particular risk, based on technical standards and best practice guides issued by international and national (Italian) standardisation bodies.

Conclusions

The EMF risk assessment process outlined in this paper takes into account the provisions of Directive 2013/35/EU [32] and of technical standard EN 50499:2019 [48], as well as the peculiar requirements of Italian regulations as referred to in the Framework Law 36/2001 [43] and relevant implementation decrees [41][42] along with the Legislative Decree 81/2008 and s.m.a. [39]. To this end, a useful compass to assess and manage EMF exposure at workplaces taking into account the specific provisions of Italian regulations is represented by the EMF Guide CEI 106-45 [44].

A semi-quantitative methodology for EMF risk assessment is proposed based on a two-dimensional matrix for risk analysis. The matrix reports the indexes of risk calculated as the product of the severity rate of a dangerous event and the likelihood of occurrence of such an event. The severity rating assigned to the effect should reflect the expected outcome of the hazardous event, meanwhile the probability of occurrence should take into account a number of factors related to the workplace and work practice. In relation to assessed index of risk can be identified the prevention and protection measures for risk mitigation as well as the intervention priorities, which shall be adapted to the workers at particular risk. The outcomes of the risk assessment process should be documented in the risk assessment report along with the improvement actions included in the Company Program for the Reduction of Exposure to EMF.

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Evaluation of oxidative stress and genotoxicity of 900 MHz electromagnetic radiations using Trigonella foenum-graecum (fenugreek) test system

Surbhi Sharma, Shalini Bahel, Jatinder Kaur Katnoria. Evaluation of oxidative stress and genotoxicity of 900 MHz electromagnetic radiations using Trigonella foenum-graecum test system.
Protoplasma. 2022 May 11. doi: 10.1007/s00709-022-01768-9.

Abstract

Unprecedented growth in the communication sector and expanded usage of the number of wireless devices in the past few decades have resulted in a tremendous increase in emissions of non-ionizing electromagnetic radiations (EMRs) in the environment. The widespread EMRs have induced many significant changes in biological systems leading to oxidative stress as well as DNA damage. Considering this, the present study was planned to study the effects of EMRs at 900 MHz frequency with the power density of 10.0 dBm (0.01 W) at variable exposure periods (0.5 h, 1 h, 2 h, 4 h, and 8 h per day for 7 days) on percentage germination, morphological characteristics, protein content, lipid peroxidation in terms of malondialdehyde content (MDA), and antioxidant defense system of Trigonella foenum-graecum test system. The genotoxicity was also evaluated using similar conditions. It was observed that EMRs significantly decreased the germination percentage at an exposure time of 4 h and 8 h. Fresh weight and dry weight of root and shoot did not show significant variations, while the root

and shoot length have shown significant variations for 4 h and 8 h exposure period. Further, EMRs enhanced MDA indicating lipid peroxidation. In response to exposure of EMRs, there was a significant up-regulation in the activities of enzymes such as ascorbate peroxidase (APX), superoxide dismutase (SOD), glutathione-S-transferase (GST), guaiacol peroxidase (POD), and glutathione reductase (GR) in the roots and shoots of Trigonella-foenum graecum. The genotoxicity study showed the induction of chromosomal aberrations in root tip cells of the Trigonella foenum-graecum test system. The present study revealed the induction of oxidative stress and genotoxicity of EMRs exposure in the test system.

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A Systematic Method to Explore Radio-Frequency Non-Thermal Effect on the Growth of Saccharomyces Cerevisiae

D. Ye, G. Cutter, T. P. Caldwell, S. W. Harcum, P. Wang. A Systematic Method to Explore Radio-Frequency Non-Thermal Effect on the Growth of Saccharomyces Cerevisiae.*IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology*. 6(1):52-60. March 2022, doi: 10.1109/JERM.2021.3101408.

Abstract

Radio frequency (RF) non-thermal (NT) bio-effects have been a subject of debate and attracted significant interests due to potential health risks or beneficial applications. In this work, we report a systematic method for broadband investigation of RF NT effects on *Saccharomyces cerevisiae* yeast growth. The method includes a transverse electro-magnetic (TEM) device and a dielectric spectroscopy technique for RF frequency selection. A stripline-based TEM device has two 240-μL chambers 3D printed for cell cultures. The fabricated device operates up to a few GHz and produces uniform RF fields for cell exposure testing. A vector network analyzer (VNA) was used to provide ~20 dBm continuous-wave (CW) RF power. The heating effects on cell growth were estimated to be negligible. Frequency regions, where large permittivity differences between the medium and yeast cultures were obtained and used to select RF testing frequencies, e.g., 1.0 MHz, 3.162 MHz, 10 MHz. These differences may indicate RF field gradients near cell membrane, and the gradients may affect local nutrient transport. Additionally, RF at 905 MHz is tested for comparison purpose. Yeast cells in the exponential growth phase were examined at four RF frequencies and compared with two controls. One control device held at the same temperature as the test device, while the other control was held at a temperature 1 degree C higher. The results showed that the RF fields at 3.162 MHz reduced yeast growth rates by 15.1%; however, the RF fields at 1.0 MHz enhanced cell growth by 13.7%, while the observed 4.3% growth rate increase at 10 MHz is insignificant and the RF fields at 905 MHz had no effects on the cell growth. These results showed a clear RF NT effects on *S. cerevisiae* growth that was frequency dependent. The hypothesized mechanisms of these effects, i.e., non-uniform RF fields near cell membranes and fluidic diodes in cell membrane ion channels may play important roles in nutrient transport, need to be further investigated.

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Comparison of the effect of changing the spatial distance with exposure time to mobile phones radiation on the structure and function of the testis in NMRI mice

Homa Soleimani, Mahbobeh Gafori Ghadarijani, Fatemeh Rafiei, Parvindokht Bayat. Comparison of the effect of changing the spatial distance with exposure time to mobile phones radiation on the structure and function of the testis in NMRI mice. Journal of Microwave Power and Electromagnetic Energy, 56(2):87-102. 2022. doi:10.1080/08327823.2022.2066769.

Abstract

The present study was conducted to compare the effect of changing the spatial distance and time radio frequency (RF) radiation from mobile phone in standby mode on the structure and function of testicles. NMRI mice were randomly divided into three groups. The first group was the control and the second group (exposed group) was divided into four subgroups: groups A (A1 and A2) and groups B (B1 and B2), which were placed in plastic holder units at two distances of 5 cm and 20 cm from RF radiation, respectively. A1 and B1, and A2 and B2 were exposed to RF radiation for six and 10 weeks, respectively. The exposure duration was 5 days/week, 6 hours/day. The third group with two subgroups (sham1 and sham2) were kept in plastic holder units without being exposed to radiation and were evaluated after six and 10 weeks, respectively. The changes in the external diameters of seminiferous tubules and the height of germinal epithelium obviously depended more on the distance from the radiation source than on the exposure time. The decrease in the diameter of the testicles and sperm motility were found to be time-dependent. These effects had a clear but unpredictable dependence on the two variables of distance and RF radiation time.

Excerpts

The intensity of waves was measured at a distance of 5 and 20 cm every 10 seconds in water within 6 minutes (the time of thermal balance of human body, at a density similar to the body density). Measurement of the electromagnetic field intensity showed that the mean value in both cases, without mobile phone (1.39 $\mu W/m^2$) and with the mobile phone, in standby mode at a distance of 20 cm were almost equal. However, the amount of electromagnetic field fluctuated over time in the presence of a mobile phone (Table 1)....

We also exhibited that each of the factors of stress and radiation alone led to a significant decrease in sperm motility (Grade 1 and 2). Meanwhile, the effects of stress and RF field were not synergistic. Moreover, sperm motility (Grade 1) in sham2 group was not significantly different with that in control group. This may be attributed to the adaptation of biological tissues to stressor factors.

It seemed as though the effect of RF field and decreased distance from the radiation source leads to a decrease in the rate of sperm in Grades 1 and 2 and an increase rate sperm in Grades 3 and 4. According to the obtained results, the effect of the RF exposure on sperm motility might probably change according to the distance from the radiation source, which is more important than the exposure time.

Conclusion

This research shed light on the fact that although decreased distance or increased irradiation time led to histological or physiological changes in the structure and function of the male reproductive system, these effects

were not similar. These changes had significant impacts, but unforeseeable dependence, on the two variables of distance and radiation time of mobile phone in standby mode. Our findings also depicted the significant and superior role of stress against mobile phone radiation in the decrease in the diameter of testis, sperm motility, and the reduction in sperm count. Furthermore, stress was the predominant factor in comparison with radiation exposure and once the stress was eliminated due to the habituation of the animal, the biological effects of radiation exposure on the tissue became detectable.

https://www.tandfonline.com/doi/abs/10.1080/08327823.2022.2066769?journalCode=tpee20

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Preliminary Chronic Effects of Radiation from Mobile Phones on Heart Rate Variability, Cardiac Function, Blood Profiles, and Semen Quality in Healthy Dogs

Dong VNK, Tantisuwat L, Setthawong P, Tharasanit T, Sutayatram S, Kijtawornrat A. The Preliminary Chronic Effects of Electromagnetic Radiation from Mobile Phones on Heart Rate Variability, Cardiac Function, Blood Profiles, and Semen Quality in Healthy Dogs. Vet Sci. 2022 Apr 21;9(5):201. doi: 10.3390/vetsci9050201.

Abstract

The present study aims to determine the effects of long-term exposure to electromagnetic radiation from mobile phones (MPs) on heart rate variability (HRV), cardiac function, blood profiles, body surface temperature, and semen quality in healthy dogs. Eight male dogs were exposed to MPs (1962-1966 MHz; specific absorption rate 0.96 W/kg) for 2 h/day, 5 days/week, for 10 weeks. Holter monitoring for HRV analysis was performed at baseline (BL) and every 2 weeks, until the end of the study. Electrocardiograms (ECG), blood pressure (BP), echocardiography, cardiac troponin I (cTnI), hematology and biochemistry profiles, body surface temperature, and semen quality were evaluated at BL, week 5, and week 10 during exposure. The results showed that most of the HRV parameters did not significantly differ among timepoints, except for the mean of an interval between continuous normal R waves in week 6 that was higher than that at BL (p = 0.022). The RR and QT intervals from ECG in week 5 were prolonged, compared to the BL values (p = 0.001 and p = 0.003, respectively), but those parameters were within the normal limits. The echocardiography, BP, cTnI concentrations, body surface temperature, and semen quality results were not different from BL values. In conclusion, this study found no evidence suggesting an adverse effect of cell phone exposure on HRV, cardiac function, blood profiles, body surface temperature, or semen quality in healthy dogs, when exposed for 10 weeks.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9147188

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Experimental Evidence of Radio Frequency Radiation From Staphylococcus aureus Biofilms

M. Rao, K. Sarabandi, J. Soukar, N. A. Kotov and J. S. VanEpps. Experimental Evidence of Radio Frequency Radiation From Staphylococcus aureus Biofilms.*IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology*, doi: 10.1109/JERM.2022.3168618.

Abstract

This paper reports the first successful detection of electromagnetic (EM) radiation from Staphylococcus aureus biofilms in the gigahertz (GHz) frequency range. Two novel sensing systems are deployed for the measurement. A very sensitive wideband near-zone radiative system specifically designed for this application is first used to search for signals in the 1–50 GHz frequency region. Notable radiation is observed in the 3–4 GHz band. Exposure to lethal doses of Zinc oxide nanopyramids (ZnO-NPY) is used to verify that the signals are indeed produced by living cells rather than material thermal emission. Afterwards, a spiral antenna system is exploited to further examine the band of interest in the near-field region. Radiation from 3 identical biofilm samples is monitored and recorded over 70 days. Two distinct frequency bands, namely the 3.18 GHz and the 3.45 GHz bands, are identified as potential “communication bands”. Furthermore, long-term and short-term cycles of the total radiation intensity within the band are observed over the course of the experiment. This work confirms the presence of EM radiation within bacterial communities, which is a key requirement to demonstrate EM signaling among bacterial cells. The insight could lead to breakthroughs in demystifying how cells communicate as well as advancement of important technologies in biology and communication systems.

Conclusion

Although it has long been suggested that biological cells may transmit and receive EM waves, no prior convincing experimental evidence has been generated to support this hypothesis prior to this paper. Our work is the first successful attempt to measure EM radiation from S. aureus biofilms in the GHz frequency range. Two measurement systems are used in the experiments. Two distinct radiating bands in the 3-4 GHz frequency range are identified. Over the course of a 70-day experiment, we discovered a long-term cycle of the radiated signal with short-term fluctuations. This work proves the existence of EM radiation in biofilm communities, which is validated by examining multiple samples over a long period of time and comparing the measured power with that of PNG media (no biofilms) in the same petri dish. In addition, it is shown that exposing biofilms with significant RF radiation to lethal doses of ZnO-NPYs, which inhibits metabolic activity, eliminates the biofilm RF emission.

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Exposure effects of non-ionizing radiation of radio waves on antimicrobial potential of medicinal plants

Chandni Upadhyaya, Trushit Upadhyaya, Ishita Patel. Exposure effects of non-ionizing radiation of radio waves on antimicrobial potential of medicinal plants. Journal of Radiation Research and Applied Sciences. 15(1):1-10. 2022. doi:10.1016/j.jrras.2022.01.009.

Abstract

The high frequency electromagnetic (EM) waves have been proven as potent environmental polluters. The radio towers are considerably increasing to cater to the growing telecommunication requirements. The presented research focuses on the investigation of EM waves on antimicrobial potential of pharmaceutically important

medicinal plants viz. Tulsi (Ocimum sanctum L.) and Brahmi (Bacopa monnieri). The similar work has not been reported till date at the best of our knowledge. The medicinal plants were exposed to EM waves of 900 MHz possessing a 1.9 mG magnetic field. Our former investigation on plant physiology gave deteriorative effects on selected plants physiology in terms of growth, chlorophyll content, protein and carbohydrate content. In the presented article, the antimicrobial activity of two plants was inspected through various bacterial and fungal species. In case of B. monnieri, investigations revealed raise in Zone of Inhibition (ZOI) for both the bacterial and fungal strains in the range of 50%, whereas for O. sanctum increase of 63.26% and 59.42% ZOI for bacterial and fungal strains were noted respectively upon 24 h of exposure. Minimum Inhibitory Concentration (MIC) also decreased for 24 and 48 h of exposure. The transient raise in antimicrobial activity indicated the induction of plant defense system which can be considered as positive influence of short term radiation on medicinal properties of plants. Both plants exhibited the highest antimicrobial potential for E. coli and P. chrysogenum showing a prominent decline after 72 h of exposure. A substantial decline in antimicrobial in MIC of B. monnieri reported was 211% against E. coli and 166% against P. chrysogenum upon 144 h of exposure compared to control plants. The antimicrobial potential of O. sanctum was also decreased upon radiation, which is having a 392% reduction against E. coli and a 225% reduction against P. chrysogenum upon 144 h of exposure. The noteworthy deteriorative effects of radio waves on antimicrobial potential have been observed for both the medicinal plants.

https://www.sciencedirect.com/science/article/pii/S1687850722001091

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Preliminary Study: the Electromagnetics Radiation from Epipremnum Aureum (Money Plant) Using Frequency Detector

F. A. A. Shahrien, Z. H. Murat, R. S. S. A. Kadir. Preliminary Study: the Electromagnetics Radiation (EMR) from Epipremnum Aureum Using Frequency Detector. *2021 6th IEEE International Conference on Recent Advances and Innovations in Engineering (ICRAIE)*, 2021, pp. 1-5, doi: 10.1109/ICRAIE52900.2021.9703990.

Abstract

Epipremnum Aureum or money plant is a popular indoor plant known to emanate positive energy flow into space. Energy or aura is essentially the frequency radiated from a body, including from plants, and scientifically known as Electromagnetics Radiation (EMR). This preliminary study is to investigate the EMR pattern from money plant using frequency detector. The EMR are measured in a common sized room during five specific time range each day for three weeks with the presence of money plants and for two weeks without money plants (absence). The seven observation points of the EMR are taken around the money plant and in the middle of the room. The results shows that the EMR increases by 24% in the presence of money plant. This finding asserts that money plant radiates and influence the EMR frequency to increase in the surrounding.

https://ieeexplore.ieee.org/document/9703990

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Magnetic field interactions between current consumer electronics and cardiac implantable electronic devices

Xu K, Sengupta J, Casey S, Peltier J, Stahl W, Peterson N, Settimi D, Taylor A, Kippola J, Steele E, Hauser R. Magnetic field interactions between current consumer electronics and cardiac implantable electronic devices. J Interv Card Electrophysiol. 2022 May 10. doi: 10.1007/s10840-022-01241-w.

Abstract

Background: Electronic products, including the iPhone 12, Apple Watch Series 6, and 2nd Generation AirPods, contain magnets to facilitate wireless charging. Permanent magnets may affect CIED magnet mode features by causing pacemakers to pace asynchronously and defibrillators to suspend arrhythmia detection. This study determined if CIEDs are affected by static magnetic fields from commonly used portable electronics (PE) at any distance and intends to reinforce FDA recommendations concerning consumer PE which contain permanent magnets.

Methods: The maximum magnet field measurement was evaluated by a Gauss meter. The interaction between PE and CIEDs from Boston Scientific and Medtronic were tested ex vivo using a body torso model. The CIED was placed in physiologic saline, and the PE was placed at the surface and at increasing distances of 0.5, 1.0, and 1.5 cm. Interactions were recorded by assessment of magnet mode status.

Results: The iPhone 12 had almost three times the static magnetic field measured at the surface as the iPhone XR, but magnetic field strength decreased dramatically with increasing distance. At the surface of the model, PE triggered magnet mode in all CIEDs. The maximum interaction distance for all combinations of CIEDs and Apple products was 1.5 cm.

Conclusions: The iPhone 12 produces a stronger static magnetic field than previous iPhone models. Magnets in PE tested will not interact with CIEDs when they are 15 cm from the implanted device. Since no interaction was observed beyond 1.5 cm, it is unlikely that magnet mode activation will occur during most daily activities.

https://pubmed.ncbi.nlm.nih.gov/35538270/

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Exposure of Infants to Gradient Fields in a Baby MRI Scanner

Fangfang Tang, Luca Giaccone, Jiahao Hao, Fabio Freschi, Tongning Wu, Stuart Crozier, Feng Liu. Exposure of Infants to Gradient Fields in a Baby MRI Scanner. Bioelectromagnetics. 2022 Feb;43(2):69-80. doi: 10.1002/bem.22387.

Abstract

In pediatric magnetic resonance imaging (MRI), infants are exposed to rapid, time-varying gradient magnetic fields, leading to electric fields induced in the body of infants and potential safety risks (e.g. peripheral nerve stimulation). In this numerical study, the in situ electric fields in infants induced by small-sized gradient coils for

a 1.5 T MRI scanner were evaluated. The gradient coil set was specially designed for the efficient imaging of infants within a small-bore (baby) scanner. The magnetic flux density and induced electric fields by the small x, y, z gradient coils in an infant model (8-week-old with a mass of 4.3 kg) were computed using the scalar potential finite differences method. The gradient coils were driven by a 1 kHz sinusoidal waveform and also a trapezoidal waveform with a 250 μs rise time. The model was placed at different scan positions, including the head area (position I), chest area (position II), and body center (position III). It was found that the induced electric fields in most tissues exceeded the basic restrictions of the ICNIRP 2010 guidelines for both waveforms. The electric fields were similar in the region of interest for all coil types and model positions but different outside the imaging region. The y-coil induced larger electric fields compared with the x- and z- coils.

https://pubmed.ncbi.nlm.nih.gov/35005795/

Conclusions

In this paper, we have numerically studied the field exposure of an infant model inside the baby *x, y, z* gradient coils during an MRI scan. The *B*-fields have exceeded the reference level 0.08 mT in most tissues for the frequency 1 kHz in ICNIRP 2010 guidelines. Based on the simulation results, it has been found that baby positioning primarily affected the induced *E*-field profiles. In most tissues, the *EI* values are larger than 1, indicating that the exposures have exceeded the reference level 0.4 V/m in ICNIRP 2010 guidelines for the frequency of 1 kHz. The largest $E_{99.9\%}$ and *EI* are 5.41 V/m and 9.56, found in fat produced by *y*-coil in position III. The *EI* is determined based on the basic restrictions of ICNIRP 2010 guidelines; the results are possibly conservative as applicable guidelines/restrictions are not yet accessible for exposure of infants in MRI gradient fields.

The field exposure varies due to the variation of the driving current and rise time. It is likely stronger when all three gradient coils are switched faster and simultaneously during a realistic MRI scan. Further work is required to characterize more realistic field-infant tissue interactions with detailed nerve models, and it is hoped that these simulations will help inform compliance of clinical procedures.

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The effect of exposure to non-ionising radiofrequency field on Escherichia coli, Klebsiella oxytoca and Pseudomonas aeruginosa biofilms

Dobroslava Bujňáková, Samuel Bucko, Marek Češkovič, Vladimír Kmeť, Lívia Karahutová. The effect of exposure to non-ionising radiofrequency field on Escherichia coli, Klebsiella oxytoca and Pseudomonas aeruginosa biofilm. Environ Technol. 2022 May 4;1-21. doi: 10.1080/09593330.2022.2074317.

Abstract

An environment with a higher accumulation of electromagnetic non-ionising radiofrequency (RF) emissions generated by various telecommunication, data transport and navigation devices (mobile phones, Wi-Fi, radar, etc.) may have a major impact on biological systems. This study aimed to evaluate the incidence of an electromagnetic field (EMF) on the development of bacterial biofilm. Quantification of biofilm production was

done by using microtiter plate assay. Bacterial isolates of Escherichia coli, Klebsiella oxytoca and Pseudomonas aeruginosa were exposed with EMF of frequencies 1-5 and 2.4 GHz with an exposure time 3 or 24 hours, respectively. Exposure of bacteria to EMF produced a statistically significant increase in biofilm production mainly at 1, 2 and 4 GHz, and in contrast, a significant inhibition of biofilm development occurred at frequencies 3 and 5 GHz, both with exception of Klebsiella oxytoca and Pseudomonas aeruginosa. Wi-Fi operating at 2.4 GHz caused biofilm reduction. The results indicate that EMF exposure act on bacteria in both ways, depending on the frequency: as stressful by enhancing bacterial biofilm formation (under environmental stress, bacteria produce a polysaccharide matrix and aggregate to form biofilms to increase virulence and resistance), although some frequencies leading to biofilm damage could be caused by changes to the physicochemical properties of bacteria.

Conclusions

In conclusion, the results of our study revealed that EMF can stimulate/inhibit the ability of *Escherichia coli, Klebsiella oxytoca* and *Pseudomonas aeruginosa* to form biofilms, depending on the frequency and/or specific type of bacteria used. Based on the acquired results of the biofilm modulation (increasing/decreasing) EMF can also be expected to influencs the pathogenicity of microorganisms, since biofilm-associated bacteria are considered more resistant and difficult to treat; however, some results demonstrated EMF as a potential tool for biofilm removal, for example, on medical devices and biomaterials. Further studies are in progress (and need to be performed) to extend the current state of knowledge of the influence of EMF on microorganisms and to gather more information on other bacterial biological changeovers that may occur due to exposure to EMF, including antibiotic susceptibility (resistance) as a next substantial factor of bacterial pathogenicity.
Undervaluing the problem of exposure to electromagnetic non-ionising RF radiation generated by various telecommunication and data transport as common part of the environment could lead to a further rise in infectious diseases or their complications.

https://pubmed.ncbi.nlm.nih.gov/35506486/

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Thapsigargin blocks electromagnetic field-elicited intracellular Ca 2+ increase in HEK 293 cells

Federico Bertagna, Rebecca Lewis, S Ravi P Silva, Johnjoe McFadden, Kamalan Jeevaratnam. Thapsigargin blocks electromagnetic field-elicited intracellular Ca 2+ increase in HEK 293 cells. Physiol Rep. 2022 May;10(9):e15189. doi: 10.14814/phy2.15189.

Abstract

Biological effects of electromagnetic fields (EMFs) have previously been identified for cellular proliferation and changes in expression and conduction of diverse types of ion channels. The major effect elicited by EMFs seems to be directed toward Ca2+ homeostasis. This is particularly remarkable since Ca2+ acts as a central modulator in various signaling pathways, including, but not limited to, cell differentiation and survival. Despite this, the mechanisms underlying this modulation have yet to be unraveled. Here, we assessed the effect of EMFs on intracellular [Ca2+], by exposing HEK 293 cells to both radio-frequency electromagnetic fields (RF-EMFs) and

static magnetic fields (SMFs). We detected a constant and significant increase in [Ca2+] subsequent to exposure to both types of fields. Strikingly, the increase was nulled by administration of 10 µM Thapsigargin, a blocker of sarco/endoplasmic reticulum Ca2+ -ATPases (SERCAs), indicating the involvement of the endoplasmic reticulum (ER) in EMF-related modulation of Ca2+ homeostasis.

Open access paper: https://physoc.onlinelibrary.wiley.com/doi/10.14814/phy2.15189

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Extremely low frequency magnetic field enhances expression of a specific recombinant protein in bacterial host

Behnaz Rashidieh, Alireza Madjid Ansari, Mahdi Behdani, Behrad Darvishi, Mahdi Habibi-Anbouhi. Extremely low frequency magnetic field enhances expression of a specific recombinant protein in bacterial host. Anal Biochem. 2022 May 21;114745. doi: 10.1016/j.ab.2022.114745.

Abstract

Expression of proteins in bacterial host cells, particularly E.coli, has gained much attention in recent years. Low expression outcome is the main technical drawback associated with this procedure, further restricting its largescale application in industry. Therefore, application of new amendments or reformations are required before further proceedings. Extremely low frequency magnetic fields (ELF-MFs) have shown to significantly affect biological processes, including gene expression, in E.coli. In current study, we investigated whether application of ELF-MF could result in overexpression of proteins in E.coli or not. Cluster of differentiation-22 (CD22), as a model protein, was expressed in E.Coli Rosetta (DE3) under continuous exposure to ELF-MF after applying various concentrations of Isopropyl ß-d-1-thiogalactopyranoside (IPTG) (0.25-1.25 mM) as inducer. The strength and frequency of electromagnetic fields (EMFs) ranged between 15-100 mT and 2.5-20 Hz respectively. Interestingly, application of 55mT EMFs with frequencies ranging from 2.5 to 2.8 Hz significantly enhanced the yield of expression at all studied IPTG concentrations. Contrarily, EMFs with intensities other than 55 mT meaningfully declined protein expression at IPTG concentrations equal to 1 and 1.25 mM. In conclusion, application of specific range of ELF-MFs may be exploited as a new modification for enhancing heterologous expression of proteins in E.coli.

https://pubmed.ncbi.nlm.nih.gov/35609685/

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Commercial outdoor plant nurseries as a confounder for electromagnetic fields and childhood leukemia risk

A Nguyen, C M Crespi, X Vergara, L Kheifets. Commercial outdoor plant nurseries as a confounder for electromagnetic fields and childhood leukemia risk. Environ Res. 2022 May 10;212(Pt C):113446. doi: 10.1016/j.envres.2022.113446.

Highlights

• Close proximity to plant nurseries is a potential childhood leukemia risk factor.
• Proximity to nurseries did not explain distance to power lines and CL associations.
• Proximity to nurseries did not explain magnetic field and CL associations.
• First detailed study of pesticides as a confounder for magnetic fields and CL.

Abstract

Background: Close residential proximity to powerlines and high magnetic fields exposure may be associated with elevated childhood leukemia risks as reported by prior studies and pooled analyses. Magnetic fields exposure from high-voltage powerlines is associated with proximity to these powerlines and consequently with any factor varying with distance. Areas underneath powerlines in California may be sites for commercial plant nurseries that can use pesticides, a potential childhood leukemia risk factor.

Objectives: Assess if potential pesticide exposure from commercial plant nurseries is a confounder or interacts with proximity or magnetic fields exposure from high-voltage powerlines to increase childhood leukemia risk.

Methods: A comprehensive childhood leukemia record-based case-control study with 5788 cases and 5788 controls (born and diagnosed in California, 1986-2008) was conducted. Pesticide, powerline, and magnetic field exposure assessment utilized models that incorporated geographical information systems, aerial satellite images, site visits and other historical information.

Results: The relationship for calculated fields with childhood leukemia (odds ratio (OR) 1.51, 95% confidence interval (CI) 0.70-3.23) slightly attenuated when controlling for nursery proximity (OR 1.43, 95% CI 0.65-3.16) or restricting analysis to subjects living far (>300 m) from nurseries (OR 1.43, 95% CI 0.79-2.60). A similar association pattern was observed between distance to high-voltage powerlines and childhood leukemia. The association between nursery proximity and childhood leukemia was unchanged or only slightly attenuated when controlling for calculated fields or powerline distance; ORs remained above 2 when excluding subjects with high calculated fields or close powerline proximity (OR 2.16, 95% CI 0.82-5.67 and OR 2.15, 95% CI 0.82-5.64, respectively). The observed relationships were robust to different time periods, reference categories, and cut points.

Discussion: Close residential proximity to nurseries is suggested as an independent childhood leukemia risk factor. Our results do not support plant nurseries as an explanation for observed childhood leukemia risks for powerline proximity and magnetic fields exposure, although small numbers of subjects concurrently exposed to high magnetic fields, close powerline proximity and plant nurseries limited our ability to fully assess potential confounding.

Open access paper: https://www.sciencedirect.com/science/article/pii/S0013935122007733?via%3Dihub

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An overview of the biological effects of extremely low frequency electromagnetic fields combined with ionizing radiation

Bahareh Gholipour Hamedani, Bahram Goliaei, Seyed Peyman Shariatpanahi, Maryamsadat Nezamtaheri. An overview of the biological effects of extremely low frequency electromagnetic fields combined with ionizing radiation. Prog Biophys Mol Biol. 2022 May 2;S0079-6107(22)00037-2. doi: 10.1016/j.pbiomolbio.2022.04.008.

Abstract

By growing the electrical power networks and electronic devices, electromagnetic fields (EMF) have become an inseparable part of the modern world. Considering the inevitable exposure to a various range of EMFs, especially at extremely low frequencies (ELF-EMF), investigating the biological effects of ELF-EMFs on biological systems became a global issue. The possible adverse consequences of these exposures were studied, along with their potential therapeutic capabilities. Also, their biological impacts in combination with other chemical and physical agents, specifically ionizing radiation (IR), as a co-carcinogen or as adjuvant therapy in combination with radiotherapy were explored. Here, we review the results of several in-vitro and in-vivo studies and discuss some proposed possible mechanisms of ELF-EMFs' actions in combination with IR. The results of these experiments could be fruitful to develop more precise safety standards for environmental ELF-EMFs exposures. Furthermore, it could evaluate the therapeutic capacities of ELF-EMFs alone or as an improver of radiotherapy.

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Toxicant-Associated Fatty Liver Disease and Liver Neoplastic Progress in Rats Treated with Aflatoxin B1 Alone or in Combination with Extremely Low Frequency EMF

Vornoli A, Tibaldi E, Gnudi F, Sgargi D, Manservisi F, Belpoggi F, Tovoli F, Mandrioli D. Evaluation of Toxicant-Associated Fatty Liver Disease and Liver Neoplastic Progress in Sprague-Dawley Rats Treated with Low Doses of Aflatoxin B1 Alone or in Combination with Extremely Low Frequency Electromagnetic Fields. Toxins (Basel). 2022 May 3;14(5):325. doi: 10.3390/toxins14050325. PMID: 35622572; PMCID: PMC9143281.

Abstract

The term toxicant-associated fatty liver disease (TAFLD) has been proposed to describe fatty liver diseases connected to toxicants other than alcohol. Aflatoxins are mycotoxins commonly found as contaminants in foods and feeds, which are known liver toxicants and potential candidates as potential causes of TAFLD. Aflatoxin B1 (AFB1) was administered at low doses to Sprague-Dawley (SD) rats, alone or in combination with S-50 Hz an extremely low frequency electromagnetic field (ELFEMF), to study the evolution of TAFLD, preneoplastic and neoplastic lesions of the liver and the potential enhancing effect of lifespan exposure to ELFEMF. Steatosis, inflammation and foci of different types were significantly increased in both aflatoxin-treated males and females, which is consistent with a pattern of TAFLD. A significant increase in adenomas, cystic dilation of biliary ducts, hepatocellular hyperplasia and hypertrophy and oval cell hyperplasia were also observed in treated females only. The administration of low doses of AFB1 caused TAFLD in SD rats, inducing liver lesions encompassing fatty infiltration, foci of different types and adenomas. Furthermore, the pattern of change

observed in preneoplastic liver lesions often included liver steatosis and steatohepatitis (TASH). ELFEMF did not result in any enhancing or toxic effect in the liver of SD rats.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9143281/

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Lung Cell Toxicity of Co-Exposure to Airborne Particulate Matter and Extremely Low-Frequency Magnetic Field

Zahra Panjali, Parviz Abdolmaleki, Behnam Hajipour, Omar Hahad, Rezvan Zendehdel. Lung Cell Toxicity of Co-Exposure to Airborne Particulate Matter and Extremely Low-Frequency Magnetic Field. Xenobiotica. 2022 May 24;1-34. doi: 10.1080/00498254.2022.2082342.

Abstract

Although the toxic effects of urban airborne particulate matter (PM) have been known on lung cells, there is less attention to co-exposure to PM and extremely low frequency magnetic (ELF-MF) in occupational settings. The present study investigated the influences of PM and ELF-MF co-exposure on toxicity in human lung cells (A549). In this case, total PM (TPM) was evaluated according to NIOSH-0500. The TPM SiO2 and metal contents were determined based on NIOSH-7602 and 7302, respectively. Besides, 900 mG ELF-MF exposure was simulated based on field measurements. The toxicity mechanisms were assessed by examining malondialdehyde, glutathione ratio, gene expression, and DNA strand breaks. Also, the toxicity indicators of the TPM samples were MDA generation, glutathione depletion, and DNA damage, and their impacts were analyzed at doses below the LD50 (4 µg). In addition, gene expression of OGG1 and MTH1 was upregulated after TPM exposure at the lowest dose (2 µg). But ITPA was upregulated in the presence of ELF-MF. The co-exposure to TPM and ELF-MF decreased oxidative stress and DNA damage levels compared to a single exposure to TPM. Although the ELF-MF reduced toxicity in response to TPM, this reduction was not lower than the unexposed cells.

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The effect of electromagnetic field (EMF) exposure on synthesis and release of steroid hormones by the porcine conceptuses during the peri-implantation period

Anita Franczak, Ewa Monika Drzewiecka, Wiktoria Kozlowska, Agata Zmijewska, Pawel Jozef Wydorski, Anna Koziorowska. The effect of electromagnetic field (EMF) exposure on synthesis and release of steroid hormones by the porcine conceptuses during the peri-implantation period. Reprod Fertil Dev. 2022 May 2. doi: 10.1071/RD22040.

Abstract

Context: Electrical devices and power systems are the sources of EM-waves which propagate everywhere in the environment.

Aims: The study aimed to determine whether EMF induced changes in the steroidogenesis of conceptuses and whether progesterone (P4) may be a possible protectant against the effects of EMF radiation.

Methods: The entire porcine conceptuses were collected during the peri-implantation period (days 15-16 of pregnancy), divided into fragments (100mg) and treated in vitro with EMF (50Hz or 120Hz, 2 or 4h exposure), and examined to determine of CYP17A1, HSD3B1, CYP19A3, and HSD17B4 mRNA transcript and encoded protein abundance and the release of steroid hormones. Selected fragments of conceptuses were treated with P4.

Key results: In conceptuses incubated without P4, EMF at 120Hz decreased androstenedione (A4) and testosterone (T) release after 2h and increased oestrone (E1) release at 50Hz and 120Hz after 4h exposure. In P4-treated conceptuses, EMF (50 and 120Hz, 4h exposure) decreased CYP19A3 mRNA transcript abundance, and increased (120Hz, 2h exposure) oestradiol-17β (E2) release.

Conclusions: The EMF radiation alters androgen and oestrogen synthesis and release from the conceptuses of pigs during the peri-implantation period. The P4 exerts protective effects on androgens and E1 release but it sensitises the conceptuses when comes to the mechanism of oestrogen synthesis and release during EMF radiation.

Implications: The effect of EMF radiation on the steroidogenic pathway in conceptuses may induce disturbances in their proper development and implantation.

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Scrutinizing the Impact of Alternating Electromagnetic Fields on Molecular Features of the Model Plant Arabidopsis thaliana

Sonja Michèle Schmidtpott, Saliba Danho, Vijay Kumar, Thorsten Seidel, Wolfgang Schöllhorn, Karl-Josef Dietz. Scrutinizing the Impact of Alternating Electromagnetic Fields on Molecular Features of the Model Plant Arabidopsis thaliana. Int J Environ Res Public Health. 2022 Apr 23;19(9):5144. doi: 10.3390/ijerph19095144.

Abstract

Natural and anthropogenic electromagnetic fields (EMFs) are ubiquitous in the environment and interfere with all biological organisms including plants. Particularly the quality and quantity of alternating EMFs from anthropogenic sources are increasing due to the implementation of novel technologies. There is a significant interest in exploring the impact of EMFs (similar to those emitted from battery chargers of electric cars) on plants. The model plant Arabidopsis thaliana was exposed to a composite alternating EMF program for 48 h and scrutinized for molecular alterations using photosynthetic performance, metabolite profiling, and RNA sequencing followed by qRT-PCR validation. Clear differences in the photosynthetic parameters between the

treated and control plants indicated either lower nonphotochemical quenching or higher reduction of the plastoquinone pool or both. Transcriptome analysis by RNA sequencing revealed alterations in transcript amounts upon EMF exposure; however, the gene ontology groups of, e.g., chloroplast stroma, thylakoids, and envelope were underrepresented. Quantitative real-time PCR validated deregulation of some selected transcripts. More profound were the readjustments in metabolite pool sizes with variations in photosynthetic and central energy metabolism. These findings together with the invariable phenotype indicate efficient adjustment of the physiological state of the EMF-treated plants, suggesting testing for more challenging growth conditions in future experiments.

Conclusions

EMF exposure occurs ubiquitously on Earth and is a regular environmental parameter all life forms have to deal with. Anthropogenic alternating and rapidly changing EMF emission accentuate the requirement to research the EMF–life and, as conducted here, EMF–plant interaction. The data show that alternating EMF-exposed plants undergo significant alterations at the levels of photosynthesis, transcriptome, and metabolome. The underlying perception and response mechanisms to weak EMF still need deeper scrutiny and could involve changes in cell signaling, e.g., by interfering with Ca2+ fluxes and concentrations [57]. The changes in photosynthetic features are remarkable particularly since the gross growth parameters were unaltered. A profound metabolic readjustment was detectable upon EMF exposure that would merit further experiments, both in the context of photosynthesis and respiratory energy metabolism. The growth conditions with about 5% of full sunlight (100 µmol photons.m−2 s−1) might not be ideal to work out possible negative effects of the EMF treatment on plant performance. In future experiments, it would be worthwhile to combine such EMF treatments with challenging growth conditions, e.g., by growth in saturating light or combinatorial stress applications [58]. Future experiments could also include the study of early development such as seed germination and seedling establishment similar to [57].

Open access paper: https://www.mdpi.com/1660-4601/19/9/5144

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Prussian blue technique is prone to yield false negative results in magnetoreception research

Franziska Curdt, Katrin Haase, Laura Ziegenbalg, Helena Greb, Dominik Heyers, Michael Winklhofer. Prussian blue technique is prone to yield false negative results in magnetoreception research. Sci Rep. 2022 May 25;12(1):8803. doi: 10.1038/s41598-022-12398-9.

Abstract

Perls's Prussian blue staining technique has been used in magnetoreception research to screen tissues for iron-rich structures as proxies for putative magnetoreceptor structures based on magnetic particles. However, seemingly promising structural candidates in the upper beak of birds detected with Prussian blue turned out to be either irreproducible or located in non-neuronal cells, which has spurred a controversy that has not been settled yet. Here we identify possible pitfalls in the previous works and apply the Prussian blue technique to

tissues implicated in magnetic-particle-based magnetoreception, in an effort to reassess its suitability for staining single-domain magnetite, i.e., the proposed magnetic substrate for the interaction with the external magnetic field. In the upper beak of night-migratory songbirds, we found staining products in great numbers, but not remotely associated with fiber terminals of the traced ophthalmic branch of the trigeminal nerve. Surprisingly, staining products were absent from the lamina propria in the olfactory rosette of rainbow trout where candidate magnetoreceptor structures were identified with different techniques earlier. Critically, magnetosome chains in whole cells of magnetotactic bacteria remained unstained. The failure to label single-domain magnetite in positive control samples is a serious limitation of the technique and suggests that two most influential but antipodal studies conducted previously stood little chances of obtaining correct positive results under the assumption that magnetosome-like particles were present in the tissues. Nonetheless, the staining technique appears suitable to identify tissue contamination with iron-rich fine dust trapped in epithelia already in vivo.

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Effects of pre and postnatal 2450 MHz continuous wave (CW) radiofrequency radiation on thymus: Four generation exposure

Fazile Cantürk Tan, Betül Yalçin, Arzu Hanım Yay, Burak Tan, Korkut Yeğin, Süleyman Daşdağ. Effects of pre and postnatal 2450 MHz continuous wave (CW) radiofrequency radiation on thymus: Four generation exposure. Electromagn Biol Med. 2022 May 30;1-10. doi: 10.1080/15368378.2022.2079673.

Abstract

This study aims to investigate the effects of pre- and postnatal 2450 MHz continuous wave (CW) radiofrequency radiation (RFR) on the thymus of rats spanning four generations. Four groups; sham, irradiated female, irradiated male, irradiated male and female, each consisting of four rats (one male and three females), were created. During the experiment, rats in the exposure groups were whole-body exposed to 2450 MHz CW-RFR for 12 h/day. Irradiation started one month before the fertilization in the experimental group. When the offspring were two months old, four rats, one male and three female, were allocated for the second-generation study. The remaining offspring were sacrificed under general anesthesia, and their thymuses were removed. The same procedure was applied to the next generation. Two months after the second generation gave birth, third-generation rats were decapitated, and their thymuses were removed. In all groups, cortex, medulla and resident cells could be clearly distinguished in the second and third generations. No differences were observed between the control and two experimental groups, defined as irradiated female and irradiated male. In contrast, vascularization was observed in the thymus of the fourth-generation offspring of the group where both males and females were irradiated. The number of offspring and mass of all rats decreased in the third-generation group. Pre-and postnatal 2450 MHz continuous wave radiofrequency radiation exposure may potentially affect the thymus of future generations.

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Effect of an Extremely Low-Frequency Electromagnetic Field on the Concentration of Salivary Immunoglobulin A

Piotr Skomro, Danuta Lietz-Kijak, Olga Bogdziewicz-Wałęsa, Joanna Janiszewska-Olszowska. Effect of an Extremely Low-Frequency Electromagnetic Field on the Concentration of Salivary Immunoglobulin A. Int J Environ Res Public Health. 2022 May 10;19(10):5786. doi: 10.3390/ijerph19105786.

Abstract

Extremely Low-Frequency Electromagnetic Field (ELF MF) therapy is effective in the treatment of injury, inflammation and postoperative complications. Its clinical applications relate to bone unification, pain reduction, soft tissue oedema and the decrease of electric potentials in the oral cavity. It enhances regeneration of periapical bone lesions. It is obvious that cells (leukocytes, platelets, keratinocytes, osteoblasts) and proteins (fibrin, collagen, elastin and growth factors) exhibit alterations when exposed to an Extremely Low-Frequency Electromagnetic Field. The aim of the study was to evaluate the effect of an Extremely Low-Frequency Electromagnetic Field (ELF MF) on the parotid gland on the concentration of salivary immunoglobulin A. The study group consisted of 24 patients, aged 14-16, who underwent ELF MF on the parotid gland region. The control group comprised 25 matching persons. The IgA concentration in saliva samples was established using radial immunodiffusion. Following ELF MF, a statistically significant increase in the concentration of secretory immunoglobulin A was found in the study group, whereas in the control group, no statistically significant differences were noted. It can be concluded that an Extremely Low-Frequency Electromagnetic Field increases the activity of the immune system of the parotid gland.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9141657/

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Interference thresholds for active implantable cardiovascular devices in occupational low-frequency electric and magnetic fields: a numerical and in vitro study

Zhou M, Kourtiche D, Claudel J, Deschamps F, Magne I, Roth P, Schmitt P, Souques M, Nadi M. Interference thresholds for active implantable cardiovascular devices in occupational low-frequency electric and magnetic fields: a numerical and in vitro study. Med Eng Phys. 2022 Jun;104:103799. doi: 10.1016/j.medengphy.2022.103799.

Abstract

In light of concerns regarding the occupational safety and health of workers wearing active implantable medical devices (AIMDs), this study aims to investigate the potential risks of electromagnetic interference (EMI) between AIMDs and low-frequency 50/60 Hz electromagnetic fields (EMFs) in the workplace. A total of 58 AIMDs, consisting of pacemakers (PMs) and implantable cardiac defibrillators (ICDs) of different brands, models, and configurations were tested to determine the immunity thresholds for high-voltage electric fields (EFs) and magnetic fields (MFs) at 50/60 Hz. The EFs and MFs at the levels in workplaces are reproduced by setups using

Helmholtz coils and aluminum plates, respectively, to ensure that the EM/MF exposures are controllable and reproducible. The EMI thresholds were recorded by observing the occurrences of PM or ICD dysfunctions. In addition, numerical studies on anatomical models were carried out using CST® software. The results indicate that the recorded thresholds all exceed the EF and MF public exposure limits given in the ICNIRP 2010 guidelines. No dysfunction was observed among four ICDs tested under MF exposure up to 2750 µT at 50 Hz and 2480 µT at 60 Hz. However, among the 43 PMs and 11 ICDs tested under EF exposures, potential hazards may occur below the occupational exposure level proposed in the ICNIRP guidelines.

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Human magnetic sense is mediated by a light and magnetic field resonance-dependent mechanism

Kwon-Seok Chae, Soo-Chan Kim, Hye-Jin Kwon, Yongkuk Kim. Human magnetic sense is mediated by a light and magnetic field resonance-dependent mechanism. Sci Rep. 2022 May 30;12(1):8997. doi: 10.1038/s41598-022-12460-6.

Abstract

Numerous organisms use the Earth's magnetic field as a sensory cue for migration, body alignment, or food search. Despite some contradictory reports, yet it is generally accepted that humans do not sense the geomagnetic field. Here, we demonstrate that a magnetic field resonance mechanism mediates light-dependent magnetic orientation in men, using a rotary chair experiment combined with a two-alternative forced choice paradigm. Two groups of subjects were classified with different magnetic orientation tendencies depending on the food context. Magnetic orientation of the subjects was sensitive to the wavelength of incident light and was critically dependent on blue light reaching the eyes. Importantly, it appears that a magnetic field resonance-dependent mechanism mediates these responses, as evidenced by disruption or augmentation of the ability to orient by radiofrequency magnetic fields at the Larmor frequency and the dependence of these effects on the angle between the radiofrequency and geomagnetic fields. Furthermore, inversion of the vertical component of the geomagnetic field revealed a non-canonical inclination compass effect on the magnetic orientation. These results establish the existence of a human magnetic sense and suggest an underlying quantum mechanical magnetoreception mechanism.

Open access paper: https://www.nature.com/articles/s41598-022-12460-6

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The roles of intensity, exposure duration, and modulation on the biological effects of radiofrequency radiation and exposure guidelines

Henry Lai, B. Blake Levitt. The roles of intensity, exposure duration, and modulation on the biological effects of radiofrequency radiation and exposure guidelines. Electromagn Biol Med. 2022 Apr 19:1-26. doi: 10.1080/15368378.2022.2065683.

Abstract

In this paper, we review the literature on three important exposure metrics that are inadequately represented in most major radiofrequency radiation (RFR) exposure guidelines today: intensity, exposure duration, and signal modulation. Exposure intensity produces unpredictable effects as demonstrated by nonlinear effects. This is most likely caused by the biological system's ability to adjust and compensate but could lead to eventual biomic breakdown after prolonged exposure. A review of 112 low-intensity studies reveals that biological effects of RFR could occur at a median specific absorption rate of 0.0165 W/kg. Intensity and exposure duration interact since the dose of energy absorbed is the product of intensity and time. The result is that RFR behaves like a biological "stressor" capable of affecting numerous living systems. In addition to intensity and duration, man-made RFR is generally modulated to allow information to be encrypted. The effects of modulation on biological functions are not well understood. Four types of modulation outcomes are discussed. In addition, it is invalid to make direct comparisons between thermal energy and radiofrequency electromagnetic energy. Research data indicate that electromagnetic energy is more biologically potent in causing effects than thermal changes. The two likely function through different mechanisms. As such, any current RFR exposure guidelines based on acute continuous-wave exposure are inadequate for health protection.

Excerpts

"Over the last 25–30 years, significant information has been published that in other regulated areas would have resulted in re-examination and adjustments to allowable exposure limits. This has not been the case with these two groups [the FCC and ICNIRP] which adhere to a model based on obsolete scientific evidence, especially in light of the new 5G network that uses higher frequencies and novel modulation forms that have never been used before in broad civilian telecommunications and which are poorly studied."

"RFR effects have been observed at low intensities (< 0.4 W/kg) – a list of which is included in Supplement 1 – far below the guidelines. This points to both the nonlinearity of how living systems couple with nonionizing radiation as well as the inadequacy of acute thresholds. The studies encompass many different biological effects to myriad systems, including: apoptosis induction, adrenal gland activity, blood–brain barrier permeability, brain transmitter levels, calcium concentration in heart muscle, calcium efflux, calcium movement in cells, cell growth, cognitive functions, cellular damage in liver, decreased cell proliferation, embryonic development, endocrine changes, enolose activity, genetic effects, hippocampal neuronal damage, immunological functions, kidney development, memory functions, latency of muscular contraction, membrane chemistry, nerve cell damage, metabolic changes, neural electrical activity, oxidative stress, plant growth, prion level, protein changes, renal injury, serum testosterone concentration, heat-shock protein induction, testis morphology, testosterone synthesis, thymidine incorporation, and ultrastructural alteration in cell cytoplasm. In fact, there are not many physiological functions in humans, animals, or plants that are not affected by low-level RFR."

"As reflected in Supplement 1, SARs at which effects were observed were available from 112 studies. Of these, 75 (67%) were *in vivo* exposure studies with whole body/organ SARs available. The other 37 (33%) studies were *in vitro* experiments.... The level at which biological effects occur represents data from *in vivo* and *in vitro* and acute and chronic/repeated-exposure experiments. There is a very wide range of effects seen. With an exposure that induces a SAR of 0.0165 W/kg, and using a ten-fold protection, the SAR would be 0.00165 W/kg (i.e.,

1.65 mW/kg). For rate of energy absorption in body organs, 0.00165 W/kg is far below the maximum level allowed in the guidelines (whether over 1 or 10 gm of tissue as per FCC/ICNIRP allowances). Given the large body of work as illustrated in Supplement 1, the SAR at, or below, 4 W/kg as a safe threshold is insupportable."

"The duration of exposure is another important factor in biological effects. Other than demarcations for whole body exposures averaged over 30 minutes and local body areas averaged over 6 minutes, neither FCC nor ICNIRP address duration, especially pertaining to long-term and low-level RFR exposures. These are prevalent in both near-field exposures to people with WiFi routers, for example, as well as cell phones, and far-field exposures from infrastructure that have created chronic rising ambient background levels (Levitt et al. 2021a). The guidelines are written only for short-term acute durations.... What we do know is that the supposition that all exposures are the same above and below the SAR threshold set by FCC/ICNIRP is fundamentally flawed in light of the most current research. **One feasible and logical solution to such uncertainties regarding duration as an exposure factor would be to adopt an SAR level commensurate with the studies summarized in Supplement 1 at no higher than 0.00165 W/kg, no matter the exposure conditions**."

"It is generally believed that modulated RFR is more biologically active than continuous-wave (CW) radiation, i.e., the carrier-wave. To understand the biological and possible hazardous health effects of RFR, it is therefore important to understand modulation effects. Below we discuss what is known about modulation from the research literature (mostly from 1990 to date) and examine the claim that modulation makes RFR more biologically significant...There is research showing no significant biological effects of CW-RFR (Table 1a) but there are also studies that reported CW-RFR effects too (Table 1b). The reason why CW-RFR produced effects in some studies but not others is unknown. Both types of studies (with “effect” and “no effect” outcomes) involved many different biological endpoints, exposure intensities, and duration of exposure – with no discernible differences. A possible explanation is that different tissue types respond differently to CW-RFR. But that just adds another level of inquiry. One of the most puzzling observations is when CW caused an effect but modulation did not (e.g., Kubinyi et al. 1996; Luukkonen et al. 2009). In some studies, a modulated field produced an effect that was not produced by CW. These observations may indicate that the CW carrier-wave itself and modulation act on different mechanisms.... Differences in responses between CW and modulated fields of the same frequency and incident power density provide strong proof that non-thermal effects occur since the two conditions should produce the same amount of heating.... Some studies reported that different frequencies of modulation caused different biological responses .... CW and modulated fields can cause the same effects but with different degrees of biological activity and intensity of reactions. In most instances, a modulated field was found to be more potent than CW versus only one study in which the opposite was reported (Persson et al. 1997).... To add to the complexities described above, effects with modulated fields have also been shown to depend on exposure duration.... there are many studies that used intermittent exposure (e.g., 10 min ON/10 min OFF) instead of continuous exposure with the supposition that intermittent exposure is more biologically active. But not much data showed this to be true.... There are many studies using pulsed fields (i.e., mobile phone signals are pulsed), but there are not many studies that compared pulsed and CW fields of the same SAR in the same study. However, there are reports that effects only occurred with a pulsed field but not CW.... there are many studies showing effects of RFR on the hippocampus..."

"Oxidative changes and stress have been reported in many papers on exposure to electromagnetic fields (Lai 2020; Yakymenko et al. 2016). These are the most consistent cellular responses to RFR exposure. Mechanisms have been proposed to account for oxidative effects that may involve the low-frequency component of modulation (e.g., see Barnes and Greenebaum 2015; Castello et al. 2021). ... But there is not enough data to conclude that modulation effects are caused by oxidative processes. In fact some effects of CW exposure alone also found changes in free radical mechanisms."

"It is important to point out as significant proof of non-thermal RFR effects that CW and modulated-waves of the same frequency and incident power density can/and do produce different effects. The bottom line is that certainty is elusive regarding precise effects in all circumstances. What is clear is that both modulation and continuous-wave RFR are biologically active and both should be considered in exposure guidelines. In situations where enough evidence exists to warrant specific caution, such as with pulsed fields used in cell phones and phased modulation with 5G, particular attention should be paid to include modulation in the guidelines beyond the suppositions of safety contained within the safety allowances. Peak exposures must also be factored in and not just the averaged values which only hide their significance."

"It is apparent that the biological outcome of changing the intensity and duration of RFR exposure is basically unpredictable. This is mainly due to the complex nature of the biological system studied. Intensity and duration can interact and produce different response patterns as shown in the literature reviewed above.

It is also apparent that how RFR modulation affects biological functions is difficult to quantify. Observed effects are multi-variant and involve many factors such as intensity, carrier frequencies and modulation, the modulation waveform itself, exposure duration, and properties of the exposed object. Not enough research data are presently available to provide an explanation or prediction of modulation effects under all circumstances. It may also turn out that modulation is of little major health concern or conversely that it is the only factor that matters – evidence is thus far too contradictory regarding modulation's ability to consistently enhance the biological effects of carrier-waves. Then again, with most modulation forms the carrier-wave is completely altered. All of this awaits proper investigation with comparison studies. In the meantime, there are legitimate reasons for concern, given the contradictions in the literature.

In general, anthropogenic RFR – with highly unusual waveform characteristics and intensities that do not exist in the natural world – is new to the environment and thus has not been a factor in the evolution of species. Living organisms evolved over millions of years in the presence of static and extremely-low frequency (ELF) electromagnetic fields. These fields play critical roles in their survival, e.g., in migration, food foraging, and reproduction, etc. (see Levitt et al. 2021b). Living organisms are extremely sensitive to the presence of these environmental fields and thus, they can easily be disturbed by man-made EMF. RFR probably acts upon and modifies these primordial EMFs and affects biological functions. Interactions of static/ELF EMF and RFR are basically not well studied, not to mention the mechanisms of involvement of RFR modulations. The interactions are inevitably complex. Such interaction studies would provide answers to wildlife effects.

Regarding the perennial thermal- versus non-thermal- effects criticism inherent in human RFR exposure guidelines, it must be said that the underlying mechanisms of effects should *not* be a matter of concern in setting of exposure guidelines as is common today. *What is important is the level at which energy absorption causes an effect*. One such powerful proof – among so very many others – of non-thermal effects is evidenced in

the fact that CW and modulated-waves of the same frequency and incident power density can produce different effects, as seen in the modulation section of this paper and Table 2."

"When effects continue to be observed over a long period of time that go against prevailing beliefs, even when mechanisms remain imperfectly understood, the appropriate course of regulatory action is to examine the underlying basis upon which an original premise was formed. When proven incomplete or invalid by new information, the change in a regulatory course is not only justified but is imperative. Disproven or incomplete deductions of how RFR affects living cells and tissues, as well as suppositions of safety for exposed individuals and the environment are insupportable given the wealth of studies to draw from today that have filled in many gaps. **We need to more responsibly address the increasing near- and far-field RFR exposures of contemporary life with an eye toward 5G technology's unique characteristics.** A new conceptual framework is called for."

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Estimation of RF and ELF dose by anatomical location in the brain from wireless phones in the MOBI-Kids study

Carolina Calderón, Gemma Castaño-Vinyals, Myron Maslanyj, Joe Wiart, Ae-Kyoung Lee, Masao Taki, Kanako Wake, Alex Abert, Francesc Badia, Abdelhamid Hadjem, Hans Kromhout, Patricia de Llobet, Nadège Varsier, Emmanuelle Conil, Hyung-Do Choi, Malcolm R. Sim, Elisabeth Cardis. Estimation of RF and ELF dose by anatomical location in the brain from wireless phones in the MOBI-Kids study. Environment International. 163. 2022. 107189. doi:10.1016/j.envint.2022.107189.

Highlights
• Epidemiological studies on mobile phone radiation typically rely on phone use history.
• MOBI-Kids is the first study to estimate RF and ELF dose from wireless phones.
• RF and ELF doses vary by age, phone model, communication system and amount of use.
• Communication system and location in the brain are key determinants of dose.
• Duration and number of calls are likely to be crude proxies of dose.

Abstract

Wireless phones (both mobile and cordless) emit not only radiofrequency (RF) electromagnetic fields (EMF) but also extremely low frequency (ELF) magnetic fields, both of which should be considered in epidemiological studies of the possible adverse health effects of use of such devices. This paper describes a unique algorithm, developed for the multinational case-control MOBI-Kids study, that estimates the cumulative specific energy (CSE) and the cumulative induced current density (CICD) in the brain from RF and ELF fields, respectively, for each subject in the study (aged 10–24 years old). Factors such as age, tumour location, self-reported phone models and usage patterns (laterality, call frequency/duration and hands-free use) were considered, as was the prevalence of different communication systems over time. Median CSE and CICD were substantially higher in GSM than 3G systems and varied considerably with location in the brain. Agreement between RF CSE and mobile phone use variables was moderate to null, depending on the communication system. Agreement between mobile phone use variables and ELF CICD was higher overall but also strongly dependent on communication

system. Despite ELF dose distribution across the brain being more diffuse than that of RF, high correlation was observed between RF and ELF dose. The algorithm was used to systematically estimate the localised RF and ELF doses in the brain from wireless phones, which were found to be strongly dependent on location and communication system. Analysis of cartographies showed high correlation across phone models and across ages, however diagonal agreement between these cartographies suggest these factors do affect dose distribution to some level. Overall, duration and number of calls may not be adequate proxies of dose, particularly as communication systems available for voice calls tend to become more complex with time.

Conclusion

This paper describes the algorithm constructed to assess the localised RF and ELF dose arising from the use of mobile (cellular) and DECT (cordless) phones in the MOBI-Kids study. The algorithm was based on information on phone use provided by study subjects, on information from operators on prevalence of communication systems as a function of time, on RF and ELF modelling performed as part of the exposure assessment work package (which considered morphological changes due to age), and on validation studies performed within the overall study. ELF and RF dose diminished rapidly with increasing depth, demonstrating location in the brain is an important variable in dose estimation. The agreement between CSE and phone use variables varied by communication system; it was highest for GSM and close to 0 for UMTS and CDMA. Higher agreement was observed between CICD and phone use variables, but agreement was still close to 0 for 3G systems. Analysis of cartographies showed high correlation across phone models and across ages, however diagonal agreement between these cartographies suggest these factors do affect dose distribution to some level and should thus be ideally considered. Overall, the results highlight the importance of considering the effect of communication system and anatomical location in estimating dose and suggests phone use is becoming a poorer exposure proxy as communication systems available for voice calls tend to become more complex with time

https://www.sciencedirect.com/science/article/pii/S0160412022001155

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Effects of mobile phone use on semen parameters: a cross-sectional study of 1634 men in China

Shanshan Zhang, Fengyi Mo, Yali Chang, Shufang Wu, Qing Ma, Fan Jin, Lanfeng Xing. Effects of mobile phone use on semen parameters: a cross-sectional study of 1634 men in China. Reprod Fertil Dev. 2022 Apr 19. doi: 10.1071/RD21234.

Abstract

Mobile phones play an irreplaceable role in modern people's lives. However, the radiofrequency electromagnetic radiation produced by mobile phones has also caused increasing concern. A cross-sectional study was conducted to investigate the effect of radiofrequency electromagnetic radiation produced by mobile phones on semen parameters in 1634 men who underwent semen examination at the Department of Reproductive Endocrinology, Women's Hospital, School of Medicine, Zhejiang University, China. Analysis of variance and multivariate linear regression were used to explore differences among different groups. A $P<0.05$ was considered statistically significant. The results showed significant associations among different groups of daily mobile phone use time and daily duration of phone calls in the percentage of progressively motile

spermatozoa (P=0.004 and P=0.007), rapid progressively motile spermatozoa (P=0.012 and P=0.006) and total motile spermatozoa (P=0.004 and P=0.046). After adjustments for the confounding effects of age and body mass index by multiple linear regression, the results showed that the daily duration of mobile phone use had a negative effect on sperm motility. However, there was no statistically significant correlation between daily phone call duration and sperm motility. Therefore, the daily duration of mobile phone use may negatively affect sperm motility and impair male fertility.

Conclusion

Our results suggest that the average daily cell phone use duration may affect sperm motility to some extent, leading to a decrease in sperm motility. Therefore, we recommend that men of reproductive age avoid prolonged durations of using mobile phones. In addition, more well-designed cross-sectional investigations and mechanistic studies are needed in the future to clarify the effects of RF-EMR produced by mobile phones on male semen quality.

Open access paper: https://www.publish.csiro.au/rd/RD21234

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Effect of Duration of Mobile Phone Use on the Salivary Flow and Total Antioxidant Capacity of Saliva and Salivary Immunoglobulin A Level

Bansal D, Chhaparwal Y, Pai KM, Kumar M, Vineetha R, Chhaparwal S, Kamath S, Kamath A. Effect of Duration of Mobile Phone Use on the Salivary Flow and Total Antioxidant Capacity of Saliva and Salivary Immunoglobulin A Level: A Cross-sectional Study. J Int Soc Prev Community Dent. 2022 Apr 8;12(2):260-265. doi: 10.4103/jispcd.JISPCD_361_21.

Abstract

Introduction: The objective of this study was to observe the effects of the duration of handheld mobile phone usage on the salivary flow, salivary immunoglobulin A (IgA) level, and salivary markers for oxidative stress.

Materials and methods: Eighty-one students were categorized into three groups based on their duration of mobile phone usage after age- and gender-matching. Students were grouped as: mobile phone usage <20 min/day (Group A), mobile phone usage 20-60 min/day (Group B), and mobile phone usage >60 min/day (Group C). Saliva was collected to evaluate salivary flow rate, salivary IgA level, and salivary markers for oxidative stress.

Results: The salivary flow rate showed no statistically significant difference between the three groups (P = 0.180). There was no statistically significant difference in the salivary IgA between the three groups (P = 0.237). There was a statistically significant difference in the malondialdehyde (MDA) level between the three groups (P = 0.042). On pair comparison between the groups, group B and group C had a statistically significant difference (P = 0.019) in the MDA level. There was no statistically significant difference in the salivary thiol level between the three groups (P = 0.237).

Conclusion: The duration of handheld mobile phone usage did not show any significant effects on the salivary flow rate, salivary IgA, and thiol levels. There was an increase in the salivary MDA concentration in subjects using handheld mobile phones for a longer duration, indicating higher oxidative stress in salivary glands exposed to mobile phone radiofrequency electromagnetic waves for a longer duration.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9022387/

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Role of 2.4 GHz radiofrequency radiation emitted from Wi-Fi on some miRNA and fatty acids composition in brain

Suleyman Dasdag, Mehmet Zulkuf Akdag, Mehmet Bashan, Veysi Kizmaz, Nurten Erdal, Mehmet Emin Erdal, Mehmet Tughan Kiziltug, Korkut Yegin. Role of 2.4 GHz radiofrequency radiation emitted from Wi-Fi on some miRNA and faty acids composition in brain. Electromagn Biol Med. 2022 Apr 17;1-12. doi: 10.1080/15368378.2022.2065682.

Abstract

The purpose of this study is to investigate the effects of 2.4 GHz Wi-Fi exposure, which is continuously used in the internet connection by mobile phones, computers and other wireless equipment, on microRNA and membrane and depot fatty acid composition of brain cells. Sixteen Wistar Albino rats were divided equally into two groups such as sham and exposure. The rats in the experimental group (n = 8) were exposed to 2.4 GHz RFR emitted from a Wi-Fi generator for 24 h/day for one year. The animals in the control group (n = 8) were kept under the same conditions as the experimental group, but the Wi-Fi generator was turned off. At the end of the study, rats were sacrificed and brains were removed to analyze miRNA expression and membrane and depot fatty acids of brain cells. We analyzed the situation of ten different miRNA expressions and nineteen fatty acid patterns in this study. We observed that long-term and excessive exposure of 2.4 GHz Wi-Fi radiation increased rno-miR-181a-5p, phosphatidylserine (PS) and triacylglycerol (TAG) in the brain. In conclusion, 2.4 GHz Wi-Fi exposure has the potential to alter rno-miR-181a-5p expression and the fatty acid percentage of some membrane lipids such as phospholipid (PL), phosphatidylserine (PS) and triacylglycerol (TAG), which are depot fats in the brain. However, the uncontrolled use of RFRs, whose use and diversity have reached incredible levels with each passing day and which are increasing in the future, may be paving the way for many diseases that we cannot connect with today.

https://pubmed.ncbi.nlm.nih.gov/35435088/

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Evidence Base on the Potential Carcinogenicity of Radiofrequency Radiation

Grimes DR. Radiofrequency Radiation and Cancer: A Review. JAMA Oncol. 2022 Mar 1;8(3):456-461. doi: 10.1001/jamaoncol.2021.5964. Erratum in: JAMA Oncol. 2022 Apr 21;: PMID: 34882171.

Abstract

Importance: Concerns over radiofrequency radiation (RFR) and carcinogenesis have long existed, and the advent of 5G mobile technology has seen a deluge of claims asserting that the new standard and RFR in general may be carcinogenic. For clinicians and researchers in the field, it is critical to address patient concerns on the topic and to be familiar with the existent evidence base.

Observations: This review considers potential biophysical mechanisms of cancer induction, elucidating mechanisms of electromagnetically induced DNA damage and placing RFR in appropriate context on the electromagnetic spectrum. The existent epidemiological evidence in humans and laboratory animals to date on the topic is also reviewed and discussed.

Conclusions and relevance: The evidence from these combined strands strongly indicates that claims of an RFR-cancer link are not supported by the current evidence base. Much of the research to date, however, has been undermined by methodological shortcomings, and there is a need for higher-quality future research endeavors. Finally, the role of fringe science and unsubstantiated claims in patient and public perception on this topic is highly relevant and must be carefully considered.

https://pubmed.ncbi.nlm.nih.gov/34882171/

Critical responses:

Carpenter DO, Hardell L, Sage C. Evidence Base on the Potential Carcinogenicity of Radiofrequency Radiation. JAMA Oncol. 2022 Apr 21. doi: 10.1001/jamaoncol.2022.0928.

https://pubmed.ncbi.nlm.nih.gov/35446341/

Jooyan N, Mortazavi SM. Evidence Base on the Potential Carcinogenicity of Radiofrequency Radiation. JAMA Oncol. 2022 Apr 21. doi: 10.1001/jamaoncol.2022.0931. https://pubmed.ncbi.nlm.nih.gov/35446369/

Naidenko OV. Evidence Base on the Potential Carcinogenicity of Radiofrequency Radiation. JAMA Oncol. 2022 Apr 21. doi: 10.1001/jamaoncol.2022.0925. https://pubmed.ncbi.nlm.nih.gov/35446371/

Moskowitz JM. Why did JAMA Oncology publish a paper written by a Telecom industry spokesperson? Electromagnetic Radiation Safety. 2022 Jan 21. https://bit.ly/GrimesRebuttal

EHT. Wireless Industry Spokesperson Pens Article on Wireless Health Effects for Top Academic Journal. Environmental Health Trust. 2022 Jan 18. https://ehtrust.org/wireless-industry-spokesperson-pens-article-on-wireless-health-effects-for-top-academic-journal/

Author's response to criticism:

Grimes DR. Evidence Base on the Potential Carcinogenicity of Radiofrequency Radiation-Reply. JAMA Oncol. 2022 Apr 21. doi: 10.1001/jamaoncol.2022.0934. https://pubmed.ncbi.nlm.nih.gov/35446368/

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The Microwave Auditory Effect

James C. Lin. The Microwave Auditory Effect. *IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology*. 6(1):16-28. March 2022. doi: 10.1109/JERM.2021.3062826.

Abstract

The microwave auditory effect has been widely recognized as one of the most interesting and significant biological phenomena from microwave exposure. The hearing of pulsed microwaves is a unique exception to sound waves encountered in human auditory perception. The hearing of microwave pulses involves electromagnetic waves. This paper reviews the research in humans and animals leading to scientific documentations that absorption of a single microwave pulse impinging on the head may be perceived as an acoustic zip, click, or knocking sound. A train of microwave pulses may be sensed as buzz, chirp, or tune by humans. It describes neurophysiological, psychophysical, and behavioral observations from laboratory studies involving humans and animals. Mechanistic studies show that the microwave pulse, upon absorption by tissues in the head, launches a pressure wave that travels by bone conduction to the inner ear, where it activates the cochlear receptors via the same process involved for normal sound hearing. Depending on the impinging microwave pulse powers, the level of induced sound pressure could be considerably above the threshold of auditory perception to cause tissue injury. The microwave auditory effects and associated pressures could potentially render damage to brain tissue to cause lethal or nonlethal injuries.

Open access paper: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9366412&isnumber=9716150

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The effect of mobile phone use at night on the sleep of pre-adolescent, early adolescent, and late adolescent children: A study of 252,195 Australian children

Valentina Salcedo Correa, Stephanie Centofanti, Jillian Dorrian, Andrew Wicking, Peter Wicking, Kurt Lushington. The effect of mobile phone use at night on the sleep of pre-adolescent (8-11 year), early adolescent (12-14 year) and late adolescent (15-18 year) children: A study of 252,195 Australian children. Sleep Health. 2022 Apr 8;S2352-7218(22)00015-8. doi: 10.1016/j.sleh.2022.02.004.

Abstract

Objectives: To examine whether the association previously reported between mobile phone use at night and poor sleep in adolescents also generalizes to pre-adolescent children.

Design: Cross sectional.

Participants: Survey completed by 84,915 pre-adolescent (8-11 years), 99,680 early adolescent (12-14 years) and 67,600 late adolescent Australian children (15-18 years).

Measurement: Children were asked how frequently they obtained 8 hours of sleep on most nights and if they used their mobile phone at night to send and receive messages between 10 PM and 6 AM. Binary logistic

regression analyses were used to examine the association between mobile phone use at night and sleeping 8h or more on most nights with gender, socioeconomic status and year of study (2014-2018) as covariates.

Results: For all age cohorts including pre-adolescent children, mobile phone use at night was associated with lower odds of obtaining 8 hours of sleep on most nights.

Conclusion: The present findings confirm that the association between mobile phone use at night and poor sleep previously reported in adolescent children also generalises to pre-adolescent children. Given the increased uptake of smartphone devices in ever younger children the findings point to the need to provide parents, schools and communities with resources to promote child sleep hygiene and media use at bedtime.

https://pubmed.ncbi.nlm.nih.gov/35400615/

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Personal radiofrequency electromagnetic field exposure of adolescents in the Greater London area and the association with restrictions on permitted use of mobile communication technologies at school and at home

Claudia Schmutz, Alexandra Bürgler, Narain Ashta, Jana Soenksen, Yasmin Bou Karim, Chen Shen, Rachel B. Smith, Rosemary H. Jenkins, Michael O. Mireku, Julian Mutz, Mikaël J.A. Maes, Rosi Hirst, Irene Chang, Charlotte Fleming, Aamirah Mussa, Daphna Kesary, Darren Addison, Myron Maslanyj, Mireille B. Toledano, Martin Röösli, Marloes Eeftens. Personal radiofrequency electromagnetic field exposure of adolescents in the Greater London area and the association with restrictions on permitted use of mobile communication technologies at school and at home. Environmental Research. 2022. 113252. doi:10.1016/j.envres.2022.113252.

Abstract

Personal measurements of radiofrequency electromagnetic fields (RF-EMF) have been used in several studies to characterise personal exposure in daily life, but such data are limitedly available for adolescents, and not yet for the United Kingdom (UK). In this study, we aimed to characterise personal exposure to RF-EMF in adolescents and to study the association between exposure and rules applied at school and at home to restrict wireless communication use, likely implemented to reduce other effects of mobile technology (e.g. distraction). We measured exposure to RF-EMF for 16 common frequency bands (87.5 MHz–3.5 GHz), using portable measurement devices (ExpoM-RF), in a subsample of adolescents participating in the cohort Study of Cognition, Adolescents and Mobile Phones (SCAMP) from Greater London (UK) (n = 188). School and home rules were assessed by questionnaire and concerned the school's availability of WiFi and mobile phone policy, and parental restrictions on permitted mobile phone use. Adolescents recorded their activities in real time using a diary app on a study smartphone, while characterizing their personal RF-EMF exposure in daily life, during different activities and times of the day. Data analysis was done for 148 adolescents from 29 schools who recorded RF-EMF data for a median duration of 47 h. The majority (74%) of adolescents spent part of their time at school during the measurement period. Median total RF-EMF exposure was 40 µW/m2 at home, 94 µW/m2 at school, and 100 µW/m2 overall. In general, restrictions at school or at home made little difference for adolescents' measured exposure to RF-EMF, except for uplink exposure from mobile phones while at school, which was

found to be significantly lower for adolescents attending schools not permitting phone use at all, compared to adolescents attending schools allowing mobile phone use during breaks. This difference was not statistically significant for total personal exposure. Total exposure to RF-EMF in adolescents living in Greater London tended to be higher compared to exposure levels reported in other European countries. This study suggests that school policies and parental restrictions are not associated with a lower RF-EMF exposure in adolescents.

https://www.sciencedirect.com/science/article/pii/S0013935122005795

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Assessment of varied mobile network topologies on human exposure, mobile communication quality and sustainability

Margot Deruyck, German Castellanos, Wout Joseph, Luc Martens, Sven Kuehn, Niels Kuster. Assessment of varied mobile network topologies on human exposure, mobile communication quality and sustainability. Final Report of Project CRR-954. Zurich, Switzerland, IT'IS Foundation. Sep 21, 2021.

Executive Summary

In October 2020, the Swiss Federal Office of Communications (OFCOM) mandated the IT'IS Foundation to evaluate various 5G network topologies regarding human exposure, mobile communication quality, and sustainability to address the questions posed by the political Motion Häberli-Koller (19.4043) dated July 30, 2020. The study was conducted jointly with the IMEC WAVES group of the Department of Information Technology of Ghent University, Belgium, and it supplements an earlier project performed by IT'IS for the Swiss Federal Office for the environment in 2019 [1].

Statement of work. Prior to the study, OFCOM specified a number of endpoints in the statement of work (SoW), each of which is addressed below. The study was conducted using a mobile network planning tool developed by the IMEC WAVES group that was adapted to the specifics of the mobile network and regulatory situation in Switzerland. Using this tool, we simulated a variety of mobile networks to address the study endpoints specified by OFCOM. The simulations included 4G and 5G networks in rural, suburban, and urban environments with usage requirements extrapolated to the year 2030. We analyzed the effects of separate operators compared to a unified network, the separation of indoor and outdoor networks, and different data rates and networks optimized for low downlink exposure. Human exposure to the electromagnetic field from the mobile communication system is expressed as the exposure ratio, the induced 6-minute time-averaged electromagnetic field level divided by the safety limits in percent, separately for the uplink (exposure to a user's own mobile device) and downlink (exposure to the base station network). All mobile networks were realized to comply with an approximation to the current precautionary limits imposed by the Swiss Ordinance for Protection against Non-Ionizing Radiation, i.e., the effect of an increase of the precautionary limits was not studied.

Note that for all of the following statements, in general, the user's own mobile device (uplink) exposure ratio contributed to the user's total exposure on average with a minimum tenfold higher level than the downlink

(base station) exposure. Therefore, for any active mobile device user, a reduction of the downlink exposure will always remain insignificant in terms of the overall exposure.

Which network structures are possible based on the technologies available today (4G, 5G, Wireless Local Area Network WLAN, etc.), and what influence do they have on the spatial distribution of radiation exposure of the population? In the present study, network infrastructures based on the 4G and 5G communication technologies were simulated. The use of WLAN as a supplementary link for indoor reception was not considered in the simulation models as 4G and 5G provide better spectral efficiency technology and output power control than WLAN. Therefore, the use of WLAN in terms of network quality and exposure reduction is not considered beneficial. Other reasons such as network separation and costs may favor the use of WLAN.

Our results show that the transition from 4G to 5G will reduce human exposure in most simulated scenarios while offering a tenfold capacity.

A unified mobile network results in downlink exposure ratios similar to that of the largest user base in Switzerland; however, the unified network can serve twice as many users. Network unification would improve the uplink exposure compared to the uplink exposure in the networks of the second and third largest user base in Switzerland. A unified network would also reduce the number of required base station locations between -13% and -50% (depending on technology and environment).

In particular, the frequently propagated approaches of the "St. Gallen model", the separation of indoor and outdoor coverage are to be analyzed in depth. We analyzed the coverage of indoor and outdoor locations as well as indoor and outdoor exposure. Our results show that a complete separation of indoor and outdoor coverage will lead to lower (factor o 4) downlink exposure outdoors and uncovered indoor locations on average. Indoor downlink exposure is not affected by the separation of indoor and outdoor coverage. Uplink exposure remained in the same range for separate indoor and outdoor networks despite additional building attenuation. We found a trend towards lower uplink exposure (factor of 4) of the 5G technology compared to 4G. This effect is likely related to the use of the MaMIMO (Massive Multiple Input Multiple Output) capabilities in 5G.

In addition, the advantages and disadvantages of using adaptive antennas, also with regard to the data rate and spatial distribution of radiation exposure, should be shown. The 5G network employing adaptive antenna systems is well suited to reduce human exposure while increasing the network capacity by a factor of 10. Especially, in less densely populated environments, adaptive antennas improve the exposure ratio. In the rural environment, the exposure ratio is reduced by a factor of two, while in the urban and suburban environments the average exposure is not affected by the use of adaptive antennas. We found a clear trend towards lower uplink and downlink exposure ratios for the 5G networks using adaptive antennas compared to 4G networks not using adaptive antenna technology.

What influence do the various network structures have on the quality of mobile communication coverage in Switzerland? All networks in the study were planned with a user coverage of at least 95% such that a lack of coverage was compensated by additional base station sites. Our results show that coverage with 5G speeds compared to 4G speeds requires on average three times as many base stations. The coverage of only outdoor locations would primarily reduce the need for base stations in urban environments and only for 4G. 5G will

result in a base station densification for outdoor coverage that is already suited for indoor coverage in many locations. Where insufficient, e.g., in large buildings, the full coverage can be obtained by supplementary 5G indoor base stations.

What influence do the various network structures have on the expansion of mobile communications networks in Switzerland (number of antenna systems)? The transition from a 4G to a 5G network with a tenfold data bandwidth requires, on average, three times more base stations in our network optimization simulations. Base station count is increased by 60% (4G) and 14% (5G) if indoor locations are also covered by the mobile network in the urban environment. The reduction decreases to 20% (4G) and 6% (5G) for the suburban environment and vanishes in the rural environment. Extending the data rate capacity by an additional factor of ten for 5% of the users resulted in only a few additional base station locations but in higher human exposure.

The study also demonstrated that future 5G networks can be realized without an increase of precautionary limits. The number of base stations is mostly driven by the data requirements and not by the exposure limits.

What influence does the number of mobile communication networks have on the radiation exposure of the population or would a single network lead to less radiation exposure than three separate networks? Our results show that a unification of the mobile network infrastructure does not change human exposure considerably compared to multiple operators. However, a unification of the network infrastructure could lead to a smaller number of required base station sites (-13% to -50% depending on the environment and communication system). Due to the user limitation per base station for 5G adaptive antennas, the possible site reduction is greater for 4G (-30% to -50%) than for 5G (-13% to -30%).

What does an ideal network structure look like in order to minimize radiation exposure for the population and at the same time ensure a good quality of cell phone coverage? To minimize human exposure to electromagnetic fields, network planning should always take into account both uplink and downlink exposure. For active users, the uplink exposure is tenfold higher than the downlink exposure. Our results also show that consideration of downlink-only exposure in the planning stage will not reduce the exposure for non-users (members of the society without their own mobile device). A network for minimizing the combined uplink and downlink exposure employs 5G technology and has a dense base station infrastructure, supplemented locally, such as in large buildings, by indoor base stations. Another important outcome is that the 5G base station density is mainly driven by the coverage requirements, i.e., lower base station count under higher limits is not expected. The same rationale leads to the conclusion that relaxed precautionary limits likely increase the uplink exposure, i.e., the overall exposure.

Although the frequencies above 6 GHz are not yet available in Switzerland, the study should also include the future use of these frequencies (millimeter waves, in Switzerland probably in the 24.25-27.5 GHz range). At present, the use of millimeter-wave technologies in Switzerland cannot be predicted. Therefore, we did not include millimeter waves in our mobile network simulation model. Based on initial roll-outs internationally, the current main application of 5G millimeter links is for the last mile. The last mile application (fixed wireless access) is not strictly limited to mobile communication. Here, wireless point-to-point links would replace copper

or fiber links. Based on the point-to-point nature, human exposure to last-mile links is unlikely.

Recently, the first mobile devices (US models of Apple iPhone 12, Samsung S21) with millimeter-wave communication capabilities were placed on the market. This development is driven by the unavailability of the 3.5 GHz band in the United States (US) and the attempt to offload the majority of the data volume over millimeter waves. There is still very little use of millimeter-wave communications in the US [2]. Due to shadowing effects of the human body [3] and the highly directive beam-forming in this frequency range, it can be assumed that the usage of millimeter waves for mobile applications will also mostly be limited to line-of-sight situations. This may lower human exposure due to the highly directive and adaptive nature of the communication links required for signal quality reasons.

Study limitations. Even though the study includes the most currently advanced simulations on user exposure as a function of network topology, several assumptions were made due to the limitations of the tools and to missing information, which are described in detail in the Methods Section (Section 4). The impact of these assumptions on the results is discussed in detail in Section 6 of this report.

Remaining Knowledge Gaps. In the course of this study, we identified future work and research needs to fill the remaining knowledge gaps. As soon as a possible application of millimeter waves emerges in Switzerland, its influence on human exposure should be analyzed. In the present study, we applied harmonized, yet simplified models to analyze indoor exposure to mobile networks. To lower the uncertainties on exposure in indoor scenarios, additional indoor modeling would help to substantiate our results. They could further be strengthened by validation measurements in the up- and downlinks of real 4G and 5G networks in Switzerland. Other areas of future research include the extension of the networks with distributed MaMIMO, mixed technology networks as well as more realistic assignment and weighting of user and base station locations.

Excerpt

To the knowledge of the authors, this study is currently the most advanced study on user exposure as a function of network topology. In order to perform the study using the developed tools and available information, several assumptions were made and described in detail in the Methods Section (Section 4). The impact of these assumptions on the results are as follows:

- The use of simplified models for the propagation and environments (buildings, etc.) may not exactly represent the propagation environment present in the real mobile network environments.
- The chosen coverage goal of 95% of the users in all the study environments at any user location might be higher in some environments than in real networks.
- The selected configurations for the modeling of mobile networks may be different in the actual network implementation.
- A global 5 V/m downlink exposure limit and a 6 minute average of the exposure were applied to map the regulatory boundaries. This means that not all details of the current regulatory requirement with respect to mobile communication exposure could be modeled 1:1 in the simulation tool.
- Even though the precautionary limits were only approximated, the results imply that the networks can be realized under the current regulation.

• The results were based on average usage, yet due to the dominating effect of the uplink exposure, exposure ratios are strongly dependent on personal mobile device usage which was not studied in detail here.
• Base station locations in the extended set were assigned by the optimization algorithm irrespective of the actual building feasibility.
• Currently, there is relatively limited knowledge about the actual deployment and development of 5G in Switzerland.
• Only frequency ranges currently licensed for mobile communication use in Switzerland were included, i.e., millimeter-wave communication links (5G NR FR2) were neglected in the network planning.
• The statistical-based modeling of exposure and limited environmental details and resolution statements on the absolute levels of exposure have a higher level of uncertainty than relative comparisons between scenarios.

• Other sources of exposure than from the simulated mobile communication networks were not included.
• It was assumed that other mobile communication services, e.g., 2G, 3G, were not present in the analyzed scenarios.
• The currently discussed relaxation of the precautionary limits was not studied in detail; however, the simulations indicate that the 5G base station density is mainly driven by the coverage requirements, i.e., lower base station count under higher limits is not expected. Furthermore, [1] relaxed limits likely increase the uplink exposure, i.e., the overall exposure.

Open access report: https://bit.ly/Deruyck2021

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SAR and thermal distribution of pregnant woman and child inside elevator cabin

Ioanna Karatsi, Sofia Bakogianni, Stavros Koulouridis. (2022). SAR and thermal distribution of pregnant woman and child inside elevator cabin. International Journal of Microwave and Wireless Technologies, 1-14. doi:10.1017/S1759078722000253.

Abstract

A detailed dosimetry study of electromagnetic absorption and temperature rise under real scenarios is delivered when a mobile phone is used inside an elevator cabin. Numerically accurate human models of a 7th month pregnant woman and a 5-year-old female child are utilized as the exposed subjects. The female child acts as the phone user. The mobile phone is modeled in three talk positions (parallel, tilt, and cheek) operating at 1000 MHz and 1800 MHz. From the obtained numerical results for the specific absorption rate (SAR) and temperature rise induced by the mobile radiofrequency (RF) radiation, it is found that the child's RF exposure is significantly affected by the phone position and less affected by the relevant position of the human models. The exact opposite case applies for the pregnant woman model and its fetus. Almost all numerical investigations are carried out inside a metallic elevator cabin.

Open access paper: https://bit.ly/SARelevator

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Exposure to RF Electromagnetic Fields in the Connected Vehicle: Survey of Existing and Forthcoming Scenarios

G. Tognola, M. Bonato, M. Benini, S. Aerts, S. Gallucci, E. Chiaramello, S. Fiocchi, M. Parazzini, B. Masini, W. Joseph, J. Wiart, P. Ravazzani. Exposure to RF Electromagnetic Fields in the Connected Vehicle: Survey of Existing and Forthcoming Scenarios.IEEE Access, doi: 10.1109/ACCESS.2022.3170035.

Abstract

Future vehicles will be increasingly connected to enable new applications and improve safety, traffic efficiency and comfort, through the use of several wireless access technologies, ranging from vehicle-to-everything (V2X) connectivity to automotive radar sensing and Internet of Things (IoT) technologies for intra-car wireless sensor networks. These technologies span the radiofrequency (RF) range, from a few hundred MHz as in intra-car network of sensors to hundreds of GHz as in automotive radars used for in-vehicle occupant detection and advanced driver assistance systems. Vehicle occupants and road users in the vicinity of the connected vehicle are thus daily immersed in a multi-source and multi-band electromagnetic field (EMF) generated by such technologies. This paper is the first comprehensive and specific survey about EMF exposure generated by the whole ensemble of connectivity technologies in cars. For each technology we describe the main characteristics, relevant standards, the application domain, and the typical deployment in modern cars. We then extensively characterize the EMF exposure scenarios resulting from such technologies by resuming and comparing the outcomes from past studies on the exposure in the car. Results from past studies suggested that in no case EMF exposure was above the safe limits for the general population. Finally, open challenges for a more realistic characterization of the EMF exposure scenario in the connected car are discussed.

Open access paper: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9762806&isnumber=6514899

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Design and manufacture of electromagnetic absorber composed of boric acid-incorporated wastepaper composites

ALİ İHSAN KAYA, AHMET ÇİFCİ, FİLİZ KIRDIOĞULLARI, MESUD KAHRİMAN, OSMAN ÇEREZCI. Design and manufacture of electromagnetic absorber composed of boric acid-incorporated wastepaper composites. Turk J Elec Eng & Comp Sci. 2022. 30: 839 – 854. doi:10.3906/elk-2106-21.

Abstract

With the effect of technological advances, the use of electrical and electronic devices has increased dramatically in recent years. Wireless technologies and related applications are mostly preferred for the communication of these devices with each other. Thus, people are easily exposed to electromagnetic waves in daily life. The extensive global use of these devices raises the question of their possible biological effects on human health. Also, electromagnetic waves influence the functioning of a nearby device. In this study, an electromagnetic absorber based on boric acid (5, 10, 20, and 30 wt%) added wastepaper was developed. Copper (Cu) and aluminum (Al) were also used as mineral additives for comparison. Three different kinds of wastepaper namely, office paper, newsprint, and cardboard paper were selected for the experimental study. The effect of varying boric acid contents on the electromagnetic absorption of the boards manufactured was evaluated and compared to Cu (30 wt%) and Al (30 wt%) added boards. The results show that newsprint has better absorption effectiveness than office and cardboard paper and absorption up to 40 dB was achieved. The absorption effectiveness of Al, Cu, and boric acid added boards was achieved at approximately 40, 30, and 20 dB,

respectively. As a result, the electromagnetic absorption effectiveness of boric acid added the board is acceptable levels. Also, apart from the use of boric acid as a powder, it has been determined that the application of the surface as a layer is effective in absorption.

Open access paper: https://journals.tubitak.gov.tr/elektrik/issues/elk-22-30-3/elk-30-3-23-2106-21.pdf

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Cell Responsiveness to Physical Energies: Paving the Way to Decipher a Morphogenetic Code

Ricardo Tassinari, Claudia Cavallini, Elena Olivi, Federica Facchin, Valentina Taglioli, Chiara Zannini, Martina Marcuzzi, Carlo Ventura. 2022. Cell Responsiveness to Physical Energies: Paving the Way to Decipher a Morphogenetic Code. *International Journal of Molecular Sciences* 23(6):3157. doi: 10.3390/ijms23063157.

Abstract

We discuss emerging views on the complexity of signals controlling the onset of biological shapes and functions, from the nanoarchitectonics arising from supramolecular interactions, to the cellular/multicellular tissue level, and up to the unfolding of complex anatomy. We highlight the fundamental role of physical forces in cellular decisions, stressing the intriguing similarities in early morphogenesis, tissue regeneration, and oncogenic drift. Compelling evidence is presented, showing that biological patterns are strongly embedded in the vibrational nature of the physical energies that permeate the entire universe. We describe biological dynamics as informational processes at which physics and chemistry converge, with nanomechanical motions, and electromagnetic waves, including light, forming an ensemble of vibrations, acting as a sort of control software for molecular patterning. Biomolecular recognition is approached within the establishment of coherent synchronizations among signaling players, whose physical nature can be equated to oscillators tending to the coherent synchronization of their vibrational modes. Cytoskeletal elements are now emerging as senders and receivers of physical signals, “shaping” biological identity from the cellular to the tissue/organ levels. We finally discuss the perspective of exploiting the diffusive features of physical energies to afford in situ stem/somatic cell reprogramming, and tissue regeneration, without stem cell transplantation.

Open access paper: https://www.mdpi.com/1422-0067/23/6/3157/htm

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An International Collaborative Animal Study of the Carcinogenicity of Mobile Phone Radiofrequency Radiation: Considerations for Preparation of a Global Project

Ahn YH, Imaida K, Kim YB, Han KH, Pack JK, Kim N, Jeon SB, Lee AK, Choi HD, Wang J, Kawabe M, Kim HS. An International Collaborative Animal Study of the Carcinogenicity of Mobile Phone Radiofrequency Radiation: Considerations for Preparation of a Global Project. Bioelectromagnetics. 2022 Apr 27. doi: 10.1002/bem.22407

Abstract

Radiofrequency radiation (RFR) was classified as a "possible" human carcinogen in 2011, which caused great public concern. A carcinogenicity study by the National Toxicology Program (NTP) found Code Division Multiple

Access-and Global System for Mobile Communications-modulated mobile phone RFR to be carcinogenic to the brain and heart of male rats. As part of an investigation of mobile phone carcinogenesis, and to verify the NTP study results, a 5-year collaborative animal project was started in Korea and Japan in 2019. An international animal study of this type has two prerequisites: use of the same study protocol and the same RF-exposure system. This article discusses our experience in the design of this global study on radiofrequency electromagnetic fields (RF-EMFs).

https://pubmed.ncbi.nlm.nih.gov/35476263/

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Transcriptomic and Long-Term Behavioral Deficits Associated with Developmental 3.5 GHz Radiofrequency Radiation Exposures in Zebrafish

Subham Dasgupta, Connor Leong, Michael T Simonich, Lisa Truong, Huaping Liu, Robyn L Tanguay. Transcriptomic and Long-Term Behavioral Deficits Associated with Developmental 3.5 GHz Radiofrequency Radiation Exposures in Zebrafish. Environ Sci Technol Lett. 2022 Apr 12;9(4):327-332. doi: 10.1021/acs.estlett.2c00037.

Abstract

The rapid deployment of the fifth-generation (5G) spectrum by the telecommunication industry is intended to promote better connectivity and data integration among various industries. However, concerns among the public about the safety and health effects of radiofrequency radiations (RFRs) emitted from the newer-generation cell phone frequencies remain, partly due to the lack of robust scientific data. Previously, we used developmental zebrafish to model the bioactivity of 3.5 GHz RFR, a frequency used by 5G-enabled cell phones, in a novel RFR exposure chamber. With RFR exposures from 6 h post-fertilization (hpf) to 48 hpf, we observed that, despite no teratogenic effects, embryos showed subtle hypoactivity in a startle response behavior assay, suggesting abnormal sensorimotor behavior. This study builds upon the previous one by investigating the transcriptomic basis of RFR-associated behavior effects and their persistence into adulthood. Using mRNA sequencing, we found a modest transcriptomic disruption at 48 hpf, with 28 differentially expressed genes. KEGG pathway analysis showed that biochemical pathways related to metabolism were significantly perturbed. Embryos were grown to adulthood, and then a battery of behavioral assays suggested subtle but significant abnormal responses in RFR-exposed fish across the different assays evaluated that suggest potential long-term behavioral effects. Overall, our study suggests the impacts of RFRs on the developing brain, behavior, and the metabolome should be further explored.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9009179/

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Biological Effects of Non-Ionizing Electromagnetic Fields at 27 GHz on Sperm Quality of *Mytilus galloprovincialis*

Roberta Pecoraro, Santi C. Pavone, Elena M. Scalisi, Carmen Sica, Sara Ignoto, Martina Contino, Antonio Salvaggio, Dimitra Marmara, Gino Sorbello, Loreto Di Donato, Maria V. Brundo. 2022. Biological Effects of Non-Ionizing Electromagnetic Fields at 27 GHz on Sperm Quality of *Mytilus galloprovincialis. Journal of Marine Science and Engineering*. 10(4):521. doi: 10.3390/jmse10040521

Abstract

Recently, an increasing use of wireless internet technologies has been demonstrated. The devices which use these technologies emit in new spectral regions an electromagnetic radiation (EMF) which could interact with the male reproductive system. The aim of this study was to investigate in vitro the effect of electromagnetic fields at 27 GHz on sperm quality in Mytilus galloprovincialis. Sperm samples were collected from sexually mature males of M. galloprovincialis and placed in seawater. Once we evaluated the number and quality of spermatozoa, sperm cells were exposed to electromagnetic fields radiated by a pyramidal horn antenna. The effect of exposure was evaluated after 10, 20, 30, 40 and 60 min by a light microscope and using an Eosin test. Ten replications were performed for each time series, and statistical analysis was carried out by t-test. Sperm motility decreased after 10 min of exposure, and after 30 min most of the spermatozoa were immobile and not vital. This study provides useful data on the potential ecological impact of the high-band 5G on animal fertility, the effect of which is currently under investigation.

Conclusions

This study indicates that electromagnetic fields at 27 GHz can affect the sperm quality in marine mussel Mytilus galloprovincialis. The significative decrease observed in sperm motility after only 10 min of exposure represents a crucial factor to be considered because it can threaten the reproductivity of the species. This study provides useful data on the potential impact of high frequency EMFs on aquatic animals and cells, which is currently poorly investigated. Future research could benefit from specific investigations into the impact of 5G to better monitor the effects on animal organisms and to fill the gap currently known about the interactions with artificial sources of electromagnetic fields.

Open access paper: https://www.mdpi.com/2077-1312/10/4/521

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Stereological Study on the Effect of Carnosine on Purkinje Cells in the Cerebellum of Rats Exposed to 900 MHz Electromagnetic Field

Arslan A, Acer N, Kesici H, Sonmez MF, Ertekin T, Gultekin M, Dagdelen U, Saracoglu OG. Stereological Study on the Effect of Carnosine on Purkinje Cells in the Cerebellum of Rats Exposed to 900 MHz Electromagnetic Field. Turk Neurosurg. 2021 Aug 28. doi: 10.5137/1019-5149.JTN.35313-21.2.

Abstract

Aim: Electromagnetic fields have been known to reduce the number of Purkinje neurons in the cerebellum, whereas carnosine has been known to protect them. This study aimed to evaluate the impact of carnosine on Purkinje neurons in rats exposed to a 900 Mhz electromagnetic field.

Material and methods: This study evaluated 24 rats divided into the following three different groups: a control group, a group exposed to the electromagnetic field, and a group that was injected with carnosine while being exposed to the electromagnetic field. The electromagnetic field group was exposed to a 900 Mhz electromagnetic field for an hour daily over 28 days. Thereafter, stereological analysis was performed histologically on cerebellar sections, and the number of Purkinje cells were counted.

Results: The electromagnetic field group had remarkably fewer Purkinje cell compared to control. The electromagnetic field group plus 20 mg of carnosine had significantly more total Purkinje cells compared to the electromagnetic field group (p 0.05).

Conclusion: The present study showed that electromagnetic field exposure decreases the number of Purkinje cell, whereas carnosine protected the cerebellum from neural damage induced by electromagnetic field exposure.

Open access paper: http://www.turkishneurosurgery.org.tr/pdf/JTNEPUB_35313_online.pdf

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In Vivo Functional Ultrasound (fUS) Real-Time Imaging and Dosimetry of Mice Brain Under Radiofrequency Exposure

Rosa Orlacchio, Yann Percherancier, Florence Poulletier De Gannes, Annabelle Hurtier, Isabelle Lagroye, Philippe Leveque, Delia Arnaud-Cormos. In Vivo Functional Ultrasound (fUS) Real-Time Imaging and Dosimetry of Mice Brain Under Radiofrequency Exposure. Bioelectromagnetics. 2022 Apr 29. doi: 10.1002/bem.22403.

Abstract

This study aims to analyze in real-time the potential modifications induced by low-level continuous-wave and Global System for Mobile Communications radiofrequency (RF) exposure at 1.8 GHz on brain activation in anesthetized mice. A specific in vivo experimental setup consisting of a dipole antenna for the local exposure of the brain was fully characterized. A unique neuroimaging technique based on a functional ultrasound (fUS) probe was used to observe the areas of mice brain activation simultaneously to the RF exposure with unprecedented spatial and temporal resolution (~100 µm, 1 ms) following manual whisker stimulation using a brush. Numerical and experimental dosimetry was carried out to characterize the exposure and to guarantee the validity of the biological results. Our results show that the fUS probe can be efficiently used during in vivo exposure without interference with the dipole. In addition, we conclude that exposure to brain-averaged specific absorption rate levels of 2 and 6 W/kg does not introduce significant changes in the time course of the evoked fUS response in the left barrel field cortex. The proposed technique represents a valuable instrument for providing new insights into the possible effects induced on brain activation under RF exposure. For the first time, brain activity under mobile phone exposure was evaluated in vivo with fUS imaging, paving the way for more realistic exposure configurations, i.e. awake mice and new signals such as the 5 G networks.

https://pubmed.ncbi.nlm.nih.gov/35485721/

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Neurological effects of static and extremely-low frequency electromagnetic fields (Review)

Henry Lai. Neurological effects of static and extremely-low frequency electromagnetic fields. Electromagn Biol Med. 2022 Apr 15:1-21. doi: 10.1080/15368378.2022.2064489.

Abstract

This is a review of studies on the neurological effects of static/extremely-low frequency (ELF) electromagnetic fields (EMF). The review is mainly on research carried out in the last two decades. There are studies that showed effects on various neurotransmitters, including NMDA, serotonin, dopamine, endogenous opioids, etc. Each of these transmitters plays different critical roles on behavior and brain functions. Studies on behavioral effects of static/ELF EMF bear out these connections. Static/ELF EMF-induced behavioral and pathological effects, such as locomotor activity, memory and learning deficits, and neurological diseases (Alzheimer's, Parkinson's disease, Huntinton's diseases and atropical lateral scleroses, etc.) are discussed. Static/ELF EMF exposure has also been shown to have beneficial effects on functional deficits and progression of some neurological diseases. These fields provide a non-invasive treatment or treatment-adjuvant for these detrimental neurological conditions. Results suggest that free radicals, both reactive oxygen species and reactive nitric species could be involved. Depending on the conditions of exposure, either harmful or beneficial effects could result. It is important to carry out further investigation to identify these conditions. However, caution should be taken to extrapolate the experimental data to human exposure, since higher field intensities than environmental levels were used in most laboratory research.

https://pubmed.ncbi.nlm.nih.gov/35426330/

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Effects of Moderate to High Static Magnetic Fields on Reproduction (Review)

Chao Song, Biao Yu, Junjun Wang, Yiming Zhu, Xin Zhang. Effects of Moderate to High Static Magnetic Fields on Reproduction. Bioelectromagnetics. 2022 Apr 29. doi: 10.1002/bem.22404.

Abstract

With the wide application of magnetic resonance imaging in hospitals and permanent magnets in household items, people have increased exposure to various types of static magnetic fields (SMFs) with moderate and high intensities, which has caused a considerable amount of public concern. Studies have shown that some aspects of gametogenesis and early embryonic development can be significantly affected by SMFs, while others have shown no effects. This review summarizes the experimental results of moderate to high-intensity SMFs (1 mT-16.7 T) on the reproductive development of different model animals, and we find that the effects of SMFs are variable depending on experimental conditions. In general, the effects of inhomogeneous SMFs seem to be more significant compared to that of homogeneous SMFs, which is likely due to magnetic forces generated by the magnetic field gradient. Moreover, some electromagnetic fields may have induced bioeffects because of nonnegligible gradient and heat effect, which are much reduced in superconducting magnets. We hope this

review can provide a starting point for more in-depth analysis of various SMFs on reproduction, which is indispensable for evaluating the safety and potential applications of SMFs on living organisms in the future.

https://pubmed.ncbi.nlm.nih.gov/35485707/

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LF-EMF Compound Block Type Signal Activates Human Neutrophilic Granulocytes In Vivo

Jan J M Cuppen, Cristian Gradinaru, Bregje E Raap-van Sleuwen, Anna C E de Wit, Ton A A J van der Vegt, Huub F J Savelkoul. LF-EMF Compound Block Type Signal Activates Human Neutrophilic Granulocytes In Vivo. Bioelectromagnetics. 2022 Apr 28. doi: 10.1002/bem.22406.

Abstract

This research aims to demonstrate in a randomized, placebo-controlled crossover design study that a nominal 5 μT low-frequency electromagnetic field (LF-EMF) signal for 30 min activates neutrophils in vivo in humans. Granularity of neutrophils was measured in blood samples of healthy human volunteers (n = 32) taken before and after exposure for both the exposure and control sessions. A significant decrease in the granularity, indicative of neutrophil activation, was observed both in the exposure measurements and the exposure minus control measurements. Earlier EMF publications show immune function increase in isolated cells and more effective immune responses in animals with infections. This result, therefore, supports the thesis that the exposure can activate the innate immune system in humans, speed up the innate immune response, and may have potential beneficial effects in infectious disease.

https://pubmed.ncbi.nlm.nih.gov/35481557/

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Exposure to Magnetic Fields Changes the Behavioral Pattern in Honeybees under Laboratory Conditions

Paweł Migdał, Ewelina Berbeć, Paweł Bieńkowski, Mateusz Plotnik, Agnieszka Murawska, Krzysztof Latarowski. Exposure to Magnetic Fields Changes the Behavioral Pattern in Honeybees (Apis mellifera L.) under Laboratory Conditions. Animals (Basel). 2022 Mar 29;12(7):855. doi: 10.3390/ani12070855.

Abstract

Earth's magnetic field (MF) plays an important role for many species, including the honeybee, in navigation. Nowadays, much larger alternating fields are emitted by miscellaneous electric infrastructure components, such as transformers and power lines, and the environment is therefore polluted by an anthropogenic electromagnetic field, though little is known regarding its impact on living organisms. The behavior of animals is the first and easiest way to establish the impact of stress. It shows if the animal can detect the exposure and react to it. To investigate this, one-day-old bees were exposed to a 50 Hz magnetic field of induction at 1 mT and 1.7 mT for 10 min, 1 h, and 3 h under laboratory conditions. All groups exposed to the magnetic field showed

differences in behavioral patterns. What is more, they presented a behavior absent in the control: loss of balance. There were differences, both in the ratio of behaviors and in the number of bouts-exposed bees more often changed behavior. Occurrence of differences is an indication of the reaction of the honeybee organism to the magnetic field. Loss of balance is a disturbing symptom, and behavior changes indicate a disturbance of the honeybee by the electromagnetic field.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8996969/

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Exposure to the electromagnetic field alters the transcriptomic profile in the porcine endometrium during the peri-implantation period

Kozlowska W, Drzewiecka EM, Paukszto L, Zmijewska A, Wydorski PJ, Jastrzebski JP, Franczak A. Exposure to the electromagnetic field alters the transcriptomic profile in the porcine endometrium during the peri-implantation period. J Physiol Pharmacol. 2021 Dec;72(6). doi: 10.26402/jpp.2021.6.04.

Abstract

A low-frequency electromagnetic field (EMF) is an environmental pollutant that may influence female reproduction. This research was undertaken to test the hypothesis that EMF causes alterations in the transcriptomic profile of the endometrium. This study investigated the in vitro effects of EMF treatment (50 Hz, 2 h) on global transcriptome alterations in the endometrium isolated from pigs during the peri-implantation period. The control endometrium was not treated with EMF. The EMF treatment altered the expression of 1561 transcriptionally active regions (TARs) in the endometrium. In the group of 461 evaluated DEGs, 156 were up-regulated (34%), 305 were down-regulated (66%) and 341 (74%) had known biological functions. A total of 210 long noncoding RNAs (lncRNAs) with changes in expression profiles, and 146 predicted RNA editing sites were also evaluated. Exposure to EMF changes the expression of genes encoding proteins that are involved in proliferation and metabolism in endometrial tissue. These results provide useful inputs for further research into the impact of EMF on molecular changes in the uterus during the peri-implantation period and, consequently, pregnancy outcome.

Open access paper: https://www.jpp.krakow.pl/journal/archive/12_21/pdf/10.26402/jpp.2021.6.04.pdf

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Electromagnetic field exposure alters in vitro estrogen biosynthesis and its release by the porcine endometrium in the peri-implantation period

Wiktoria Kozlowska, Ewa Monika Drzewiecka, Agata Zmijewska, Anita Franczak. Electromagnetic field exposure alters in vitro estrogen biosynthesis and its release by the porcine endometrium in the peri-implantation period. Reprod Biol. 2022 Apr 26;22(2):100642. doi: 10.1016/j.repbio.2022.100642.

Abstract

The electromagnetic field (EMF) is an environmental risk factor that may impair living organisms. This study aims

to determine the functional effects of EMF exposure at 50 and 120 Hz for 2 or 4 h on estrogen synthesis and release in the endometrium. Endometrial slices were isolated from pigs (n = 5) during the peri-implantation period. To check whether progesterone (P4) exerts any protective effects against EMF, selected EMF-treated slices were also treated with P4. CYP19A3 mRNA transcript abundance was higher in slices exposed to EMF (50 Hz, 4 h) and treated with P4. HSD17B4 mRNA transcript abundance was higher in slices exposed to EMF (50 and 120 Hz, 2 h) without P4 treatment. Both EMF (50 Hz, 2 h) and EMF (50 and 120 Hz, 4 h) increased HSD17B4 mRNA transcript abundance in the presence of P4; EMF (120 Hz, 2 h, and 50 Hz, 4 h) decreased cytochrome P-450arom protein abundance in tissue slices not treated with P4. Under exposure to EMF at 120 Hz (2 h), the abundance of hydroxysteroid 17β dehydrogenase decreased in P4-treated slices and increased in slices not treated with P4 (4 h). Progesterone treatment decreased the release of estradiol-17β (E2) in endometrial slices exposed to EMF at 50 Hz (2 h), whereas in slices not treated with P4, EMF (120 Hz, 2 h) increased estrone (E1) release compared to control (without EMF). The EMF could disrupt the synthesis and release of E1 and E2 by the porcine endometrium during the peri-implantation period.

Open access paper: https://www.sciencedirect.com/science/article/pii/S1642431X22000419?via%3Dihub

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Searching for unity in diversity of animal magnetoreception: From biology to quantum mechanics and back

Can Xie. Searching for unity in diversity of animal magnetoreception: From biology to quantum mechanics and back. Innovation (N Y). 2022 Mar 11;3(3):100229. doi: 10.1016/j.xinn.2022.100229.

Abstract

How animals sense the geomagnetic field remains a mystery today. A remarkable diversity has been revealed in animal magnetoreception and several sophisticated models have been put forward in the past few decades, but none have been commonly accepted yet. Cryptochrome (Cry) has been proposed in both the radical pair model and the MagR/Cry-based biocompass model. How exactly it participates in magnetic sensing is an ongoing discussion. Here we wish to suggest an intermolecular electron transport (ET) pathway conserved in evolution in the MagR/Cry complex, in which electrons travel stepwise along a flavin-tryptophan chain as described in the classic radical pair model, and further extends to iron-sulfur clusters in MagR via a series of stepping-stone amino acids as an ET bridge. The hypothesis we presented here may provide a solution to unite different models, and a feasible explanation for the intrinsic magnetic features of MagR, as well as a mechanism for signaling in animal magnetoreception, which are of considerable interest in both biology and physics.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8966150/

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Individual variability in space use near power lines by a long-lived territorial raptor

Marques AT, Palma L, Lourenço R, Cangarato R, Leitão A, Mascarenhas M, Tavares JT, Tomé R, Moreira F, Beja P. Individual variability in space use near power lines by a long-lived territorial raptor. Ecol Evol. 2022 Apr 7;12(4):e8811. doi: 10.1002/ece3.8811.

Abstract

Evaluating species responses to anthropogenic infrastructures and other habitat changes is often used to assess environmental impacts and to guide conservation actions. However, such studies are generally carried out at the population level, disregarding inter-individual variability. Here, we investigate population- and individual-level responses toward power lines of a territorial raptor, the Bonelli's eagle A*quila fasciata*. We used GPS-PTT tracking data of 17 adult eagles to model space use as a function of distance to transmission and distribution lines, while accounting for other habitat features known to affect this species. At population level, eagles increased the intensity of space use in the proximity of power lines (up to 1,000 m), suggesting an attraction effect. At individual level, some eagles shared the general population attraction pattern, while others showed reduced intensity of space use in the proximity of power lines. These differential responses were unrelated to the sex of individuals, but were affected by the characteristics of the power grid, with a tendency for apparent attraction to be associated with individuals occupying home ranges with a denser network of transmission lines and transmission pylons. However, the study could not rule out the operation of other potentially influential factors, such as individual idiosyncrasies, the spatial distribution of prey availability, and the availability of natural perches and nesting sites. Overall, these results suggest that power lines may drive different behaviors and have differential impacts across individuals, with those attracted to the proximity of power lines potentially facing increased risk of mortality through electrocution and collision, and those avoiding power lines being potentially subject to exclusion effects. More generally, our results reinforce the need to understand individual variability when assessing and mitigating impacts of anthropogenic infrastructures.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8987490/

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The moral hazard of lax FCC land use oversight for advanced network infrastructure

Benjamin W. Cramer. The moral hazard of lax FCC land use oversight for advanced network infrastructure. Telecommunications Policy. 46(1). 2022. doi: 10.1016/j.telpol.2021.102232.

Abstract

This article discusses issues that arise when service providers place network equipment on publicly owned lands in the United States. Based on land use policy at the Federal Communications Commission, this paper theorizes that the use of public lands for 5G network development will create a moral hazard, as service providers may be tempted to take risks in the way they use public lands. Per economic theory the firm could behave recklessly when knowing that the costs will be borne by someone else – in this case local citizens. This is an example of the moral hazard problem in economics.

Conclusion and recommendations

This article has argued that FCC land usage regulations, covered by Section 253 in the Telecommunications Act of 1996, remove local governments as decisionmakers in land management. The result is that telecommunications firms have little incentive to use publicly owned land efficiently or equitably, and the FCC has little incentive to make sure that they do. Without these incentives, a moral hazard forms in which local citizens must accept the costs (financial or otherwise) of poor land use practices for telecom infrastructure. The FCC's more recent enhancement of such regulations in order to speed up the 5G rollout, regardless of the interests of local governments and citizens, will create additional moral hazards that in turn will encourage firms to abuse the land that they have been permitted to build upon.

The FCC's plans for the 5G rollout, as described for the public at the Commission website, include many promises to “speed up the process” of deployment and “make it easier for companies to invest” in network equipment (FCC, 2021(a)), which could indeed encourage cutting corners and making land use decisions without considering the longer-term consequences. There have in fact been a few successful local challenges against land use decisions made by telecom providers for 5G and other recent infrastructure. Douglas County, Colorado denied a visually unattractive tower proposed by T-Mobile and prevailed in court (Reid, 2020). The city of San Jose, California has convinced AT&T and Verizon to adapt their local 5G infrastructure plans with San Jose's “smart city” initiative, with a focus on environmental protection and sustainability (Moss, 2018).

On the other hand, the telecommunications industry also has a history of ignoring local restrictions or regulations on land use. The present author does not wish to imply that this will happen often, and in fact it may be quite rare. However, such things have happened before in the telecommunications sector and other networked industries. For example, in 2001 MCI Worldcom started building network infrastructure on a strategic plot of public land in Indiana; due to vague local permitting processes the company was able to ignore the wishes of the local community and did not bother to get permission to build. In Peeler v. MCI Worldcom, an Indiana court charged the company with willful trespass and ordered it to remove all the equipment it had placed at the location, which cost the company millions of dollars per month until the matter was resolved. During that same period, researchers uncovered internal documents at AT&T in which the company admitted to using various public land parcels without adequate permission. The company rationalized its actions by claiming pressure to build network coverage that was demanded by the marketplace, but admitted that its legal position was “precarious” and “far from sound” (Ackerson, 2003, pp. 184–185). This behavior seems to have been inherited from telecom's ancestor in the realm of networked industries – railroads – which in the late 1800s often built tracks across public lands without permission (because overseeing governments were often very far away or unable to enforce regulations), and used the same argument about market pressure to build first and ask questions later (Ackerson, 2003, pp. 180–181).

Those unauthorized uses of land caused various environmental or economic harms with various levels of severity, but they were all enabled by the type of moral hazard covered in this article. While telecommunications firms have other incentives to behave, especially public relations benefits, there is little guarantee that land-use horror stories will never happen during the 5G rollout, as shown by older history and current regulatory practices.

The economics literature has shown that moral hazards are more common than usual among complex corporations that are pressured by shareholders to take risks for profit purposes, and in industries dominated by natural monopolies or oligopolies (Laffont, 1995, pp. 319–320). The telecommunications industry exhibits both of these characteristics. Large corporations are also expected to make large profits in ways that conflict with risk reduction efforts in non-economic areas like environmental compliance, while the structure of such corporations reduces the ability of managers to oversee the environmental activities of workers at the level needed to prevent damage before it occurs (Gabel & Sinclair-Desgagné, 1993, pp. 229–233).

These are traditional reasons for regulatory oversight of corporations and industries, and such oversight has been lacking for the use of publicly owned lands by telecom firms. Well-designed public policy is necessary in any advanced society, especially for practices that create moral hazards and principal-agent problems (Bergman & Lane, 1990, p. 339). Oversight of corporate actors ("agents") will discourage them from hiding information, which in turn gives them an advantage over the contractual relationship; regulators ("principals") could level the informational playing field with incentives and rewards for behaving equitably (Hiriart & Martimort, 2004, pp. 4–5). This article also positions the FCC as a somewhat aloof player in the principal-agent problem of telecom land usage, and this increases the distance and misunderstandings between the ultimate regulator (the FCC) and the ultimate sufferers of land use inequities (citizens), with the potential intermediary (local government) largely cut out of the process. This type of fractured arrangement is known to induce additional moral hazards as well (Bergman & Lane, 1990, p. 345).

This problem can be addressed with stronger institutional oversight (Braun & Guston, 2003, p. 303). Such oversight has been found to be particularly effective in encouraging firms to manage their environmental impact by reducing their temptations to engage in risky behavior (Gabel & Sinclair-Desgagné, 1993, pp. 238–239). This article recommends that FCC regulations regarding usage of public lands for advanced network construction should acknowledge the needs of affected landowners and local communities. This can be accomplished with a replacement of Section 253 of the Telecommunications Act, or at least a softer interpretation of it. This may require Congressional action.

By requiring the needs of the network and of telecom firms to be considered first in any local land use regulation, the concerns of local governments – who are much more knowledgeable about local conditions and the interests of citizens – are frozen out of the process almost a priori. This regulatory pattern incentivizes firms to never consider any interests other than their own when they use publicly owned lands. While few well-managed firms will succumb to the temptation, history shows that some might, and the effects must be suffered by everyone else. A possible solution is to encourage more equitable viewpoints on the American telecommunications regulations that enable the discrepancies of knowledge and power embodied in the principal-agent relationship at hand, which in turn will reduce the possible moral hazard of risky land use by one party who knows that someone else will have to deal with the consequences.

https://www.sciencedirect.com/science/article/pii/S0308596121001361

Conference paper (open access): https://bit.ly/FCCmoralhazard

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Cellular Telephone Use and the Risk of Brain Tumors: Update of the UK Million Women Study

Joachim Schüz, Kirstin Pirie, Gillian K Reeves, Sarah Floud, Valerie Beral, for the Million Women Study Collaborators. Cellular Telephone Use and the Risk of Brain Tumors: Update of the UK Million Women Study. *JNCI: Journal of the National Cancer Institute*, 2022, djac042, doi: 10.1093/jnci/djac042.

Abstract

The ongoing debate of whether use of cellular telephones increases the risk of developing a brain tumor was recently fueled by the launch of the fifth generation of wireless technologies. Here, we update follow-up of a large-scale prospective study on the association between cellular telephone use and brain tumors.During 1996-2001, 1.3 million women born in 1935-1950 were recruited into the study. Questions on cellular telephone use were first asked in median year 2001 and again in median year 2011. All study participants were followed via record linkage to National Health Services databases on deaths and cancer registrations (including nonmalignant brain tumors).During 14 years follow-up of 776 156 women who completed the 2001 questionnaire, a total of 3268 incident brain tumors were registered. Adjusted relative risks for ever vs never cellular telephone use were 0.97 (95% confidence interval = 0.90 to 1.04) for all brain tumors, 0.89 (95% confidence interval = 0.80 to 0.99) for glioma, and not statistically significantly different to 1.0 for meningioma, pituitary tumors, and acoustic neuroma. Compared with never-users, no statistically significant associations were found, overall or by tumor subtype, for daily cellular telephone use or for having used cellular telephones for at least 10 years. Taking use in 2011 as baseline, there were no statistically significant associations with talking for at least 20 minutes per week or with at least 10 years use. For gliomas occurring in the temporal and parietal lobes, the parts of the brain most likely to be exposed to radiofrequency electromagnetic fields from cellular telephones, relative risks were slightly below 1.0.Our findings support the accumulating evidence that cellular telephone use under usual conditions does not increase brain tumor incidence.

Open access paper: https://doi.org/10.1093/jnci/djac042

For a critique of this paper see: https://www.saferemr.com/2022/03/the-uk-million-women-study-of-cell.html

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The Dynamics of the Radiated Field Near a Mobile Phone Connected to a 4G or 5G Network

D. B. Deaconescu, A. M. Buda, D. Vatamanu, S. Miclaus. The Dynamics of the Radiated Field Near a Mobile Phone Connected to a 4G or 5G Network. Eng. Technol. Appl. Sci. Res. 12(1):8101–8106, Feb. 2022.

Abstract

Characterizing the time variations of signals emitted by mobile terminals provides complementary information to health authorities, especially with the increase of frequency and energy of radiation towards millimeter waves. This experimental work aimed to quantify and classify the time variability of the electric field level measured at 10cm from a mobile phone connected sequentially to a 4^{th} and 5^{th} generation mobile network. Statistic analysis was performed on data from real-time spectrum analyzers, while self-similarity was computed

by first recurrence plots of the radiated emissions, corresponding to five different types of mobile applications. Moreover, specificities to the communication standard and the type of application were identified.

Conclusions

This study aimed to identify the differences in the time variability of signals emitted by a mobile phone when sequentially connected to a 4G-LTE or 5G-NR network. The main reason behind this study was the need of describing not only the dose of radiation absorbed by a human body while using a phone but also the average or the momentary dose rate. While the present safety exposure standards do not yet expressly require such knowledge, increasing the frequency towards tens of GHz in 5G networks means an increase in the energy of the radiation so it might need a time-dependent description similar to the ionizing radiation. Moreover, the averaging time used to describe the biological impact of the field is also very important to accurately describe the safety of people exposed to very short and quasi-stochastic pulses [31].

By experimentally determining the E-field strength variation during the 25s usage of 5 different mobile communication activities in either 4G or 5G networks, which allowed TDD technique and respectively had 20 and 40MHz bandwidths for the transmission, streams of 250 field values were gathered and treated as time-series. The boxplot representations of these data allowed obtaining descriptive statistic distributions, while the Poincare plots showed self similarity by first recurrence means. The results showed that: a) more intensive dynamics are encountered generally in 5G UL signal than in 4G, b) the time variability is dependent not only on the communication standard but also on the type of mobile application used, c) short-term variability is lower than long term when using a 4G application, as compared to 5G where the short-term variability of field level is higher than the long term, d) the lowest ratio between short- and long-time variabilities was encountered for file upload in 4G, while the highest ratio was encountered for file download in 5G, and e) the largest total variabilities in 4G were associated to upload and video call, while in 5G they were noted during voice call and file download. These results provide important knowledge that completes the picture of amplitude-time variation of human exposure to near-the-body used mobile devices.

Open access paper: https://etasr.com/index.php/ETASR/article/view/4670/2663

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Psychological Drivers of Individual Differences in Risk Perception: A Systematic Case Study Focusing on 5G

Renato Frey. Psychological Drivers of Individual Differences in Risk Perception: A Systematic Case Study Focusing on 5G. Psychol Sci. 2021 Oct;32(10):1592-1604. doi: 10.1177/0956797621998312.

Abstract

What drives people's perceptions of novel risks, and how malleable are such risk perceptions? Psychological research has identified multiple potential drivers of risk perception, but no studies have yet tested within a unified analytic framework how well each of these drivers accounts for individual differences in large population samples. To provide such a framework, I harnessed the deployment of 5G-the latest generation of cellular network technology. Specifically, I conducted a multiverse analysis using a representative population sample in Switzerland (Study 1; N = 2,919 individuals between 15 and 94 years old), finding that interindividual differences in risk perceptions were strongly associated with hazard-related drivers (e.g., trust in the institutions regulating

5G, dread) and person-specific drivers (e.g., electromagnetic hypersensitivity)-and strongly predictive of people's policy-related attitudes (e.g., voting intentions). Further, a field experiment based on a national expert report on 5G (N = 839 individuals in a longitudinal sample between 17 and 79 years old) identified links between intraindividual changes in psychological drivers and perceived risk, thus highlighting potential targets for future policy interventions.

Excerpt

... three hazard-related drivers stood out in terms of their associations with interindividual differences in risk perceptions: Dread of 5G was strongly associated with higher risk perceptions, whereas trust in the institutions regulating 5G and objective knowledge about 5G were strongly associated with lower risk perceptions. Two more generic, person-specific drivers (electromagnetic hypersensitivity and gender) were further predictors of interindividual differences. Crucially, changes in risk perception that occurred within individuals across time were primarily associated with intraindividual changes in dread and trust, whereas changes in perceived benefit were primarily associated with intraindividual changes in trust and objective knowledge. Finally, people's policy-related attitudes proved to hinge strongly on perceived risk (inversely) and benefit (positively) as well as to be sensitive to respective changes in these two dimensions that occurred across time.

Open access paper: https://journals.sagepub.com/doi/10.1177/0956797621998312

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New Technique to Study the Effect of Fifth Generation (5G) Radiation Antenna on Human Body

G. G. Emam, G. M. Amer, W. A. Mohamed, K. A. Mustafa. New Technique to Study the Effect of Fifth Generation (5G) Radiation Antenna on Human Body. *2021 13th Biomedical Engineering International Conference (BMEiCON)*, 2021, pp. 1-12, doi: 10.1109/BMEiCON53485.2021.9745216.

Abstract

With the invention of the 5G network, the world has witnessed response to change in communication networks and is working on an unprecedented scale. This raises the question of whether high frequencies and constant exposure to nonparticulate radiation (EMF) radiation have a negative impact on human health. Some scientists believe that these waves don't cause effects on the physical body. In this paper, simulation was done by using MATLAB R2019a. To do this simulation the tissues were divided into 5 groups according to the type of tissues which are nerve, connective, epithelial and muscle tissues. The specific absorption rate (SAR) and power density (PD) in different frequencies (20, 30, 40, 60,70,S0,100 GHZ) for more than 40 tissues are calculated. The comparison is done with other researches which have used the same techniques but most of these papers used the effect of the above frequencies on two or three tissues. In this paper, about 40 types of tissue are used for the simulation, and the simulation results show that the nerve tissues are the most affected tissue.

Excerpt

Tissues have four major types which are connective tissues, nerve tissues, epithelial tissues, and muscle tissues. It is found that the nerve tissues are the most tissue affected by the chosen frequencies than other tissues understudy. The connective tissue and the epithelia tissue are affected by radiation in the same range. The least affected is muscle tissues. It was found that the breast fat is the most effective (affected) by radiation although it is epithelia tissues. We can refer to this as abnormal jump that we the breast fat is outside the body.

Conclusions

This article examines the influence of 5G networks on the human body. The importance of EMF exposure on various organs in downlinks at frequencies above 20 GHz is highlighted. Following the simulation, we discovered that 5G resulted in increased EMF exposure due to the usage of stronger directionality in electromagnetic beams and smaller cell size.

To do this simulation the tissues were divided into 5 groups according to the type of tissues which are nerve, connective, epithelial and muscle tissues. The specific absorption rate (SAR) and power density (PD) in different frequencies (20, 30, 40,60,70,80,100 GHZ) for more than 40 tissues are calculated. Results show that the nerve tissues are the most tissue affected by the chosen frequencies, then the connective tissues and the epithelia tissue, while muscle tissues were the least affected type.

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9745216&isnumber=9745198

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Occupational Exposures to Radiofrequency Electromagnetic Fields and the risk of cancer

Rohan Mate, Ken Karipidis, Michael Abramson, Geza Benke, Sarah Loughran. Occupational Exposures to Radiofrequency Electromagnetic Fields and the risk of cancer. Safety and Health at Work. Volume 13, Supplement:S207-S208. 2022. doi: 10.1016/j.shaw.2021.12.1400.

Abstract

Introduction: Previous cohort and case-control studies have investigated possible associations between occupational exposure to radiofrequency (RF) electromagnetic fields (EMF) and a range of cancers. The findings to date give no consistent evidence of a causal relation between occupational RF EMF exposure and cancer, however previous studies have too many deficiencies to rule out an association and further research is warranted. A key concern across all previous studies is the quality of the RF EMF exposure assessment.

Methods: We plan to overcome previous methodological shortcomings by applying a newly developed job exposure matrix (JEM) to three separate case-control studies investigating glioma, follicular lymphoma and multiple myeloma, respectively. We further plan to investigate the validity of the JEM by conducting personal exposure measurements of workers in the highest exposure occupations identified by the JEM. We will also investigate how the level of occupational RF EMF exposure correlates with the level of risk perception to environmental RF EMF exposure.

Results: Initial results from this long-term project will be presented on the possible risk of occupation RF EMF and cancer. We will also present initial results on the agreement between local measurements and the highest exposure occupations identified by the JEM.

Conclusion: Our investigation will add to the body of knowledge on whether occupational RF EMF is a risk factor for cancer outcomes.

https://www.sciencedirect.com/science/article/pii/S2093791121014992

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Low Intensity Electromagnetic Fields Act via Voltage-Gated Calcium Channel (VGCC) Activation to Cause Very Early Onset Alzheimer's Disease: 18 Distinct Types of Evidence

Martin L. Pall. Low Intensity Electromagnetic Fields Act via Voltage-Gated Calcium Channel (VGCC) Activation to Cause Very Early Onset Alzheimer's Disease: 18 Distinct Types of Evidence. Curr Alzheimer Res. 2022 Feb 2. doi: 10.2174/1567205019666220202114510.

Abstract

Electronically generated electromagnetic fields (EMFs) including those used in wireless communication such as cell phones, Wi-Fi and smart meters, are coherent, producing very high electric and magnetic forces which act on the voltage sensor of voltage-gated calcium channels to produce increases in intracellular calcium [Ca2+]i. The calcium hypothesis of Alzheimer's disease (AD) has shown that each of the important AD-specific and nonspecific causal elements are produced by excessive [Ca2+]i. [Ca2+]i acts in AD via excessive calcium signaling and the peroxynitrite/oxidative stress/inflammation pathway which are each elevated by EMFs. An apparent vicious cycle in AD involves amyloid-beta protein (Aβ) and [Ca2+]i. Three types of epidemiology each suggest EMF causation of AD including early onset AD. Extensive animal model studies show that low intensity EMFs cause neurodegeneration including AD, with AD animals having elevated levels of Aβ, amyloid precursor protein and BACE1. Rats exposed to pulsed EMFs every day are reported to develop universal or near universal very very very early onset neurodegeneration including AD; these findings are superficially similar to humans with digital dementia. EMFs producing modest increases in [Ca2+]i can also produce protective, therapeutic effects. The therapeutic pathway and peroxynitrite pathway inhibit each other. A summary of 18 different findings is provided, which collectively provide powerful evidence for EMF causation of AD. The author is concerned that smarter, more highly pulsed "smart" wireless communication may cause widespread very, very early onset AD in human populations.

https://pubmed.ncbi.nlm.nih.gov/35114921/

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Measurements of radiofrequency electromagnetic fields, including 5G, in the city of Columbia, SC, USA

Tarmo Koppel, Lennart Hardell. Measurements of radiofrequency electromagnetic fields, including 5G, in the city of Columbia, SC, USA. World Academy of Sciences Journal 4(3):23. 2022. doi: 10.3892/wasj.2022.157.

Abstract

The present study aimed to characterize the wireless infrastructure and public exposure to radiofrequency (RF) electromagnetic fields, including the sub-millimeter wave 5G, in the city center of Columbia, SC, USA. A downtown measurement route was designed to cover popular outdoor areas, including business, recreational and shopping areas. The route was measured five times during different days and times. An exposimeter, was used to cover all the main civilian wireless broadcasting and downlink sources in frequencies 88-5,850 MHz. The measurement route at the streets and squares calculated 1.240 V/m as a mean exposure (total as a sum of all frequency bands) and 6.867 V/m as all times maximum. The most common contributors to the exposure budget were bands FM US, 14DL, 27DL, 25DL and 66DL - mainly indicating 4G. The exposure levels were found to be 12-16% lower during weekends as compared to business hours ($P<0.001$). The spatial analysis of the field distribution revealed 15-20 hotspot areas. A number of hotspots were found where cell phone base station antennas were mounted on top of the utility poles and therefore positioned at low levels, close to street level. On the whole, the findings of the present study suggest that cell phone base station antennas should be distinct and noticeable, as this would assist individuals who need to limit their exposure by distancing themselves from RF sources.

Excerpt

In conclusion, in the city of Columbia, SC, USA, the present study determined that the highest exposure areas were due to two reasons: i) Cell phone base station antennas on top of high-rise buildings provide good cell coverage reaching far away, but creating elevated public exposure to the RF RMFs at the immediate vicinity; and ii) cell phone base station antennas installed on top of the utility poles have placed the radiation source closer to humans walking on the street level.

RF exposure levels from mobile phone base station antennas near the street level reached high levels. It is thus recommended, that all such close proximity transmitters should be labeled with relevant signs to warn of high RF exposure in the area (24). Cell phone base station antennas should be distinct and noticeable so that people who need to limit their exposure, have been given a chance to do so by distancing themselves from the RF sources. Considering the current trend of cell phone service providers expanding their 5G network, more utility pole base station antennas are expected. Consequently, the public exposure is also likely to increase in the coming years.

Open access paper: https://www.spandidos-publications.com/10.3892/wasj.2022.157

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Physiological changes and symptoms associated with short-term exposure to electromagnetic fields: a randomized crossover provocation study

Po-Chang Huang, Jui-Chin Chiang, Ya-Yun Cheng, Tain-Junn Cheng, Chien-Yuan Huang, Ya-Ting Chuang, Ti Hsu, How-Ran Guo. Physiological changes and symptoms associated with short-term exposure to electromagnetic fields: a randomized crossover provocation study. Environ Health. 2022 Mar 8;21(1):31. doi: 10.1186/s12940-022-00843-1.

Abstract

Background: The biological association between electromagnetic fields (EMF) and idiopathic environmental intolerance attributed to EMF (IEI-EMF) has not been established. To assess the physiological changes and symptoms associated with exposure to EMF, we conducted a randomized crossover provocation study.

Methods: We recruited 58 individuals with IEI-EMF (IEI-EMF group) and 92 individuals without IEI-EMF (control group). In a controlled environment, all participants received EMF signals mimicking those from mobile phone base stations in a randomized sequence under the blinded condition. During the course, participants reported their symptoms and whether they perceived EMF, and we monitored their physiological parameters, including blood pressure (BP), heart rate (HR), and HR variability.

Results: The IEI-EMF and control groups reported similar frequencies of symptoms during both the provocation and sham sessions. No participant could accurately identify the provocation. In both groups, physiological parameters were similar between the two sessions. The control group, but not the IEI-EMF group, had elevated HR when they perceived EMF exposure.

Conclusions: No symptoms or changes in physiological parameters were found to be associated with short-term exposure to EMF, and no participant could accurately detect the presence of EMF. Moreover, the participants in the control group, but not those in the IEI-EMF group, had elevated HR when they perceived EMF.

Open access paper: https://ehjournal.biomedcentral.com/articles/10.1186/s12940-022-00843-1

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Longitudinal study of exposure to radio frequencies at population scale

Yanis Boussad, Xi (Leslie) Chen, Arnaud Legout, Augustin Chaintreau, Walid Dabbous. Longitudinal study of exposure to radio frequencies at population scale. Environment International. Volume 162, 2022. doi: 10.1016/j.envint.2022.107144.

Abstract

Evaluating exposure to radio frequencies (RF) at population-scale is important for conducting sound epidemiological studies about possible health impact of RF radiations. Numerous studies reported population exposure to RF radiations used in wireless telecommunication technologies, but used very small population samples. In this context, the real exposure of the population at scale remains poorly understood. Here, to the best of our knowledge, we report the largest crowd-based measurement of population exposure to RF produced by cellular antennas, Wi-Fi access points, and Bluetooth devices for 254,410 unique users in 13 countries from January 2017 to December 2020. First, we present methods to assess the population exposure to RF radiations using smartphone measurements obtained using the ElectroSmart Android app. Then, we use these methods to evaluate and characterize the evolution of RF exposure. We show that total exposure has been multiplied by 2.3 in the four-year period considered, with Wi-Fi as the largest contributor. The cellular exposure levels are orders of magnitude lower than regulation limits and are not correlated to national regulation policies. The population

tends to be more exposed at home; for half of the study subjects, personal Wi-Fi routers and Bluetooth devices contributed to more than 50% of their total exposure. In this work, we showcase how crowdsource-based data allow large-scale and long-term assessment of population exposure to RF radiations.

Excerpts

Limitations

... First, **we only measured the downlink received** by the measuring smartphone. Therefore, **the contribution of the uplink to the exposure, that is, the emission of the measuring smartphone, is not considered** in this study. Also, we did not measure the uplink of surrounding devices....Second, the minimum and maximum measurable power for each wireless technology is capped by the Android API and the technology standards....Third, for 2G, 3G, and 4G, the RSSI is provided by the Android API as an *Arbitrary Strength Unit* (ASU), an integer value between 0 and 31. It is converted to dBm....Fourth, each wireless technology comes with some additional limitations....Fifth, the received power was measured using the Received Signal Strength Indicator (RSSI). Therefore, our measurements do not take into account the effective load of the wireless channel....Last, ElectroSmart can only measure radio frequencies produced by Wi-Fi access points, Bluetooth devices and cell towers. It does not measure radio frequencies emitted by other sources such as FM radio or TV ...

Conclusion

In this paper, we presented the largest crowd-based measurement of population exposure to RF produced by cellular antennas, Wi-Fi access points, and Bluetooth devices for 254,410 unique users in 13 countries from January 2017 to December 2020. We showcased the strength of using crowdsource data from mobile smartphones in performing a large-scale and long-term assessment of population exposure to RF radiations. This enabled us to assess the impact of various factors on the exposure using a uniform methodology, which facilitates cross-population and cross-environment analysis. We showed that total exposure has been multiplied by 2.3 in the four-year period considered, with Wi-Fi as the largest contributor. The cellular exposure levels are orders of magnitude lower than regulation limits and are not correlated to national regulation policies. The population tends to be more exposed at home; for half of the study subjects, personal Wi-Fi routers and Bluetooth devices contributed to more than 50% of their total exposure.

An interesting next step would be to consider how the deployment of 5G impacts population exposure. Indeed, in this study, we did not consider 5G as its deployment in the considered countries was small and few smartphones supported 5G before 2021. 5G comes with its own challenges for the evaluation of exposure: it uses small cells, millimeter waves, and beam forming, which changes exposure during transmission. This will undoubtedly be a challenge to correctly characterize exposure to 5G.

Open access paper: https://www.sciencedirect.com/science/article/pii/S0160412022000708

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Methodology for determining the threshold distance for estimating the main EM exposure contribution in WLAN

Marta Fernández, David Guerra. Methodology for determining the threshold distance for estimating the main EM exposure contribution in WLAN. Engineering Science and Technology, an International Journal. Volume 25, 2022, 100997, doi: 10.1016/j.jestch.2021.05.001.

Abstract

The location of radiation sources in wireless networks is a key factor to characterize their contribution to electromagnetic exposure levels in order to deploy future networks that account for minimizing electromagnetic field levels. In relation to wireless local area networks, considering that mobile communication devices comply with the SAR (Specific Absorption Rate) limits imposed by the international standardization organizations for preserving human health, the interest is nowadays focused on the signal levels coming from the WiFi access points. This paper presents a methodology to determine the threshold distance at which the field strength levels from the AP are negligible in comparison with the radiation generated by a user equipment. The theoretical concepts, which can be applied to other technologies, were implemented by means of simulations and experimental measurements. For the simulations, actual WiFi antennas were modelled. Experimental measurements completed the results obtained in simulations, resulting in a greater number of real situations. Results showed that the threshold distance depends on the WiFi standard employed by the devices connected to the network.

https://www.sciencedirect.com/science/article/pii/S2215098621001099

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Directed-Energy Weapons Research Becomes Official [Health Matters]

J. C. Lin. Directed-Energy Weapons Research Becomes Official [Health Matters]. *IEEE Microwave Magazine*, 23(4):13-90, April 2022, doi: 10.1109/MMM.2021.3136666.

Abstract

The incidents of sonic attacks on diplomatic personnel in Havana, Cuba, will likely remain a mystery until a culprit is found in the act. The one-time diplomatic affair, the Havana Syndrome, has apparently morphed into a weapons research program in the United States [1]. Indeed, it appears that research in high-power microwaves has persisted worldwide including that undertaken by some of the major military powers [2], [3].

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9724666&isnumber=9724626

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Response to the Letter by Foster, Chou, and Croft [Speaker's Corner]

J. C. Lin. Response to the Letter by Foster, Chou, and Croft [Speaker's Corner]. IEEE Microwave Magazine, 23(4): 95, April 2022, doi: 10.1109/MMM.2022.3147174.

Abstract

I appreciate the letter from Foster, Chou, and Croft expressing their concerns about my recent article on health safety guidelines for RF exposures [1]. The letter is understandable, given its authors strong convictions that there is nothing but heat to worry about with RF exposure. In the interest of clarity, I will respond to the writers' three points in their order of presentation.

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9724675&isnumber=9724626

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Exposure to 1800 MHz LTE electromagnetic fields under proinflammatory conditions decreases the response strength and increases the acoustic threshold of auditory cortical neurons

Samira Souffi, Julie Lameth, Quentin Gaucher, Délia Arnaud-Cormos, Philippe Lévêque, Jean-Marc Edeline, Michel Mallat. Exposure to 1800 MHz LTE electromagnetic fields under proinflammatory conditions decreases the response strength and increases the acoustic threshold of auditory cortical neurons. Sci Rep. 2022 Mar 8;12(1):4063. doi: 10.1038/s41598-022-07923-9.

Abstract

Increased needs for mobile phone communications have raised successive generations (G) of wireless technologies, which could differentially affect biological systems. To test this, we exposed rats to single head-only exposure of a 4G long-term evolution (LTE)-1800 MHz electromagnetic field (EMF) for 2 h. We then assessed the impact on microglial space coverage and electrophysiological neuronal activity in the primary auditory cortex (ACx), under acute neuroinflammation induced by lipopolysaccharide. The mean specific absorption rate in the ACx was 0.5 W/kg. Multiunit recording revealed that LTE-EMF triggered reduction in the response strength to pure tones and to natural vocalizations, together with an increase in acoustic threshold in the low and medium frequencies. Iba1 immunohistochemistry showed no change in the area covered by microglia cell bodies and processes. In healthy rats, the same LTE-exposure induced no change in response strength and acoustic threshold. Our data indicate that acute neuroinflammation sensitizes neuronal responses to LTE-EMF, which leads to an altered processing of acoustic stimuli in the ACx.

Excerpt

In conclusion, our study reveals that a single head-only exposure to LTE-1800 MHz can interfere with the neuronal responses of cortical neurons to sensory stimuli. In line with previous characterizations of the effect of GSM-signal, our results show that the impact of LTE signal on neuronal activity varies according to the health state. Acute neuroinflammation sensitize neuronal responses to LTE-1800 MHz, resulting in altered cortical processing of auditory stimuli.

Open access paper: https://www.nature.com/articles/s41598-022-07923-9

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Changes in the excitability of primary hippocampal neurons following exposure to 3.0 GHz radiofrequency electromagnetic fields

Ibtissam Echchgadda, Jody C Cantu, Gleb P Tolstykh, Joseph W Butterworth, Jason A Payne, Bennett L Ibey. Changes in the excitability of primary hippocampal neurons following exposure to 3.0 GHz radiofrequency electromagnetic fields. Sci Rep. 2022 Mar 3;12(1):3506. doi: 10.1038/s41598-022-06914-0.

Abstract

Exposures to radiofrequency electromagnetic fields (RF-EMFs, 100 kHz to 6 GHz) have been associated with both positive and negative effects on cognitive behavior. To elucidate the mechanism of RF-EMF interaction, a few studies have examined its impact on neuronal activity and synaptic plasticity. However, there is still a need for additional basic research that further our understanding of the underlying mechanisms of RF-EMFs on the neuronal system. The present study investigated changes in neuronal activity and synaptic transmission following a 60-min exposure to 3.0 GHz RF-EMF at a low dose (specific absorption rate (SAR) < 1 W/kg). We showed that RF-EMF exposure decreased the amplitude of action potential (AP), depolarized neuronal resting membrane potential (MP), and increased neuronal excitability and synaptic transmission in cultured primary hippocampal neurons (PHNs). The results show that RF-EMF exposure can alter neuronal activity and highlight that more investigations should be performed to fully explore the RF-EMF effects and mechanisms.

Excerpt

In conclusion, our study does not provide sufficient evidence to support nor to refute RF-EMF non-thermal mechanism of interaction. However, the results described here are consistent with previous in vitro studies of influence of RF-EMF exposure on neuronal activity. Moreover, although our investigation of RF-EMF effects is on a simple cultured system, and thus cannot directly correlate to human level responses, the results appear to support the implication of changes of neuronal activity as a cellular mechanism that could potentially underlie RF-EMF mediated changes in cognitive function. Future studies need to compare changes from other conditions including, SAR dose–response, short, repetitive or long-term exposure duration, CW or pulsed signals, as well as verify the duration or recovery of the effects, as reversible electrophysiological changes can occur without adverse health effects.

Open access paper: https://www.nature.com/articles/s41598-022-06914-0

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Measurement and Prediction of Electromagnetic Radiation Exposure Level in a University Campus

Esin Karpat, M. Rafet Bakcan. Measurement and Prediction of Electromagnetic Radiation Exposure Level in a University Campus. Tehnički vjesnik, Vol. 29 No. 2, 2022. doi: 10.17559/TV-20200418183308.

Abstract

The importance of electromagnetic (EM) sources in human life has been increasing with the development of technology. EM radiation triggers some problems in our life such as EM interference and human health problems. EM radiation level which is emitted by the base station increases in proportion to the density of population in a region. EM exposure is higher in areas where people are highly concentrated such as hospitals, military barracks, schools, shopping malls, than in any other region. It is important to show sustained concern about the EM radiation intensity in these areas to keep the levels under the permissible limits. In this study, electric field values are measured statically at locations where the population density is too high, to examine the electric field intensity levels throughout the campus. Besides, two different artificial neural models (ANN) are developed to estimate the electric field values of random locations which are specific regions for electromagnetic exposure. Moreover, measurement results and estimated results are evaluated within the limits defined by national (ICTA) and international (ICNIRP) standards. Finally, the EM exposure map is constructed with data that is average electric field intensity versus measurement locations.

Excerpt

Measurements in the campus show that the maximum EMF value is 4.314 V/m while the minimum is 0.084 V/m. Also, the standard deviation value of the EMF level is 1.157 V/m while the average EMF level is 1.024 V/m. The average electric value measured around two base stations on the campus is 3.85 V/m while the average electric field value of other locations is 1.153 V/m.

According to these data, it is determined that the contribution of locations, which are near the base station is approximately 300% higher than the other locations.

Open access paper: https://hrcak.srce.hr/272595

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Near Field Radio Frequency Electromagnetic Field Exposure of a Western Honey Bee

D. Toribio, W. Joseph, A. Thielens. Near Field Radio Frequency Electromagnetic Field Exposure of a Western Honey Bee. *IEEE Transactions on Antennas and Propagation*. 70(2): 1320-1327. Feb. 2022, doi: 10.1109/TAP.2021.3111286.

Abstract

It has been suggested that the wireless network evolution to smaller carrier wavelengths (from 2G to 5G) increases radio frequency electromagnetic field (RF-EMF) absorption in western honey bees (*Apis mellifera*). It is unknown whether the radiation performance of antennas is stable when an insect appears in their vicinity. In this research, the absorbed power in a worker honey bee and the influence of the bee's presence on antennas' radiation performance are investigated for the newly used frequencies in 5G networks from 6 to 240 GHz. To these aims, numerical simulations using the finite-difference time-domain (FDTD) method were performed, in

which a bee model, obtained by micro-CT scanning, was employed. These simulations showed that, in the near field, the absorbed power can increase by a factor of 53 from 6 to 240 GHz. This is a factor of 7 higher than the increase reported in the far-field in previous studies. Furthermore, the simulations revealed that antennas' radiation efficiency can decrease by up to −40% when a bee appears in the near field. Likewise, it was found that the gain pattern depends on the separation distance between the bee and the antenna with a stronger dependency for higher frequencies.

Conclusion

Numerical simulations using FDTD analysis were executed to calculate the RF-EMFs in and around a worker Western Honey Bee (Apis mellifera). This lead to the quantification of the whole-body averaged absorbed radio-frequency power Pabs, under near-field exposure, in the frequency range of 6–240 GHz. The simulations showed that, in the near field, Pabs decreases as the separation distance between the bee and the dipole increases and increases as frequency increases. The frequency behavior of Pabs in the near field is, thus, different from its far field behavior, since, for a given accepted power and distance, in the near field Pabs increases with frequency (an average of 30.5 dB from 6 to 240 GHz), while, in the far field, Pabs in the worker bee is maximized at 12 GHz. This near-field increase in Pabs as a function of frequency can be a factor of 7 higher than the far-field increase.

Moreover, these simulations allowed the study of the influence of the bee's position (0.1λ –10λ from the dipoles) in the radiation performance of the dipoles. In particular, it was found that, as the separation distance increases, the dipoles' isotropic gain decreases and approaches their free-space gain. Also, it was noted that, as a result of the near-field frequency behavior of Pabs, the dipoles' radiation efficiency decreases with increasing frequency and increases with increasing separation distance. In addition, it was acknowledged that the gain pattern in the direction where the bee approaches the antenna depends on the separation distance between the bee and the antenna with a stronger dependency for higher frequencies. This is important for 5G telecommunication networks because they rely on infrastructure (antennas) whose performance can be influenced by the presence of free-flying insects.

Future directions of this research project will include the experimental validation of the results from the simulations presented in this article by completing near-field RF-EMF exposure measurements of honey bees. Furthermore, the RF-EMF interactions between honey bees and phased arrays will be investigated since these are the type of antennas being deployed in high-frequency telecommunication networks. In addition, we aim to investigate the thermal increase in the bee due to near-field and far-field RF-EMF exposure, as a function of frequency, for instance, by means of infrared temperature measurements. Moreover, future work will also consist of performing simulations with heterogeneous honey bee phantoms with tissue-specific dielectric properties.

https://ieeexplore.ieee.org/document/9539081

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Effect Exposure of Mobile Phone Radiation on Blood Parameters in Rats

Al Abas, MAA, AL-Hakkak, ZMM (2021). Effect Exposure of Mobile Phone Radiation on Blood Parameters in Rats. *Iraqi Journal of Science. 62*(11): 4225–4231. doi: 10.24996/ijs.2021.62.11(SI).2.

Abstract

The aim of the research was to assess effects of short and long-period exposure to radiation from mobile phone on blood indices in experimental rats. In this study forty mature female rats were used; the animals were divided into two experimental group, each group consists of twenty animals. Short-period group of rats were exposed to cell phone radiation for different duration 30 m, 60 m, and 90 m per day for six weeks. Long-period group of rats were exposed to radiation from mobile phone for different duration 2h, 4h, and 6h per day for three months. The study noticed that there was significant (P≥0.05) elevation in total white blood cells and the study demonstrated significant increment (P≥0.05) in percentage of lymphocytes (71.1%) of rats which exposed to radiation from mobile phone for short-period in (90 minutes) compared to the control group (42.64%). While the study revealed that there was a significantly (P≥0.05) lower percentage of neutrophils (15.36%) in rats that were exposed to mobile phone radiation for long-period in (6 hours) compared with the control group (52.12%).The study recorded that there was a significant (P≥0.05) elevation in total red blood corpuscles and packed cell volume of rats exposed to radiation from mobile phone for short and long-period in different times compared with control. On the other hand, the research indicated that there was a significant (p≤0.05) decrement in mean corpuscles volume (MCV), mean corpuscle hemoglobin (MCH), mean corpuscle hemoglobin concentration and red blood cell distribution width standard deviation (RDW-SD) of rats to radiation from mobile phone for short and long-period in different times than control group.

Conclusions

It can be concluded that hematological parameters of rats were significantly affected after short and long-period exposure to radiation from mobile phone. The hematological analysis showed a significant elevation in values of white blood cells, lymphocytes, total red blood corpuscles and packed cell volume of rats after exposure to short and long-period to electromagnetic radiation from mobile phone. However, the study confirms that values of mean corpuscles volume and mean corpuscle hemoglobin concentration and red blood cell distribution width standard deviation were significantly decreased in rats after exposure to mobile phone electromagnetic radiation.

Open access paper: https://ijs.uobaghdad.edu.iq/index.php/eijs/article/download/3742/1879

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Exposure to 1.8 GHz radiofrequency field modulates ROS in human HEK293 cells as a function of signal amplitude

Marootpong Pooam, Nathalie Jourdan, Blanche Aguida, Cyril Dahon, Soria Baouz, Colin Terry, Haider Raad, Margaret Ahmad. Exposure to 1.8 GHz radiofrequency field modulates ROS in human HEK293 cells as a function of signal amplitude. Communicative & Integrative Biology, 15:1, 54-66, 2022, doi: 10.1080/19420889.2022.2027698.

Abstract

The modern telecommunications industry is ubiquitous throughout the world, with a significant percentage of the population using cellular phones on a daily basis. The possible physiological consequences of wireless emissions in the GHz range are therefore of major interest, but remain poorly understood. Here, we show that exposure to a 1.8 GHz carrier frequency in the amplitude range of household telecommunications induces the formation of ROS (Reactive Oxygen Species) in human HEK293 cultured cells. The ROS concentrations detected by fluorescent imaging techniques increased significantly after 15 minutes of RF field exposure, and were localized to both nuclear and cytosolic cellular compartments. qPCR analysis showed altered gene expression of both anti-oxidative (SOD, GPX, GPX, and CAT) and oxidative (Nox-2) enzymes. In addition, multiple genes previously identified as responsive to static magnetic fields were found to also be regulated by RF, suggesting common features in response mechanisms. By contrast, many RF effects showed evidence of hormesis, whereby biological responsivity does not occur linearly as a function of signal amplitude. Instead, biphasic dose response curves occur with 'blind' spots at certain signal amplitudes where no measureable response occurs. We conclude that modulation of intracellular ROS can be a direct consequence of RF exposure dependent on signal frequency and amplitude. Since changes in intracellular ROS may have both harmful and beneficial effects, these could provide the basis for many reported physiological effects of RF exposure.

Conclusion

In conclusion, we show that exposure to RF within the amplitude range emitted by household telecommunication devices can have a direct and immediate physiological effect on cellular ROS biosynthesis and signaling. This response is dependent in complex ways on RF signal amplitude, consistent with a biological receptor mediated process. The response to RF further shares common features with modulation of ROS by static magnetic fields. Since ROS regulates oxidative stress and cellular signaling and response pathways, our results provide a possible mechanistic explanation for the many different reported physiological effects of RF in the literature.

https://www.tandfonline.com/doi/full/10.1080/19420889.2022.2027698

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Gender differences in effects of prenatal and postnatal exposure to electromagnetic field and prenatal zinc on behaviour and synaptic proteins in rats

Burcu Acikgoz, Nevin Ersoy, Ilkay Aksu, Amac Kiray, Husnu Alper Bagriyanik, Muge Kiray. Gender differences in effects of prenatal and postnatal exposure to electromagnetic field and prenatal zinc on behaviour and synaptic proteins in rats. J Chem Neuroanat. 2022 Mar 29;122:102092. doi: 10.1016/j.jchemneu.2022.102092.

Highlights

• Electromagnetic field **(**EMF) exposure may affect the levels of synaptic proteins in the developing brain.
• EMF exposure has no effect on social behaviour but may affect activity and anxiety.
• Zinc supplementation has a partially positive effect on female, but not male rats.

Abstract

Humans are exposed to electromagnetic fields (EMF) from various sources throughout life. Because humans are easily impacted by environmental factors during early development, it is believed that EMF can cause structural and functional changes on the developing brain that may lead to behavioural changes. This paper investigates the impact of EMF exposure and zinc supplementation during the prenatal and postnatal periods on behavioural changes and synaptic proteins in a gender-dependent manner. Pups from four groups of pregnant rats were used: Sham, EMF (5 days/wk, 4 h/day EMF-exposure applied), Sham+Zinc (5 days/wk, 5 mg/kg/day zinc applied) and EMF+Zinc (5 days/wk, 4 h/day EMF-exposure and 5 mg/kg/day zinc applied). EMF exposure and zinc supplementation were initiated from the first day of pregnancy to the 42nd postnatal day. Zinc levels in blood, NLGN3 and SHANK3 levels in hippocampus and amygdala, and synaptic structures in amygdala were examined. Behavioural tests showed that EMF exposure had no effect on social behaviour, but adversely affected activity and exploratory behaviour, and led to increased anxiety formation. Zinc supplementation had a partially positive effect on female, but not male offspring. SHANK3 and NLGN3 proteins were significantly lower in EMF groups, however, no positive effect of zinc supplementation was found. In conclusion, EMF exposure may alter the levels of synaptic proteins in the developing brain, leading to behavioural changes in a gender-dependent manner. Evaluation of zinc supplementation at different doses could be beneficial to prevent or reduce the behavioural and structural effects of EMF.

https://pubmed.ncbi.nlm.nih.gov/35364275/

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Long-Term Wi-Fi Exposure From Pre-Pubertal to Adult Age on the Spermatogonia Proliferation and Protective Effects of Edible Bird's Nest Supplementation

Farah Hanan Fathihah Jaffar, Khairul Osman, Chua Kien Hui, Aini Farzana Zulkefli, Siti Fatimah Ibrahim. Long-Term Wi-Fi Exposure From Pre-Pubertal to Adult Age on the Spermatogonia Proliferation and Protective Effects of Edible Bird's Nest Supplementation. Front Physiol. 2022 Mar 11;13:828578. doi: 10.3389/fphys.2022.828578.

Abstract

Children are vulnerable to the radiofrequency radiation (RFR) emitted by Wi-Fi devices. Nevertheless, the severity of the Wi-Fi effect on their reproductive development has been sparsely available. Therefore, this study was conducted to evaluate the Wi-Fi exposure on spermatogonia proliferation in the testis. This study also incorporated an approach to attenuate the effect of Wi-Fi by giving concurrent edible bird's nest (EBN) supplementation. It was predicted that Wi-Fi exposure reduces spermatogonia proliferation while EBN supplementation protects against it. A total of 30 (N = 30) 3-week-old Sprague Dawley weanlings were divided equally into five groups; Control, Control EBN, Wi-Fi, Sham Wi-Fi, and Wi-Fi + EBN. 2.45 GHz Wi-Fi exposure and 250 mg/kg EBN supplementation were conducted for 14 weeks. Findings showed that the Wi-Fi group had decreased in spermatogonia mitosis status. However, the mRNA and protein expression of c-Kit-SCF showed no significant decrease. Instead, the reproductive hormone showed a reduction in FSH and LH serum levels. Of these, LH serum level was decreased significantly in the Wi-Fi group. Otherwise, supplementing the Wi-Fi + EBN group with 250 mg/kg EBN resulted in a significant increase in spermatogonia mitotic status. Even though EBN supplementation improved c-Kit-SCF mRNA and protein expression, the effects were insignificant. The

improvement of spermatogonia mitosis appeared to be associated with a significant increase in blood FSH levels following EBN supplementation. In conclusion, the long-term Wi-Fi exposure from pre-pubertal to adult age reduces spermatogonia proliferation in the testis. On the other hand, EBN supplementation protects spermatogonia proliferation against Wi-Fi exposure.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8963498/

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Exposure to magnetic fields and childhood leukemia: a systematic review and meta-analysis of case-control and cohort studies

Christian Brabant, Anton Geerinck, Charlotte Beaudart, Ezio Tirelli, Christophe Geuzaine and Olivier Bruyère. Exposure to magnetic fields and childhood leukemia: a systematic review and meta-analysis of case-control and cohort studies. *Reviews on Environmental Health*. Published online March 15, 2022. doi: 10.1515/reveh-2021-0112.

Abstract

The association between childhood leukemia and extremely low frequency magnetic fields (ELF-MF) generated by power lines and various electric appliances has been studied extensively during the past 40 years. However, the conditions under which ELF-MF represent a risk factor for leukemia are still unclear. Therefore, we have performed a systematic review and meta-analysis to clarify the relation between ELF-MF from several sources and childhood leukemia. We have systematically searched Medline, Scopus, Cochrane Database of Systematic Review and DARE to identify each article that has examined the relationship between ELF-MF and childhood leukemia. We have performed a global meta-analysis that takes into account the different measures used to assess magnetic field exposure: magnetic flux density measurements (<0.2 μT vs. >0.2 μT), distances between the child's home and power lines (>200 m vs. <200 m) and wire codings (low current configuration vs. high current configuration). Moreover, meta-analyses either based on magnetic flux densities, on proximity to power lines or on wire codings have been performed. The association between electric appliances and childhood leukemia has also been examined. Of the 863 references identified, 38 studies have been included in our systematic review. Our global meta-analysis indicated an association between childhood leukemia and ELF-MF (21 studies, pooled OR=1.26; 95% CI 1.06–1.49), an association mainly explained by the studies conducted before 2000 (earlier studies: pooled OR=1.51; 95% CI 1.26–1.80 vs. later studies: pooled OR=1.04; 95% CI 0.84–1.29). Our meta-analyses based only on magnetic field measurements indicated that the magnetic flux density threshold associated with childhood leukemia is higher than 0.4 μT (12 studies, >0.4 μT: pooled OR=1.37; 95% CI 1.05–1.80; acute lymphoblastic leukemia alone: seven studies, >0.4 μT: pooled OR=1.88; 95% CI 1.31–2.70). Lower magnetic fields were not associated with leukemia (12 studies, 0.1–0.2 μT: pooled OR=1.04; 95% CI 0.88–1.24; 0.2–0.4 μT: pooled OR=1.07; 95% CI 0.87–1.30). Our meta-analyses based only on distances (five studies) showed that the pooled ORs for living within 50 m and 200 m of power lines were 1.11 (95% CI 0.81–1.52) and 0.98 (95% CI 0.85–1.12), respectively. The pooled OR for living within 50 m of power lines and acute lymphoblastic leukemia analyzed separately was 1.44 (95% CI 0.72–2.88). Our meta-analyses based only on wire codings (five studies) indicated that the pooled OR for the very high current configuration (VHCC) was 1.23 (95% CI 0.72–2.10). Finally, the risk of childhood leukemia was increased after exposure to electric blankets (four studies, pooled OR=2.75; 95% CI 1.71–4.42) and, to a lesser extent, electric clocks (four studies, pooled OR=1.27; 95% CI 1.01–1.60). Our results suggest that ELF-MF higher than 0.4 μT can increase the risk of developing leukemia in children, probably acute lymphoblastic leukemia. Prolonged exposure to electric appliances that

generate magnetic fields higher than 0.4 μT like electric blankets is associated with a greater risk of childhood leukemia.

Excerpt

Our results have practical implications. Our meta-analysis suggests that exposure to residential magnetic fields higher than 0.4 μT can increase the risk of leukemia in children. Nevertheless, it is important to emphasize the fact that very few homes are exposed to magnetic fields higher than 0.4 μT generated by overhead power lines in high income countries [11, 30]. Moreover, the annual incidence of childhood leukemia is very low and ranges between 35 and 50 cases per million children in western European countries and North America [69]. Since the absolute risk of childhood leukemia is very low and children are rarely continuously exposed to magnetic fields higher than 0.4 μT in high income countries, the increased leukemia risk found in our meta-analysis does not represent a major public health concern in these countries. Magnetic flux densities higher than 0.4 μT are usually within 50 m of overhead power lines [11] even if Crespi et al. [30] found some subjects living between 50 and 200 m away from overhead power lines (over 200 kV) that were exposed to ELF-MF higher than 0.4 μT. Magnetic flux density measurements should be performed if children live within 200 m of overhead power lines to guarantee that they are not exposed to ELF-MF higher than 0.4 μT. In contrast, living more than 200 m away from overhead power lines could be considered a safe distance for children that is not linked to a higher leukemia risk. Our systematic review suggests that children from middle income countries like Mexico and Iran are more likely to be exposed to magnetic fields above 0.4 μT and the risk of leukemia attributable to ELF-MF is probably higher in these countries. It is noteworthy that none of the studies included in our review have been performed in low income countries or in Africa. More research on ELF-MF and childhood leukemia is needed in these countries, particularly in African countries.

Our meta-analyses suggest that exposure to electric appliances like electric blankets and bedside electric clocks increase the risk of leukemia in children. However, it is important to note that the studies that have found an association between these electric appliances and childhood leukemia have been performed more than 20 years ago and our findings should be interpreted based on the electric equipment used today. Electric blankets and bedside electric clocks used at the end of the twentieth century could generate magnetic fields higher than 0.4 μT and children were typically exposed to these electric appliances during several hours in a row [67]. In contrast, hair dryers can also generate magnetic fields higher than 0.4 μT but are usually used during a shorter period of time [67] and we did not find a significant association between the use of hair dryers and childhood leukemia. These findings are relevant today in the sense that the duration of exposure to ELF-MF plays a role and that children should not be exposed to electric appliances that generate magnetic fields higher than 0.4 μT during long periods of time. Importantly, Magne and colleagues [70] have measured personal exposure to ELF-MF in French children between 2007 and 2009. They have found that alarm clocks were the main variable linked to the magnetic field exposure of the children. The proportion of children exposed to magnetic fields higher than 0.4 μT was 3.1% when all children were included in the analysis and 0.8% when the analysis was restricted to children for which no alarm clock had been identified. Taken together, these results and ours suggest that “bedside” electric clocks and alarm clocks that generate magnetic fields higher than 0.4 μT at close distance should be located at least 1 m away from the bed of the child, because the magnetic flux density generated by electric clocks was lower than 0.4 μT at this distance in the study by Preece et al. [71]. To the best of our

knowledge, there is no recent update of the study by Behrens et al. [67] that has performed reliable magnetic flux density measurements for electric appliances manufactured recently that generate ELF-MF. Studies with reliable exposure characterization with respect to sources of ELF-MF are needed, especially for the electric appliances manufactured recently that we use on a daily basis.

In summary, our study suggests that exposure to ELF-MF higher than 0.4 µT increases the risk of developing leukemia in children. Acute lymphoblastic leukemia is probably the subtype of leukemia associated with ELF-MF. Prolonged exposure to electric appliances that generate magnetic fields higher than 0.4 µT like electric blankets is associated with a more elevated risk of childhood leukemia. The distance from power lines linked to leukemia is difficult to determine but living more than 200 m away from power lines is likely a safe distance for children not associated with a higher leukemia risk.

https://pubmed.ncbi.nlm.nih.gov/35302721/

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Magnetic Fields and Cancer: Epidemiology, Cellular Biology, and Theranostics

Massimo E Maffei. Magnetic Fields and Cancer: Epidemiology, Cellular Biology, and Theranostics. *International Journal of Molecular Sciences*. 2022; 23(3):1339. doi: 10.3390/ijms23031339.

(This article belongs to the Special Issue The Effect of Magnetic Fields on Living Organisms: Biomolecular and Cellular Mechanisms)

Abstract

Humans are exposed to a complex mix of man-made electric and magnetic fields (MFs) at many different frequencies, at home and at work. Epidemiological studies indicate that there is a positive relationship between residential/domestic and occupational exposure to extremely low frequency electromagnetic fields and some types of cancer, although some other studies indicate no relationship. In this review, after an introduction on the MF definition and a description of natural/anthropogenic sources, the epidemiology of residential/domestic and occupational exposure to MFs and cancer is reviewed, with reference to leukemia, brain, and breast cancer. The in vivo and in vitro effects of MFs on cancer are reviewed considering both human and animal cells, with particular reference to the involvement of reactive oxygen species (ROS). MF application on cancer diagnostic and therapy (theranostic) are also reviewed by describing the use of different magnetic resonance imaging (MRI) applications for the detection of several cancers. Finally, the use of magnetic nanoparticles is described in terms of treatment of cancer by nanomedical applications for the precise delivery of anticancer drugs, nanosurgery by magnetomechanic methods, and selective killing of cancer cells by magnetic hyperthermia. The supplementary tables provide quantitative data and methodologies in epidemiological and cell biology studies. Although scientists do not generally agree that there is a cause-effect relationship between exposure to MF and cancer, MFs might not be the direct cause of cancer but may contribute to produce ROS and generate oxidative stress, which could trigger or enhance the expression of oncogenes.

Open access paper: https://www.mdpi.com/1422-0067/23/3/1339

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Pooled analysis of recent studies of magnetic fields and childhood leukemia

Aryana T. Amoon, John Swanson, Corrado Magnani, Christoffer Johansen, Leeka Kheifets. Pooled analysis of recent studies of magnetic fields and childhood leukemia. Environmental Research. Volume 204, Part A, 2022. doi: 10.1016/j.envres.2021.111993.

Abstract

Background Over forty epidemiologic studies have addressed an association between measured or calculated extremely-low-frequency magnetic fields (MF) and childhood leukemia. These studies have been aggregated in a series of pooled analyses, but it has been 10 years since the last such.

Methods We present a pooled analysis combining individual-level data (24,994 cases, 30,769 controls) from four recent studies on MF and childhood leukemia.

Results Unlike previous pooled analyses, we found no increased risk of leukemia among children exposed to greater MF: odds ratio (OR) = 1.01, for exposure ≥0.4 μT (μT) compared with exposures <0.1 μT. Similarly, no association was observed in the subset of acute lymphoblastic leukemia, birth homes, studies using calculated fields, or when geocoding accuracy was ignored. In these studies, there is a decline in risk over time, also evident when we compare three pooled analyses. A meta-analysis of the three pooled analyses overall presents an OR of 1.45 (95% CI: 0.95–2.20) for exposures ≥0.4 μT.

Conclusions Our results are not in line with previous pooled analysis and show a decrease in effect to no association between MF and childhood leukemia. This could be due to methodological issues, random chance, or a true finding of disappearing effect.

Funding information This work was supported by the research grant from Electric Power Research Institute. SETIL was financially supported by research grants received from the Italian Association on Research on Cancer (AIRC), the Ministry for Instruction, University, and Research, the Ministry of Health, the Ministry of Labour, and Piedmont Region.

https://www.sciencedirect.com/science/article/pii/S0013935121012883

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Extremely low frequency electromagnetic fields exposure during the prenatal and postnatal periods alters pro-inflammatory cytokines levels by gender

Ozturk H, Saribal D, Gelmez YM, Deniz G, Yilmaz A, Kirectepe A, Ercan AM. Extremely low frequency electromagnetic fields exposure during the prenatal and postnatal periods alters pro-inflammatory cytokines levels by gender. Electromagn Biol Med. 2022 Mar 2:1-11. doi: 10.1080/15368378.2022.2046045.

Abstract

Maternal exposure to the excessive electromagnetic fields is considered harmful to infants and associated with several health problems in life, such as neurological or immune diseases. In this present study we aimed to investigate the potential effects of extremely low-frequency electromagnetic field (ELF-EMF) exposure during the gestational and lactational period of dams on immune system parameters. The development of white blood cells (WBC), lymphocyte subpopulations ($CD4^+$ T cells, $CD8^+$ T cells, Natural Killer (NK) cells, and B cells) and production of T cell related cytokines were explored in the offsprings. Significant changes were found in WBC and lymphocyte counts. Although no changes in lymphocyte subunits were observed among groups, $CD4^+$ cells were significantly increased in the female group exposed to ELF-EMF. Also, IL-17A and IFN-γ levels increased in plasma and spleen. The mean IL-4 level and the expression level of the IL-4 gene were not changed, in the experimental groups. But the expression of the IL-17A gene was also upregulated, which supports cytokine quantification analyses. In conclusion, ELF-EMF exposure in the prenatal and postnatal period increases the level of IL-17A in the spleen and blood of young female rats, and it upregulates IL-17 gene expression in the spleen, resulting in $CD4^+$ cell proliferation and inflammation.

https://pubmed.ncbi.nlm.nih.gov/35232334/

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Do 50/60 Hz magnetic fields influence oxidative or DNA damage responses in human SH-SY5Y neuroblastoma cells?

Ehab Mustafa, Leonardo Makinistian, Jukka Luukkonen, Jukka Juutilainen, Jonne Naarala. Do 50/60 Hz magnetic fields influence oxidative or DNA damage responses in human SH-SY5Y neuroblastoma cells? Int J Radiat Biol. 2022 Mar 23;1-35. doi: 10.1080/09553002.2022.2055803.

Abstract

Purpose: We investigated possible effects of 50 Hz and 60 Hz magnetic fields (MFs) on reactive oxygen species (ROS) production, DNA damage, DNA damage repair rate, as well as gene expression related to oxidative stress and DNA damage signaling.

Materials and methods: Human SH-SY5Y neuroblastoma cells were sham-exposed or exposed to 100 µTRMS MFs for 24 h, then assayed or further treated with 100 µM menadione for 1 h before the assay. The levels of ROS and cytosolic superoxide anion (O2•-) were assayed fluorometrically. DNA damage and gene expression were assayed by comet assay and RT-qPCR, respectively. To examine whether MFs affected DNA damage repair rate, cells were allowed to repair their DNA for 1 or 2 h after menadione treatment and then assayed for DNA damage.

Results: There was suggestive evidence of a general low-magnitude increase in the expression of ROS-related genes (primarily genes with antioxidant activity) when quantified immediately after MF exposure, suggesting a response to a small increase in ROS level. The possible upregulation of ROS-related genes is supported by the finding that the level of menadione-induced ROS was consistently decreased by 50 Hz MFs (not significantly by 60 Hz MFs) in several measurements 30 - 60 min after MF exposure. MF exposures did not affect cytosolic O2•- levels, DNA damage, or its repair rate. Changes in the expression of DNA damage-signaling genes in the MF-

exposed cells did not exceed the expected rate of false positive findings. No firm evidence was found for differential effects from 50 Hz vs. 60 Hz MFs.

Conclusions: While only weak effects were found on the endpoints measured, the results are consistent with MF effects on ROS signaling.

https://pubmed.ncbi.nlm.nih.gov/35320060/

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Assessment of Twin Fetal Exposure to Environmental Magnetic and Electromagnetic Fields

Zhang C, Li C, Yang L, Hou W, Du M, Wu T, Chen W. Assessment of Twin Fetal Exposure to Environmental Magnetic and Electromagnetic Fields. Bioelectromagnetics. 2022 Mar 1. doi: 10.1002/bem.22397.

Abstract

Fetal development is vital in the human lifespan. Therefore, it is essential to characterize exposure by a series of typical environmental magnetic and electromagnetic fields. In particular, there has recently been a sharp increase in the twin birth rate. However, lack of appropriate models has prohibited dosimetric evaluation, restricting characterization of the impact of these environmental factors on twins. The present study developed two whole-body pregnant models of 31 and 32 weeks of gestation (WG) with twin fetuses and explored several typical exposure scenarios, including 50-Hz uniform magnetic field exposure, local 125-kHz magnetic field (MF), and 13.56-MHz electromagnetic field exposure, as well as wideband planewave radiofrequency (RF) exposure from 20 to 6000 MHz. Finally, dosimetric results were derived. Compared to the singleton pregnancy with similar weeks of gestation, twin fetuses were overexposed at 50-Hz uniform MF, but they were probably underexposed in the RF scenarios with frequencies for wireless communications. Furthermore, the twin fetuses manifested large dosimetric variability compared to the singleton, which was attributed to the incident direction and fetal position. Based on the analysis, the dosimetric results over the entire gestation period were estimated. The results can be helpful to estimate the risk of twin-fetal exposure to electromagnetic fields and examine the conservativeness of the international guidelines

https://pubmed.ncbi.nlm.nih.gov/35233784/

Conclusion

In the study, we developed two pregnant models with twin fetuses of 31 and 32 WG by MRI images.The dosimetric results have been investigated for several typical scenarios, i.e. 50-Hz uniform MFexposure, EAS local MF exposure, and wide-band whole-body RF exposure. The outcomes were compared against that of the singleton. Overexposure of the twins compared with the singleton at ELF MF and RF exposure at several hundred MHz was observed from the results. Significantly large dosimetric variability was documented. Although the surveyed configurations indicated that current International Commission On Non-Ionizing Radiation Protection [2010, 2020] were conservative for twin fetuses, these dosimetric characteristics should be

considered for epidemiological analysis. The results indicate that future research employing anatomically correct twin-fetal models with various WG is needed.

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A systematic review on occupational exposure to radiofrequency electromagnetic fields and risk of cancer: preliminary results from an Italian research project

Alberto Modenese, Giulia Bravo, Carlo Grandi, Mauro Biffoni, Fabriziomaria Gobba. A systematic review on occupational exposure to radiofrequency electromagnetic fields and risk of cancer: preliminary results from an Italian research project. Safety and Health at Work. Volume 13, Supplement: S246. 2022. doi: 10.1016/j.shaw.2021.12.1521.

Abstract

Introduction: The aim of the systematic review (SR) is to evaluate available scientific evidence from human studies on the possible associations between occupational exposure to radiofrequency (RF) electromagnetic fields (EMF) and risk of cancer.

Methods: The SR is part of the Italian research project BRIC 2018 – ID 06, supported by INAIL (PROSPERO code: CRD42020200202), and is conducted according to PRISMA statements. All the studies on workers with documented occupational exposure to RF-EMF (frequency range: 3 kHz - 300 GHz) and medical diagnosis of cancer are considered for inclusion. Original research published in English language in peer-reviewed international journals are included, with no restriction for publication period.

Results: According to a preliminary evaluation of SR results, the studies have been focused on different types of cancer, including brain tumors and various other. A major problem is that, with the exception of a few studies applying a detailed exposure assessment based on individual RF exposure data, in the large majority of the studies the evaluation of occupational RF-EMF exposure is affected by various types of bias. Moreover, in many of the job categories enrolled in the studies, a co-exposure to other occupational carcinogens is expected, potentially affecting the overall results.

Conclusions: The SR is still ongoing, but preliminary results suggest that the heterogeneity of the available studies, both considering job categories and outcomes evaluation, as well as various bias in the exposure assessment, limits the possibility of a pooled quantitative synthesis of the studies' results.

https://www.sciencedirect.com/science/article/pii/S2093791121016206

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Modelling and Evaluating Electromagnetic Field Exposure in the Multiple-Source Scenario of Using IoT HF RFID Readers

Patryk Zradziński. Modelling and Evaluating Electromagnetic Field Exposure in the Multiple-Source Scenario of Using IoT HF RFID Readers. Int J Environ Res Public Health. 2022 Mar 10;19(6):3274. doi:

10.3390/ijerph19063274.

Abstract

The aim of this study was to evaluate Specific Absorption Rate (SAR) and induced electric field (Ein) values in the model of a body of a person present near multiple HF RFID readers of a passive proximity integrated circuit card (PICC) working in an IoT application in a public transport vehicle, in order to test the hypothesis that even the simultaneous use of modelled readers does not cause electromagnetic field (EMF) exposure exceeding relevant limits provided for the evaluation of exposure of the general public. SAR and Ein values were evaluated under various exposure scenarios, designed to mimic EMF exposure under realistic conditions of HF RFID readers used on a public bus and covering various reader locations and the presence of a person using a PICC and a bystander. The results obtained from numerical modelling showed that the absorption of EMF emitted continuously by HF RFID readers (located 10 cm away from a body) in the human body may have a significant influence on humans when the PICC reading ranges are longer than 15-23 cm (depending on the class of PICC) for a single reader and when multiple sources of exposure are used in a public transport vehicle-even at reading ranges 15% shorter (13-20 cm).

Open access paper: https://www.mdpi.com/1660-4601/19/6/3274

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Analysis of Red Blood Cell Movement in Whole Blood Exposed to DC and ELF Electric Fields

Miki Kanemaki, Hisae O Shimizu, Hiroshi Inujima, Takeo Miyake, Koichi Shimizu. Analysis of Red Blood Cell Movement in Whole Blood Exposed to DC and ELF Electric Fields. Bioelectromagnetics. 2022 Apr;43(3):149-159. doi: 10.1002/bem.22395.

Abstract

To evaluate hematological effects of direct current (DC) and alternating current (AC) extremely low frequency (ELF) electric field exposure, this study investigated red blood cell (RBC) movement in whole blood. Video images of RBCs were recorded under a microscope using specially designed electrode systems. Video analysis software was then used to measure the RBC velocity. The noise level and measurement system stability were confirmed based on results of a no-field exposure experiment. Using the electrode system to produce a non-homogeneous electric field, different movements were found to occur in DC and AC field exposure. The RBCs moved in the directions of the electric field and the gradient of field distribution, respectively, in the DC and AC fields. Dependences of the RBC velocity on the field strength were, respectively, linear and quadratic in the DC and AC fields. These results suggest that electrophoretic and dielectrophoretic movements were, respectively, dominant in the DC and AC fields. The magnitude of the electric field necessary to cause these effects was found to be 103 -105 times greater than the internationally publicized guideline for human safety.

https://pubmed.ncbi.nlm.nih.gov/35315542/

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Complex Electromagnetic Issues Associated with the Use of Electric Vehicles in Urban Transportation

Krzysztof Gryz, Jolanta Karpowicz, Patryk Zradziński. Complex Electromagnetic Issues Associated with the Use of Electric Vehicles in Urban Transportation. Sensors (Basel). 2022 Feb 22;22(5):1719. doi: 10.3390/s22051719.

Abstract

The electromagnetic field (EMF) in electric vehicles (EVs) affects not only drivers, but also passengers (using EVs daily) and electronic devices inside. This article summarizes the measurement methods applicable in studies of complex EMF in EVs focused on the evaluation of characteristics of such exposure to EVs users and drivers, together with the results of investigations into the static magnetic field (SMF), the extremely low-frequency magnetic field (ELF) and radiofrequency (RF) EMF related to the use of the EVs in urban transportation. The investigated EMF components comply separately with limits provided by international labor law and guidelines regarding the evaluation of human short-term exposure; however other issues need attention-electromagnetic immunity of electronic devices and long-term human exposure. The strongest EMF was found in the vicinity of direct current (DC) charging installations-SMF up to 0.2 mT and ELF magnetic field up to 100 µT-and inside the EVs-up to 30 µT close to its internal electrical equipment. Exposure to RF EMF inside the EVs (up to a few V/m) was found and recognized to be emitted from outdoor radio communications systems, together with emissions from sources used inside vehicles, such as passenger mobile communication handsets and antennas of Wi-Fi routers.

Excerpts

4.5. Health Aspects of Exposure to EMF in EVs

An EV driver's long-lasting daily exposure to EMF, even if compliant with the exposure limits, cannot be counted to be negligible when the context of possible adverse health effects due to chronic exposure to EMF is considered. The ELF MF was classified to be a possible carcinogenic to human (2B classification) based on the epidemiologically proven elevated carcinogenic health risks in populations chronically exposed to MF exceeding 0.4 µT (attention level related to yearly averaged exposure) [38,39,40]. The level of ELF MF exposure reported in various studies focused on EMF in EVs and discussed in this article may significantly contribute to the total long-lasting exposure to drivers.

The effects of EMF exposure induced in exposed objects are frequency-dependent, but the significant majority of studies performed so far in the area of EMF safety have referred to the populations exposed to high-voltage power lines (i.e., to chronic exposure to EMF of sinusoidal power frequency), and the outcome of such observations was a base for the abovementioned 2B classification for ELF MF exceeding 0.4 µT. Because of differences in the frequency patterns of the discussed exposures (near power lines and in EVs), there needs to be very careful analysis of how far the studied health and safety outcomes from ELF EMF exposures vary in such cases, and which exposure metrics are relevant to evaluate them. Consistently, the mentioned differences in

frequency characteristics of ELF EMF in EVs and EMF near regular electric power installations also need attention with respect to the exposure evaluation protocol, which in practice means that studies of the parameters of EMF exposure associated with the use of EVs require not only measurements of the RMS value (which, in practice, is usually almost equal to the RMS value of the dominant frequency component of exposure), but also attention to the higher harmonics of this exposure, the components of fundamental frequencies other than 50 Hz, the parameters of transient EMF over rapid changes in the mode of EV driving, and combined exposure including the above mentioned components.

Similar to ELF MF, RF EMF was classified by the IARC in the group of 2B carcinogenic environmental factors [41]. This component of driver EMF exposure also needs attention because of its level at least comparable to office exposure, where wireless radio communication facilities are in use and daily long-lasting exposure, potentially significantly contributing to total driver chronic exposure, combines with other components of lower frequencies (covering together exposure to: static, low frequency and radiofrequency fields).

5. Conclusions

In every urban area, there is a daily mass of passengers traveling by public transportation. Ecological and economic reasons, as well as technological development, mean that a significant percentage of the population already use EVs (trams, metro, trolleys, buses) daily, seeing as they are an increasing majority of transportation resources in various large cities. During the journeys, passengers and drivers are exposed to a specific complex EMF, with a dominant ELF component emitted by the driving systems and their supply installations, and an RF component emitted by various wireless communications systems (e.g., Wi-Fi routers located often inside vehicles, handsets of mobile communications used by passengers, and mobile communication BTS located outside vehicles). Depending on the location of the electric equipment inside the EVs, a higher exposure to EMF may affect passengers, or in some cases drivers.

Investigations into SMF, ELF and RF EMF emitted by various electrical equipment associated with the use of EV urban transportation showed that their levels, considered separately, comply with the limits provided by international labor law and guidelines aimed at protecting against the direct effects of short-term influence on humans of EMF of a particular frequency range (set up to prevent thermal load or electrical stimulation in exposed tissue) [12,13,17,20,21,22]. International guidelines and labor law do not provide rules on how to evaluate simultaneous exposure at various frequency ranges (e.g., SMF together with ELF and RF). This needs also specific attention, given that electronic devices and systems used inside EVs need to have sufficient electromagnetic immunity to ensure that their performance is not negatively affected by the impact from EMF emitted by the use of EVs.

Considering the chronic nature of exposure to EMF in EVs (in particular with respect to potential exposure to drivers when various EMF sources are located near their cabins), and the potential specific risks from exposure to EMF of complex composition in time and frequency domains, there is a need to collect research data on the complex characteristics of EMF exposure related to the use of EVs in public transportation and the associated health outcome in chronically exposed workers, as well as decreasing the level of their exposure by applying

relevant preventive measures (e.g., locating indoor Wi-Fi routers, and other such electrical equipment, away from the driver's cabin) [17,23,42,43,44].

Open access paper: https://www.mdpi.com/1424-8220/22/5/1719

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The role of the AC component in human perception of AC-DC hybrid electric fields

Kathrin Jankowiak, Andrea Kaifie, Thomas Krampert, Thomas Kraus, Michael Kursawe. The role of the AC component in human perception of AC-DC hybrid electric fields. Sci Rep. 2022 Mar 1;12(1):3391. doi: 10.1038/s41598-022-07388-w.

Abstract

Electric energy is essential to today's society. To cope with global higher demand while minimizing land use, efficient high voltage direct current (HVDC) power lines are planned to be mounted on existing alternating current (AC) structures leading to electric fields (EFs) from both AC and DC transmission lines in hybrid configurations. Due to the close proximity to residential areas, the investigation of human hybrid EF perception and underlying mechanisms will be useful to project permitting. To specify the influence of the AC component on the whole-body detection thresholds of hybrid EFs and to explore the lower bound of human hybrid EF perception, 51 participants with an EF detection ability above average were exposed in a double-blind laboratory study. A psychophysical method based on the signal detection theory was used. Very low EF strength combinations, e.g. 1 kV/m AC combined with 1 kV/m DC, were reliably perceived by at least one participant. Detection thresholds were significantly lower with increased AC EF strengths, underlining the key role of the AC component in the human perception of hybrid EFs. Findings will contribute to the assessment of public reaction to the perception of EFs around hybrid overhead power lines and to their optimal designs.

Conclusion

Within the current study, we showed that the AC component plays a key role in the human perception of hybrid EFs as increased AC EF strengths lowered detection thresholds of hybrid EFs. Therefore, not only the total EF strength but especially the AC component in a hybrid EF is decisive for estimating hybrid detection thresholds. Focusing on the lower bound of hybrid EF perception, it could be indicated that some people are even able to reliably detect very low hybrid EFs of up to 1 kV/m AC EF combined with 1 kV/m DC EF. This high sensibility, along with the synergistic effect of AC and DC, should be taken into consideration when assessing public reaction to the perception of EFs around hybrid overhead lines. In this context, the effect of environmental factors, such as relative humidity and ion currents, on the perception of low hybrid EFs could be investigated in future studies, as both factors were associated with lower detection thresholds[8]. Together with these findings, our data will help to prevent unwanted EF perception in nature and contribute to the construction of future hybrid overhead power lines.

Open access paper: https://www.nature.com/articles/s41598-022-07388-w

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Distinct fatty acid redistribution and textural changes in the brain tissue upon the static magnetic field exposure

Ilić AŽ, de Luka SR, Popović TB, Debeljak-Martačić J, Kojadinović M, Ćirković S, Ristić-Djurović JL, Trbovich AM. Distinct fatty acid redistribution and textural changes in the brain tissue upon the static magnetic field exposure. Environ Toxicol Pharmacol. 2022 Mar 19:103853. doi: 10.1016/j.etap.2022.103853.

Highlights

- Biochemical and imaging analysis of static magnetic field induced tissue changes.
- Brain fatty acid redistribution explained and linked to the pathohistology level.
- Cross-comparison of fractal, multifractal, gray level co-occurrence matrix analysis.
- Subtle initial structural changes observed by the digital imaging analysis (DIA).
- Combined biochemical / DIA analysis promising in the study of mild tissue changes.

Abstract

We observed different outcomes upon the subacute exposure to the 128 mT highly homogeneous static magnetic field (SMF) when its orientation was (i) aligned with the vertical component of the geomagnetic field; (ii) in the opposite direction. We employed the fatty acids (FA) composition and digital image analyses (DIA) to provide insights into the underlying processes and examine the possible weak SMF effects. Swiss-Webster male mice were whole-body exposed for 1h/day over five days. Brain tissue's thin liquid chromatography resulted in brain FA composition, indicating a possible sequence of changes due to the SMF exposure. Quantitative DIA accurately assessed different image parameters. Delicate textural changes were revealed in the group where pathohistological or biochemical alterations have not been detected. DIA-based biological markers seem to be very promising for studying delicate tissue changes, which results from the high sensitivity and wide availability of DIA. We observed different outcomes upon the subacute exposure to the 128 mT highly homogeneous static magnetic field (SMF) when its orientation was (i) aligned with the vertical component of the geomagnetic field; (ii) in the opposite direction. We employed the fatty acids (FA) composition and digital image analyses (DIA) to provide insights into the underlying processes and examine the possible weak SMF effects. Swiss-Webster male mice were whole-body exposed for 1h/day over five days. Brain tissue's thin liquid chromatography resulted in brain FA composition, indicating a possible sequence of changes due to the SMF exposure. Quantitative DIA accurately assessed different image parameters. Delicate textural changes were revealed in the group where pathohistological or biochemical alterations have not been detected. DIA-based biological markers seem to be very promising for studying delicate tissue changes, which results from the high sensitivity and wide availability of DIA.

https://pubmed.ncbi.nlm.nih.gov/35318121/

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Impacts of smartphone radiation on pregnancy: A systematic review

Imteyaz El Jarrah, Mohammad Rababa. Impacts of smartphone radiation on pregnancy: A systematic review. Helyion. 2022 Feb;8(2):e08915. doi: 10.1016/j.heliyon.2022.e08915.

Abstract

Introduction: The COVID-19 pandemic has impacted all aspects of people's lives, with many tasks and services now being delivered online in the aim of reducing contact and preventing further transmission of the disease. This has resulted in the increase in the use of portable electronic devices (i.e., mobile phones, smartphones, laptops), which emit different frequencies of electromagnetic field (EMF) radiation. However, the evidence on the harmful impacts of EMF radiation exposure on the human body, particularly on the abdomen of the female body during pregnancy, is scarce. Further, the related studies in the literature have yet to be systematically reviewed. If unmanaged, the absorption of EMF radiation by the maternal abdomen during pregnancy is associated with serious birth and infant outcomes.

Purpose: This study aimed to systematically review the published studies on the direct effects of EMF radiation emitted from mobile phones on pregnancy, birth, and infant outcomes.

Methods: After a systematic search using the PRISMA guidelines, a total of 18 articles were retrieved from 5 databases. Studies which addressed the negative outcomes of EMF radiation exposure on mothers, adults, and children's health were included. The research articles were then sorted based on whether their findings were related to the impacts of EMF on physiological or pregnancy outcomes.

Results: The findings of this review showed that EMF radiation exposure is associated with hormonal, thermal, and cardiovascular changes among adults. However, the reviewed studies did not consider the impacts of EMF radiation exposure on pregnancy outcomes specifically, which makes it difficult to draw conclusions from this review. Only four of the reviewed studies were conducted among pregnant women. These studies reported that EMF radiation exposure during pregnancy is associated with miscarriages and fluctuations in the fetal temperature and heart rate variability, as well as infant anthropometric measures.

Conclusions: More research should be conducted to identify the specific impacts of EMF radiation exposure on pregnancy, birth, and infant outcomes. Healthcare providers and researchers are recommended to collaborate to improve public health through public education and updated organizational policies to limit these environmental risks by encouraging the use of safe technologies.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8823972/

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The role of non-ionizing electromagnetic radiation on female fertility: A review

Pooja Jangid, Umesh Rai, Radhey Shyam Sharma, Rajeev Singh. The role of non-ionizing electromagnetic radiation on female fertility: A review. Int J Environ Health Res. 2022 Feb 8;1-16. doi: 10.1080/09603123.2022.2030676.

Abstract

With increasing technological developments, exposure to non-ionizing radiation has become unavoidable as people cannot escape from electromagnetic field sources, such as Wi-Fi, electric wires, microwave oven, radio, telecommunication, bluetooth devices, etc. These radiations can be associated with increased health problems of the users. This review aims to determine the effects of non-ionizing electromagnetic radiations on female fertility. To date, several in vitro and in vivo studies unveiled that exposure to non-ionizing radiations brings about harmful effects on oocytes, ovarian follicles, endometrial tissue, estrous cycle, reproductive endocrine hormones, developing embryo, and fetal development in animal models. Non-ionizing radiation also upsurges the free radical load in the uterus and ovary, which leads to inhibition of cell growth and DNA disruptions. In conclusion, non-ionizing electromagnetic radiation can cause alterations in both germ cells as well as in their nourishing environment and also affect other female reproductive parameters that might lead to infertility.

https://pubmed.ncbi.nlm.nih.gov/35132884/

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Three Quarters of a Century of Research on RF Exposure Assessment and Dosimetry—What Have We Learned? (Review)

Kenneth R. Foster, Marvin C. Ziskin, Quirino Balzano. 2022. Three Quarters of a Century of Research on RF Exposure Assessment and Dosimetry—What Have We Learned? *International Journal of Environmental Research and Public Health* 19, no. 4: 2067. doi: 10.3390/ijerph19042067

(This article belongs to the Special Issue Occupational and General Public Exposure to Electromagnetic Fields).

Abstract

This commentary, by three authors with an aggregate experience of more than a century in technology and health and safety studies concerning radiofrequency (RF) energy, asks what has been learned over the past 75 years of research on radiofrequency and health, focusing on technologies for exposure assessment and dosimetry. Research programs on health and safety of RF exposure began in the 1950s, initially motivated by occupational health concerns for military personnel, and later to address public concerns about exposures to RF energy from environmental sources and near-field exposures from RF transmitting devices such as mobile phones that are used near the body. While this research largely focused on the biological effects of RF energy, it also led to important improvements in exposure assessment and dosimetry. This work in the aggregate has made RF energy one of the best studied potential technological hazards and represents a productive response by large numbers of scientists and engineers, working in many countries and supported by diverse funding agencies, to the ever rapidly evolving uses of the electromagnetic spectrum. This review comments on present needs of the field, which include raising the quality of dosimetry in many RF bioeffects studies and developing improved exposure/dosimetric techniques for the higher microwave frequencies to be used by forthcoming communications technologies. At present, however, the major uncertainties in dosimetric modeling/exposure

assessment are likely to be related to the inherent variability in real-world exposures, rather than imprecision in measurement technologies.

Conclusions

In summary, seven decades of research on dosimetry/exposure assessment have led to the development of technologies that permit very detailed and accurate evaluation of RF exposure to the human body, both in the near field of devices such as mobile phones, and in the far field from environmental sources. However, accurate exposure assessment and dosimetry can require expensive equipment and specialized engineering support and is not always achieved in bioeffects studies.

Progress on dosimetry/exposure assessment is continuing at the higher microwave frequencies that used by 5G NR systems and other mm-wave communications systems. Based on the previous success of this endeavor, we can expect that the tools to assess the exposure of biological systems to mm-wave radiation from 5G NR and other applications of this part of the RF spectrum will, in time, reach the level of sophistication and accuracy that is currently achieved for RF signals at lower frequencies.

Open access paper: https://www.mdpi.com/1660-4601/19/4/2067/htm

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Electromagnetic hypersensitivity close to mobile phone base stations – a case study in Stockholm, Sweden

Lennart Hardell, Tarmo Koppel. Electromagnetic hypersensitivity close to mobile phone base stations – a case study in Stockholm, Sweden. Reviews on Environmental Health. Mar 2, 2022. doi: 10.1515/reveh-2021-0169.

Abstract

A previously healthy worker developed symptoms assigned to electromagnetic hypersensitivity (EHS) after moving to an office with exposure to high levels of anthropogenic electromagnetic fields (EMFs). These symptoms consisted of e.g. headache, arthralgia, tinnitus, dizziness, memory loss, fatique, insomnia, transitory cardiovascular abnormalities, and skin lesions. Most of the symptoms were alleviated after 2 weeks sick leave. The highest radiofrequency (RF) field level at the working place was 1.72 V/m (7,852 μW/m^2). Maximum value for extremely low frequency electromagnetic field (ELF-EMF) from electric power at 50 Hz was measured to 285 nT (mean 241 nT). For electric train ELF-EMF at 16.7 Hz was measured to 383 nT (mean 76 nT). Exposure to EMFs at the working place could be the cause for developing EHS related symptoms. The association was strengthened by the symptom reduction outside the working place.

Conclusions

This investigation established three possible reasons for developing health symptoms associated with the EMF exposure, including the following.

1. The working room was right below the mobile phone base station antenna, located on the roof of the building. The close proximity to these antennas caused significantly high RF radiation exposure in the working area.

2. The working room is also positioned close to lower radiofrequency transmitter (TETRA emergency services), located on the neighboring roof of the same building.
3. The working room was positioned within 20 m from the electric train railroad. 16 Hz magnetic field from the railroad power cable was on some instances the highest ELF MF component in the room, exceeding even the power grid 50 Hz MFs. Also, railroad power cable induced a fluctuating magnetic field in the office due to the coming and passing electric trains. As trains come and go, this introduces a change in the electric power supplied by the railroad electric cable. Consequently the magnetic field also changes in great amplitude.

In conclusion, there are at least three types of electromagnetic fields present in the working room, which cause a long term exposure to the workers. Exposure to multiple source electromagnetic fields could be the cause for developing EHS related symptoms. However, the person had been exposed to ELF-EMF also at other locations in the building, so exposure to RF-EMF seems to be the most probable cause to her developed health problems.

Open access paper: https://www.degruyter.com/document/doi/10.1515/reveh-2021-0169/html

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Assessment of Human Exposure Levels Due to Mobile Phone Antennas in 5G Networks

Marta Bonato, Laura Dossi, Silvia Gallucci, Martina Benini, Gabriella Tognola, Marta Parazzini. Assessment of Human Exposure Levels Due to Mobile Phone Antennas in 5G Networks. Int J Environ Res Public Health. 2022 Jan 29;19(3):1546. doi: 10.3390/ijerph19031546.

(This article belongs to the Special Issue EMF Exposure Assessment in 5G and 6G Emerging Scenarios in Humans and Environment)

Abstract

The recent deployment of 5G networks is bringing benefits to the population but it is also raising public concern about human RF-EMF exposure levels. This is particularly relevant considering the next 5G mobile devices, which are placed in close proximity to the subjects. Therefore, the aim of the following paper is focused on expanding the knowledge of the exposure levels in 5G exposure scenarios, specifically for mobile applications, using computational methods. The mobile antenna was designed considering the 5G technology innovations (i.e., mm-wave spectrum, beamforming capability, high gain and wide coverage), resulting in a phased-array antenna with eight elements at the working frequency of 27 GHz. To assess the exposure levels, different types of skin models with different grades of details and layers were considered. Furthermore, not only was the presence of a mobile phone user simulated, but also that of a person in their proximity, who could be hit by the main beam of the phased-array antenna. All the simulations were conducted in Sim4Life platform, where the exposure levels were assessed in terms of absorbed power density averaged over 4 cm2 and 1 cm2, following the ICNIRP guidelines. The results highlighted that the use of the homogeneous skin model led to the absorbed power density peaks being greatly underestimated, with respect to those obtained in multilayer skin models. Furthermore, interestingly, we found that the exposure levels obtained for the person passing nearby were slightly higher

than those experienced by the mobile phone user himself. Finally, using the allowed input power for real mobile applications, all the values remained below the limits indicated by the ICNIRP guidelines.

Conclusions

In conclusion, the aim of further expanding the knowledge about 5G mm-wave exposure in mobile applications was achieved. The results confirmed that at these high frequencies it is essential to consider a multilayer model of the skin rather than a simple homogeneous one that could lead to greatly underestimating the exposure levels. Furthermore, the study highlights those efforts should be focused not only on evaluating the exposure levels for the mobile phone users but also for people passing nearby, who could be hit by the main lobe of the mobile antenna pattern. Finally, it is important to underline that the maximum values of S_{ab} obtained in all the conducted simulations, when scaled for a real input power (23 dBm, i.e., 200 mW) respect the basic restrictions indicated in the ICNIRP guidelines to avoid harmful effects. Future work will deal with the investigation of detailed skin tissues to be used in anatomical models, to take into account the real morphology of human subjects, and the study of the impact of the beamforming capability of the mobile antenna on the exposure scenario.

Open access paper: https://www.mdpi.com/1660-4601/19/3/1546

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E-Field Strength Measurements of a 5G Base Station in 28 GHz Band for EMF Exposure Assessment

Sen Liu, Teruo Onishi, Masao Taki, Miwa Ikuyo, Kazuhiro Tobita, Soichi Watanabe, Yukihisa Suzuki. E-Field Strength Measurements of a 5G Base Station in 28 GHz Band for EMF Exposure Assessment. *2021 IEEE USNC-URSI Radio Science Meeting (Joint with AP-S Symposium)*, 2021, pp. 49-50, doi: 10.23919/USNC-URSI51813.2021.9703567.

Abstract

This paper presents the preliminary measurement results of the electric field (E-field) strength resulting from a fifth-generation (5G) base station operating in 28 GHz band. Three different measurement cases are discussed. The time-averaged (1 min) total E-field strength in all cases is no more than 91 dBμV/m.

Conclusion

This paper presents the measurement results of the E-field strength from a 5G base station operating in 28 GHz band. Three different situations are considered, and the total E-field strength is much lower than the limit value of 155.76 dBμV/m (61.4 V/m) in the corresponding band [4] for all cases. It is also found that although the instantaneous E-field strength during data traffic reaches 97.74 dBμV/m, the RMS E-field strength during data traffic is only 0.4 dB higher than that without data traffic-on in this measurement. Although horn antennas have the advantage of discriminating downlink and uplink in TDD, an omnidirectional antenna will be used, and the corresponding results will be compared with those in this work in the future. In addition, comprehensive measurements and verifications will also be conducted.

https://ieeexplore.ieee.org/document/9703567

My note: 97.74 dBµV/m = 0.077 V/m

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Lessons Learned from a Distributed RF-EMF Sensor Network

Sam Aerts, Günter Vermeeren, Matthias Van den Bossche, Reza Aminzadeh, Leen Verloock, Arno Thielens, Philip Leroux, Johan Bergs, Bart Braem, Astrid Philippron, Luc Martens, Wout Joseph. 2022. Lessons Learned from a Distributed RF-EMF Sensor Network. *Sensors* 22, no. 5: 1715. doi: 10.3390/s22051715.

Abstract

In an increasingly wireless world, spatiotemporal monitoring of the exposure to environmental radiofrequency (RF) electromagnetic fields (EMF) is crucial to appease public uncertainty and anxiety about RF-EMF. However, although the advent of smart city infrastructures allows for dense networks of distributed sensors, the costs of accurate RF sensors remain high, and dedicated RF monitoring networks remain rare. This paper describes a comprehensive study comprising the design of a low-cost RF-EMF sensor node capable of monitoring four frequency bands used by wireless telecommunications with an unparalleled temporal resolution, its application in a small-scale distributed sensor network consisting of both fixed (on building façades) and mobile sensor nodes (on postal vans), and the subsequent analysis of over a year of data between January 2019 and May 2020, during which slightly less than 10 million samples were collected. From the fixed nodes' results, the potential errors were determined that are induced when sampling at lower speeds (e.g., one sample per 15 min) and measuring for shorter periods of time (e.g., a few weeks), as well as an adequate resolution (30 min) for diurnal and weekly temporal profiles which sufficiently preserves short-term variations. Furthermore, based on the correlation between the sensors, an adequate density of 100 sensor nodes per km^2 was deduced for future networks. Finally, the mobile sensor nodes were used to identify potential RF-EMF exposure hotspots in a previously unattainable area of more than 60 km^2. In summary, through the analysis of a small number of RF-EMF sensor nodes (both fixed and mobile) in an urban area, this study offers invaluable insights applicable to future designs and deployments of distributed RF-EMF sensor networks.

Open access paper: https://www.mdpi.com/1424-8220/22/5/1715

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Changes in pattern of presentation of patients with unilateral vestibular schwannoma over two decades: Influence of cell phone use in early diagnosis

Adeline Hephzibah, Sanjeev Kumar Pandey, V Rupa, Ranjith K Moorthy, Vedantam Rajshekhar. Changes in pattern of presentation of patients with unilateral vestibular schwannoma over two decades: Influence of cell phone use in early diagnosis. J Clin Neurosci. 2021 Dec;94:102-106. doi: 10.1016/j.jocn.2021.10.004.

Highlights

- Utility of cell phone usage in early detection of VS has not been studied.
- Cell phone usage aided in detecting hearing loss in 50% of patients.

• Majority of patients with VS still have severe hearing loss and large tumors.

Abstract

We aimed to study whether the increased use of cell phone in south Asia over the past two decades has impacted presentation of patients with vestibular schwannoma (VS). In this observational cohort study, data on cell phone use and severity of hearing loss and tumor size was collected using a questionnaire through a patient interview (n = 62) in consecutive patients with VS managed between 2017 and 2020. Association between cell phone use and severity of hearing loss and tumor size were studied and compared with our data published earlier when telephone use was not widely prevalent. 71% of the 62 patients (aged between 15 and 81 years) had large or giant VS. Pure tone audiometry showed moderately severe or profound hearing loss in 77.4%. Sixty (96.7%) patients used cell phones. 50% of patients complained of difficulty in using their cell phone because of hearing loss. Compared to the earlier era, a higher proportion consulted an ENT surgeon first for hearing loss (59.7% vs 26%; p = 0.0005) and had small or medium sized tumors (29% vs 8%; p = 0.008) with a smaller mean tumor size (3.3 vs 3.9 cm; p = 0.03). Increased cell phone use has led to earlier diagnosis of VS and smaller tumours in recent years when compared to an earlier era. However, the vast majority of patients continue to present with severe to profound hearing loss and large tumors.

https://pubmed.ncbi.nlm.nih.gov/34863422/

Conclusions

Increased cell phone use has led to earlier diagnosis of VS and smaller tumours in recent years when compared to data from the same institution published 15 years back. A greater proportion of patients now present with mild to moderate hearing loss, have smaller tumours and consult an otolaryngologist for their problem. However, the vast majority of patients continue to present with severe to profound hearing loss and large tumors necessitating patient and physician education to further improve awareness regarding the need for early screening of patients with unilateral/asymmetrical sensorineural hearing loss with PTA and neuroimaging.

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Radiofrequency Electromagnetic Field Exposure and Apoptosis: A Scoping Review of In Vitro Studies on Mammalian Cells

Romeo S, Zeni O, Scarfì MR, Poeta L, Lioi MB, Sannino A. Radiofrequency Electromagnetic Field Exposure and Apoptosis: A Scoping Review of In Vitro Studies on Mammalian Cells. *Int J Mol Sci*. 2022;23(4):2322. 2022 Feb 19. doi:10.3390/ijms23042322

Abstract

In the last decades, experimental studies have been carried out to investigate the effects of radiofrequency (RF, 100 kHz–300 GHz) electromagnetic fields (EMF) exposure on the apoptotic process. As evidence-based critical evaluation of RF and apoptosis in vitro is lacking, we performed a scoping literature review with the aim of systematically mapping the research performed in this area and identifying gaps in knowledge. Eligible for inclusion were in vitro studies assessing apoptosis in mammalian cells exposed to RF-EMF, which met basic

quality criteria (sham control, at least three independent experiments, appropriate dosimetry analysis and temperature monitoring). We conducted a systematic literature review and charted data in order to overview the main characteristics of included studies. From the 4362 papers retrieved with our search strategy, 121 were pertinent but, among them, only 42 met basic quality criteria. We pooled data with respect to exposure (frequency, exposure level and duration) and biological parameters (cell type, endpoint), and highlighted some qualitative trends with respect to the detection of significant effect of RF-EMF on the apoptotic process. We provided a qualitative picture of the evidence accumulated so far, and highlighted that the quality of experimental methodology still needs to be highly improved.

Excerpt

We have overviewed the main characteristics and outcome of the included studies. The majority of them did not find significant alterations of the apoptotic process due to RF-EMF exposure. Looking at the experiments extracted from the studies, when a statistically significant effect was observed it mainly occurred at frequencies above 6 GHz, and for acute (≤ 1h) exposure durations. However, since the number of studies reporting effects is very small, and the considered experimental conditions are highly heterogeneous, further investigations are needed, together with replication studies, to confirm or confute these results. Moreover, even though the included studies met the basic quality criteria, most of them still presented flaws in the experimental methods (lack of blind analysis and/or positive control, assessment of single endpoints). It can be stated that, to be of value, future studies that investigate the effect of RF-EMF in mammalian cells should aim to be of high methodological quality and be sufficiently powered by performing an adequate number of experiments.

Conclusions

This scoping review sought to systematically map the research regarding the effects of RF-EMF on apoptosis in mammalian cells, and to identify any existing gaps in knowledge within health risk assessment of RF-EMF exposures. This will definitely facilitate to gain reliable information on the effects of RF exposure on the apoptotic process when in a next step, a quantitative analysis of the papers included in this scoping review will be carried out by mainly addressing questions on the direction of the effect (induction or suppression of apoptosis), effect size, possible dose–response relationship, possible association of the effect size with the quality score of the experiments, and possible major capability of certain exposure parameter ranges to exert an effect. The major gap in knowledge from the qualitative analysis conducted here is the lack of a systematic approach based on quality of the experimental methodologies adopted in the studies retrieved and analyzed in this scoping review.

Therefore, the evidence here presented is a further confirmation that, in spite of the large amount of relevant papers available in the literature, a huge effort still needs to be made in bioelectromagnetic research towards the improvement of experimental quality, which is crucial to guarantee the reliability, robustness and reproducibility of results.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8877695/

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Protocol for a systematic review of the in vivo studies on radiofrequency (100 kHz-300 GHz) electromagnetic field exposure and cancer

Pinto R, Ardoino L, Giardullo P, Villani P, Marino C. Protocol for a systematic review of the in vivo studies on radiofrequency (100 kHz-300 GHz) electromagnetic field exposure and cancer. Syst Rev. 2022 Feb 16;11(1):29. doi: 10.1186/s13643-022-01898-4.

Abstract

Background: An Italian project aims to review the scientific literature on the possible carcinogenicity of radiofrequency (100 kHz-300 GHz) electromagnetic field (RF-EMF) exposure. The ENEA team has to carry out a systematic review of the in vivo studies on this topic.

Objectives: Development of a protocol for a systematic review (meta-analysis included) to investigate the potential carcinogenic risk following RF-EMF in vivo exposure to doses above or within legal limits. The aims of this review are (1) to provide a descriptive and, if possible, a quantitative summary of the results of the examined RF-EMF in vivo studies, together with an assessment of the consistency of observations and of the causes of heterogeneity, and (2) to assess the weight of evidence to support or refute the hypothesis of carcinogenic effects caused by RF-EMF exposure and to draw conclusions about the potential for carcinogenicity of RF-EMF exposure.

Methods: We will search for relevant studies in electronic academic databases and in the reference list of selected papers and reviews on the topic, including the descriptive reviews on RF-EMF carcinogenic effect carried out by international panels of experts since 2011. The following elements of the PECO question were defined: experimental studies on rodents of both sexes, all ages and species, all genetic backgrounds (Population) exposed to RF-EMF alone, or in combination with other physical or chemical agents (Exposure); only studies reporting outcome data in exposed and sham control groups (Comparison); and all types of cancer with all tumor-related outcome measures (Outcome) will be included. Only peer-reviewed articles written in English will be considered without limit in the publication date. Eligibility criteria were defined for papers to be included. A risk of bias assessment will be performed using a tool specifically developed for animal studies. A meta-analysis will be performed, if feasible, for all outcome measures; for subgroup analysis, a minimum of 3 studies per subgroup will be required. If meta-analysis will not be possible, a narrative synthesis of the results will be reported.

Systematic review registration: PROSPERO CRD42020191105 HIGHLIGHTS: An Italian collaborative research agreement aims to review the scientific literature on the possible carcinogenicity of RF-EMF (100 kHz - 300 GHz). The ENEA team will systematically review and, if possible, meta-analyse estimates the effects of in vivo exposure to RF-EMF exposure on cancer. The ENEA group is a multidisciplinary team of researchers with a consolidated experience both in carcinogenicity experiments and radiofrequency dosimetric assessment. The proposed protocol uses the NTP OHAT Approach for Systematic Review as an organizing framework. The proposed protocol aims to lead to the first systematic review providing a strength of evidence assessment on this topic.

https://pubmed.ncbi.nlm.nih.gov/35172887/

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Should SAR Guidelines Include Variability?

K. Masumnia-Bisheh, C. Furse. Should SAR Guidelines Include Variability? *2021 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting (APS/URSI)*, 2021, pp. 1945-1946, doi: 10.1109/APS/URSI47566.2021.9703740.

Abstract

Variations in 1-g and 10-g specific absorption rate (SAR) values due to variation in tissue dielectric properties are determined. To accomplish this goal, stochastic finite difference time domain (S-FDTD) and Monte Carlo methods are compared. A 3D head model with variable dielectric properties is exposed to a half wave dipole antenna at 835 and 1900 MHz. The results show that these variations can significantly affect the peak 1-g and 10-g SAR values and should be considered in SAR guidelines for cell phone assessment.

Conclusions

Variations in 1-g and 10-g SAR values caused by dielectric properties variation of the tissues are calculated in this paper. The results are obtained using S-FDTD and Monte Carlo methods for a head model adjacent to a half wave dipole antenna at 835 MHz and 1900 MHz frequencies. S-FDTD results were sufficiently close to the Monte Carlo results at 835 MHz, that we conclude that the more efficient S-FDTD approach can provide the assessment for this study.

Table I Mean and standard deviation of 1-gram and 10-gram sar

At both frequencies, the standard deviation of the peak 1-g SAR is within 50% of the mean SAR, and the standard deviation of the peak 10-g SAR is approximately 40% of the mean. A typical interpretation of the standard deviation for a normally distributed random variable, is that we can have a 95% confidence that the values will fall within two standard deviations of the mean. The significance of these results is that the effect of tissue property variation is too large to be ignored in SAR guidelines. The normal, expected variance in SAR should be considered in SAR guidelines. We recommend the next step in this research is to model realistic cell phones, at current (5G) frequencies, to determine the mean and standard deviation of the 1-g and 10-g SAR levels. If these follow the same trends we are seeing from a dipole antenna, it is then imperative that the SAR guidelines be revisited, and that an assessment of the effect of variation in tissue electrical properties be included in them.

https://ieeexplore.ieee.org/document/9703740

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Monte Carlo Simulation of Clothed Skin Exposure to Electromagnetic Field With Oblique Incidence Angles at 60 GHz

Li Kun, Sasaki Kensuke. Monte Carlo Simulation of Clothed Skin Exposure to Electromagnetic Field With Oblique

Incidence Angles at 60 GHz. Frontiers in Public Health. Vol. 10. 2022. doi: 10.3389/fpubh.2022.795414.

Abstract

This study presents an investigation of clothed human skin exposure to obliquely incident electromagnetic waves at 60 GHz. We clarified the combined impacts of the cloth material, incidence angle, and polarization on the assessment of transmittance and absorbed power density (APD) at the skin surface. A Monte Carlo simulation was conducted considering the thickness variation of the cloth material and skin tissue. For the case of transverse magnetic™ wave exposure, the transmittance increases with increasing incident angle up to the maximum transmittance angle in the range from 60 to 80°, which is known as the Brewster effects, regardless of textile materials and air gap between cloth and skin. The air gap results in a periodic fluctuation of the APD, where the variation is almost within 1 dB when the incident power density is constant and the incident angle is smaller than 40°. Our results also show that as the air gap increases to 2.5 mm, i.e., half-wavelength at 60 GHz in the air, the APD within the skin surface covered by typical cloth materials increases up to 40% compared with that of bare skin. Although the use of several cloth materials may increase the transmittance and APD in oblique incidence scenarios, all the results of the APD do not exceed the basic restriction for local exposure, demonstrating that the current guidelines for human exposure to electromagnetic fields are appropriate for preventing the excessive exposure at 60 GHz considering the impacts of oblique incidence angles and cloth materials.

Open access paper: https://www.frontiersin.org/article/10.3389/fpubh.2022.795414

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Exposure to 1.8 GHz radiofrequency field modulates ROS in human HEK293 cells as a function of signal amplitude

Marootpong Pooam, Nathalie Jourdan, Blanche Aguida, Cyril Dahon, Soria Baouz, Colin Terry, Haider Raad, Margaret Ahmad. Exposure to 1.8 GHz radiofrequency field modulates ROS in human HEK293 cells as a function of signal amplitude. Commun Integr Biol. 2022 Feb 3;15(1):54-66. doi: 10.1080/19420889.2022.2027698.

Abstract

The modern telecommunications industry is ubiquitous throughout the world, with a significant percentage of the population using cellular phones on a daily basis. The possible physiological consequences of wireless emissions in the GHz range are therefore of major interest, but remain poorly understood. Here, we show that exposure to a 1.8 GHz carrier frequency in the amplitude range of household telecommunications induces the formation of ROS (Reactive Oxygen Species) in human HEK293 cultured cells. The ROS concentrations detected by fluorescent imaging techniques increased significantly after 15 minutes of RF field exposure, and were localized to both nuclear and cytosolic cellular compartments. qPCR analysis showed altered gene expression of both anti-oxidative (SOD, GPX, GPX, and CAT) and oxidative (Nox-2) enzymes. In addition, multiple genes previously identified as responsive to static magnetic fields were found to also be regulated by RF, suggesting

common features in response mechanisms. By contrast, many RF effects showed evidence of hormesis, whereby biological responsivity does not occur linearly as a function of signal amplitude. Instead, biphasic dose response curves occur with 'blind' spots at certain signal amplitudes where no measureable response occurs. We conclude that modulation of intracellular ROS can be a direct consequence of RF exposure dependent on signal frequency and amplitude. Since changes in intracellular ROS may have both harmful and beneficial effects, these could provide the basis for many reported physiological effects of RF exposure.

https://pubmed.ncbi.nlm.nih.gov/35126804/

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Molecular Mechanism of Malignant Transformation of Balb/c-3T3 Cells Induced by Long-Term Exposure to 1800 MHz Radiofrequency Electromagnetic Radiation (RF-EMR)

Zhen Ding, Xiaoyong Xiang, Jintao Li, Shuicai Wu. Molecular Mechanism of Malignant Transformation of Balb/c-3T3 Cells Induced by Long-Term Exposure to 1800 MHz Radiofrequency Electromagnetic Radiation (RF-EMR). Bioengineering (Basel). 2022 Jan 18;9(2):43. doi: 10.3390/bioengineering9020043.

Abstract

Purpose: We aimed to investigate RF-EMR-induced cell malignant transformation.

Methods: We divided Balb/c-3T3 cells into sham and expo groups. The expo groups were exposed to a 1800 MHz RF continuous wave for 40 and 60 days, for 4 h per day. The sham group was sham-exposed. Cells were harvested for a cell transformation assay, transplantation in severe combined immune deficient (SCID) mice, soft agar clone formation detection, and a transwell assay. The mRNA microarray assay was used to declare key genes and pathways.

Results: The exposed Balb/c-3T3 cells showed a strong increase in cell proliferation and migration. Malignant transformation was observed in expo Balb/c-3T3 cells exposed for 40 days and 60 days, which was symbolized with visible foci and clone formation. Expo Balb/c-3T3 cells that were exposed for 40 days and 60 days produced visible tumors in the SCID mice. Lipid metabolism was the key biological process and pathway involved. The mevalonate (MVA) pathway was the key metabolic pathway. The interacted miRNAs could be further research targets to examine the molecular mechanism of the carcinogenic effects of long-term exposure.

Conclusion: Exposure for 40 and 60 days to 1800 MHz RF-EMR induced malignant transformation in Balb/c-3T3 cells at the SAR of 8.0 W/kg. We declared that lipid metabolism was the pivotal biological process and pathway. The MVA pathway was the key metabolic pathway.

Open access paper: https://www.mdpi.com/2306-5354/9/2/43

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Attributes of non-ionizing radiation of 1800 MHz frequency on plant health and antioxidant content of Tomato (Solanum Lycopersicum) plants

Chandni Upadhyaya, Trushit Upadhyaya, Ishita Patel. Attributes of non-ionizing radiation of 1800 MHz frequency on plant health and antioxidant content of Tomato (Solanum Lycopersicum) plants. Journal of Radiation Research and Applied Sciences. 15(1):54-68. 2022. doi: 10.1016/j.jrras.2022.02.001.

Abstract

The Globe is marching towards the development of the telecommunication field which leads to increment of non-ionizing radiation in the environment which affects all living beings including plants grown nearby to communication base stations. The present research was focused on physiological and biochemical alterations of tomato plants exposed to high-frequency radiation. The overall plant health was analyzed by physiological changes viz., plant height, size of leaves, length to the root system, and rate of germination upon exposure of radiation and shown significant reduction ($p < 0.05$) compared to control. Consecutively, radiation also negatively affects the photosynthetic pigment content of leaves which has shown significant reduction. Yet another confirmation of stress on exposed plant tissue was reported by obtaining higher H2O2 content within exposed plant leaf than the control. The morphological alterations viz. curling of leaves, discoloration, and size reduction became more prominent with an increase in the exposure time. The significant outcomes denoted according to 95% confidence limit. There was a significant decline in total phenolic content (37.06%), flavonoid content (71.38%), Vitamin C content (72.45%), and DPPH (59.32%) as well as total antioxidant assays (71.89%) which revealed significant deteriorative effects on such waves on secondary metabolites and the antioxidant potential of tomato plants. The lycopene content was continuously increasing up to 73.13% upon radiation of 120 h and such raise was the direct indication of harmful effect on fruit skin and release of lycopene due to softening of the fruit tissue. Thus, the presented findings illustrated the negative effects of such waves on the quality of tomato plants. The limited insight of metabolic pathways involved in plant responses to such non-ionizing radiation makes such investigation worth in agricultural application. Additionally, mobile communication agencies should be informed and installation of base stations for mobile communication towers should be prohibited at agricultural lands.

Excerpts

The ambient field in the greenhouse was as low as 1.1–1.5 V/m....

With an exposure of continuous wave (CW) electromagnetic field of 8 V/m, the SAR value was found to be 3.16×10^{-2} W kg^{-1} and 0.15 W kg^{-1} for leaves and fruits samples respectively....

Conclusion

The presented investigation discovered that all measured physiological parameters revealed deterioration with increase in electromagnetic exposure. However, the transient improvement in rate of seed germination and plant growth parameters can be considered as positive effect of short-term (12–24 h) exposure. The prolonged exposure effect on antioxidant content and activity interpreted the harmful effects of such radiation. Although, exposure of 12–24 h gave positive results for phenolic and flavonoid content assays and in the range of 1–10%

for both fruit and leaf samples and indicated stimulation of plant defense system. The most significant outcomes in terms of deterioration were observed in the assays from fruit tissues viz. 36.97, 71.38, 72.45% decline in phenolic compounds, flavonoids, vitamin C content respectively. The throughout increase of lycopene in fruits (73.13%) indicated softening of skin and release of lycopene. There was a brief increase in enzymatic antioxidants POD and PPO activity upon 24–48 h of exposure which was followed by a constant decline with an increase in exposure time and revealed weakening of the defense system and plant health. The quality of exposed tomato fruits also deteriorated upon prolonged exposure. As there is constant advancement in electronics and communication and our march towards 5G frequency, the consequences of exposure to such radiation on plants should be investigated thoroughly.

https://www.sciencedirect.com/science/article/pii/S168785072200125X

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Healthy disorders by WLAN-exposure

von Klitzing L. Healthy disorders by WLAN-exposure.J Clin Images Med Case Rep 2022; 3 (2): 1-3. doi:10.52768/2766-7820/1639

Abstract

By a diagnostic routine of a “burn-out”-patient, additionally claiming an electrosensitivity, there was tested the activity of the autonomic nervous system by electromyogram (EMG). Analyzing the frequency we found an artificial 10 Hz-component like those of WLAN-emitters as a dominant signal. By the following anamnestic discussion, the patient told about a longtime exposure to an active WLAN-equipment in office. Testing other patients using this communication-technique, there was a great number with the same 10 Hz-artifact in EMG. Additionally, some of these patients point out an artificial ECG. These data demonstrate the conflicts with the ICNIRP safety guidelines for this type of electromagnetic exposures.

Open access paper: http://www.jcimcr.org/pdfs/JCIMCR-v3-1639.pdf

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Simultaneous effect of gamma and Wi-Fi radiation on gamma-H2Ax expression in peripheral blood of rat: A radio-protection note

Ehsan Khodamoradi, Shima Afrashi, Karim Khoshgard, Farshid Fathi, Soodeh Shahasavari, Rasool Azmoonfar, Masoud Najafi. Simultaneous effect of gamma and Wi-Fi radiation on gamma-H2Ax expression in peripheral blood of rat: A radio-protection note. Biochemistry and Biophysics Reports. Volume 30, 2022. doi: 10.1016/j.bbrep.2022.101232.

Abstract

Introduction Nuclear medicine patients are isolated in a room after the injection of a radiopharmaceutical. They may be active Wi-Fi option of its smartphone mobile or other environmental radiofrequency waves. The

hypothesis of this study was the evaluation of increased biological effects of the simultaneous exposure to gamma-ray and the Wi-Fi waves by measuring the level of the increased double strand-breaks DNA in peripheral blood lymphocyte in the rat.

Materials and methods Fifty male Wistar rats were exposed for 2, 24, and 72 h only by Wi-Fi, 99m Tc, and simultaneously by Wi-Fi and 99m Tc. The power density levels of Wi-Fi emitter at 15 cm was 4.2nW/ cm2. An activity of 100 μCi of 99m Tc was injected intraperitoneally. Blood samples were taken by cardiac puncture following general anesthesia. Mononuclear cells are extraction by Ficoll-Hypaque density gradient centrifugation. The number of gamma-H2AX foci per nucleus was counted by flow cytometry. The statistical differences between experimental groups at 2, 24, and 72 h were determined with a repeated measure's analysis of variance. The significant difference between groups at the same time was analyzed with the Kruskal-Wallis Test.

Results The manner of gamma-H2AX expression was not the same for three groups in time. The number of gamma-H2AX foci between the three groups was a significant difference after 72 h.

Conclusion Simultaneous Wi-Fi and gamma-ray exposures can increase the number of double-strand break DNA in peripheral blood lymphocytes to exposure of gamma-ray to 72 h after technetium injection in the rat.

Open access paper: https://www.sciencedirect.com/science/article/pii/S2405580822000334

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Associations Between a Polymorphism in the Rat 5-HT1A Receptor Gene Promoter Region (rs198585630) and Cognitive Alterations Induced by Microwave Exposure

Li Haijuan, Gao Yu, Zou Yong, Qiao Simo, Zhi Weijia, Ma Lizhen, Xu Xinping, Zhao Xuelong, Zhang Junhua, Wang Lifeng, Hu Xiangjun. Associations Between a Polymorphism in the Rat 5-HT1A Receptor Gene Promoter Region (rs198585630) and Cognitive Alterations Induced by Microwave Exposure. Frontiers in Public Health. 10. 2022. doi: 10.3389/fpubh.2022.802386.

Abstract

The nervous system is a sensitive target of electromagnetic radiation (EMR). Chronic microwave exposure can induce cognitive deficits, and 5-HT system is involved in this effect. Genetic polymorphisms lead to individual differences. In this study, we evaluated whether the single-nucleotide polymorphism (SNP) rs198585630 of 5-HT_{1A} receptor is associated with cognitive alterations in rats after microwave exposure with a frequency of 2.856 GHz and an average power density of 30 mW/cm². Rats were exposed to microwaves for 6 min three times a week for up to 6 weeks. PC12 cells and 293T cells were exposed to microwaves for 5 min up to 3 times at 2 intervals of 5 min. Transcriptional activity of 5-HT_{1A} receptor promoter containing rs198585630 C/T allele was determined in vitro. Electroencephalograms (EEGs), spatial learning and memory, and mRNA and protein expression of 5-HT_{1A} receptor were evaluated in vivo. We demonstrated that transcriptional activity of 5-HT_{1A} receptor promoter containing

rs198585630 C allele was higher than that of 5-HT_{1A} receptor promoter containing T allele. The transcriptional activity of 5-HT_{1A} receptor promoter was stimulated by 30 mW/cm² microwave exposure, and rs198585630 C allele was more sensitive to microwave exposure, as it showed stronger transcriptional activation. Rats carrying rs198585630 C allele exhibited increased mRNA and protein expression of 5-HT_{1A} receptor and were more susceptible to 30 mW/cm² microwave exposure, showing cognitive deficits and inhibition of brain electrical activity. These findings suggest SNP rs198585630 of the 5-HT_{1A} receptor is an important target for further research exploring the mechanisms of hypersensitivity to microwave exposure.

Open access paper: https://www.frontiersin.org/article/10.3389/fpubh.2022.802386

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Corneal opacity in Northern Bald Ibises (Geronticus eremita) equipped with radio transmitters

Alfonso Balmori. Corneal opacity in Northern Bald Ibises (Geronticus eremita) equipped with radio transmitters. Electromagnetic Biology and Medicine. 2022 Feb 27;1-3. doi: 10.1080/15368378.2022.2046046.

Abstract

This note is intended to try to shed light on the discoveries made entitled "Biologging is suspect to cause corneal opacity in two populations of wild living Northern Bald Ibises (Geronticus eremita)". In this article, researchers participating in a reintroduction program for this endangered species in Europe document the unilateral corneal opacity that took place after birds were equipped with solar radio transmitters fixed on their upper-back position. The authors propose several possible effects caused by the device to explain the problem, and they conclude that the most parsimonious explanation for the symptomatology is a repetitive slight temperature rise in the corneal tissue due to electromagnetic radiation by the Global System for Mobile Communications (GSM) module of the device. The proposal of this communication is that these effects do not necessarily have to be thermal, but they can be non-thermal and thus more subtle and insidious. These effects may be caused by electromagnetic radiation at low levels but in long-term exposure.

https://pubmed.ncbi.nlm.nih.gov/35220839/

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Endogenous Ca 2+ release was involved in 50-Hz MF-induced proliferation via Akt-SK1 signal cascade in human amniotic epithelial cells

An-Fang Ye, Xiao-Chen Liu, Liang-Jing Chen, Yong-Peng Xia, Xiao-Bo Yang, Wen-Jun Sun. Endogenous Ca 2+ release was involved in 50-Hz MF-induced proliferation via Akt-SK1 signal cascade in human amniotic epithelial cells. Electromagn Biol Med. 2022 Feb 7;1-10. doi: 10.1080/15368378.2022.2031211.

Abstract

The mechanism underlying the biological effects caused by an extremely low-frequency electromagnetic field (ELF-EMF) is still unclear. Previously, we found that L-type calcium channel and sphingosine kinase 1 (SK1) were involved in 50-Hz MF exposure-induced cell proliferation. In the present study, the role of intracellular Ca2+ and signal molecules related to SK1 in cell proliferation induced by 50-Hz MF was investigated in human amniotic epithelial (FL) cells. Results showed that the intracellular Ca2+ chelator, BAPTA, could completely inhibit 50-Hz MF-induced cell proliferation, whereas NIF, the inhibitor of L-type calcium channel, only partly blocked it. When cells were cultured in calcium-free medium, MF exposure also increased intracellular Ca2+, activated SK1 and promoted cell proliferation although all of those increasing levels were lower than those in complete medium. Moreover, MF-activated SK1 could be completely inhibited by BAPTA, and MF-induced cell proliferation was abolished by SKI II, the specific inhibitor of SK1. Additionally, a 50-Hz MF exposure did not affect the activation of ERK and PKCα under the condition of calcium-free medium, but activated the Akt, which could be precluded entirely by BAPTA, but not be inhibited by NIF. Treatment of FL cells with LY294002, the inhibitor of Akt, could delete the MF-induced SK1 activation under the condition of calcium-free medium. Based on the data from the present experiment, it is concluded that endogenous Ca2+ release was involved in 50-Hz MF-induced cell proliferation via Akt-SK1 signal cascade.

https://pubmed.ncbi.nlm.nih.gov/35129008/

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Detection of the chemical changes in blood, liver, and brain caused by electromagnetic field exposure using Raman spectroscopy, biochemical assays combined with multivariate analyses

Zozan Guleken, Monika Kula-Maximenko, Joanna Depciuch, Alp Mahmut Kılıç, Devrim Sarıbal. Detection of the chemical changes in blood, liver, and brain caused by electromagnetic field exposure using Raman spectroscopy, biochemical assays combined with multivariate analyses. Photodiagnosis Photodyn Ther. 2022 Feb 18;102779. doi: 10.1016/j.pdpdt.2022.102779.

Abstract

The effects of the electromagnetic field on living organisms have been studied for several years. In this article, we showed what kind of cold change an extremely low-frequency electromagnetic field (ELF-MF) exposure 500 μT 50 Hz by using a Meritt Coil System causes in the samples of the brain and liver samples. To measure oxidative load, we measured malondialdehyde (MDA) and glutathione (GSH) levels. To identify the chemical changes, we collected Raman spectra of cerebellum, left brain, right brain and liver tissue from the control group of animals and from the animal, which were exposed to an electromagnetic field (ELF-MF group). Obtained results showed that lipid peroxidation was increased and the antioxidant response was decreased. In the brain samples the shift of peaks corresponding to the amide III vibrations existed after ELF-MF exposure. Structural changes were detected in CH2 vibrations originating from lipids in both hemispheres. Additionally, the number of amide III bonds was increased with ELF-MF exposure in the cerebellum and left-brain tissue. In liver tissue higher Raman intensities were visible in the tissues from the ELF-MF group. In this group the electromagnetic field also caused structural changes in lipids. Principal component analysis (PCA) showed, that it

is possible to distinguish ELF-MF and control groups. Consequently, hierarchical component analysis (HCA) showed that tissues from ELF-MF and control groups separately created similarity with the groups. Obtained results suggest that the electromagnetic field caused structural and quantitative chemical changes in brain and liver tissue. Additionally, present data suggest that ELF-MF plays an important role in the regulation of enzyme activity and has effects on biochemical processes, possibly improved by production of ROS.

https://pubmed.ncbi.nlm.nih.gov/35189391/

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Comparing the Effects of Long-term Exposure to Extremely Low-frequency Electromagnetic Fields With Different Values on Learning, Memory, Anxiety, and β-amyloid Deposition in Adult Rats

Faraji N, Salehi I, Alizadeh A, Pourgholaminejad A, Komaki A, Taheri Azandaryani M, et al . Comparing the Effects of Long-term Exposure to Extremely Low-frequency Electromagnetic Fields With Different Values on Learning, Memory, Anxiety, and β-amyloid Deposition in Adult Rats. BCN. 2021; 12 (6) :849-860

Abstract

Introduction: Extremely Low-Frequency Electromagnetic Fields (ELF-EMFs) have gathered significant consideration for their possible pathogenicity. However, their effects on the nervous system's functions were not fully clarified. This study aimed to assay the impact of ELF-EMFs with different intensities on memory, anxiety, antioxidant activity, β-amyloid (Aβ) deposition, and microglia population in rats.

Methods: Fifty male adult rats were randomly separated into 5 groups; 4 were exposed to a flux density of 1, 100, 500, and 2000 microtesla (μT), 50 Hz frequency for one h/day for two months, and one group as a control group. The control group was without ELF-EMF stimulation. After 8 weeks, passive avoidance and Elevated Plus Maze (EPM) tests were performed to assess memory formation and anxiety-like behavior, respectively. Total free thiol groups and the index of lipid peroxidation were evaluated. Additionally, for detection of Aβ deposition and stained microglia in the brain, anti-β-amyloid and anti-Iba1 antibodies were used.

Results: The step-through latency in the retention test in ELF-EMF exposure groups (100500 & 2000 μT) was significantly greater than the control group ($P<0.05$). Furthermore, the frequency of the entries into the open arms in ELF-EMF exposure groups (especially 2000 μT) decreased than the control group ($P<0.05$). No Aβ depositions were detected in the hippocampus of different groups. An increase in microglia numbers in the 100, 500, and 2000 μT groups was observed compared to the control and one μT group.

Conclusion: Exposure to ELF-EMF had an anxiogenic effect on rats, promoted memory, and induced oxidative stress. No Aβ depositions were detected in the brain. Moreover, the positive impact of ELF-EMF was observed on the microglia population in the brain.

http://bcn.iums.ac.ir/article-1-1740-en.html

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The potential role of UV and blue light from the sun, artificial lighting, and electronic devices in melanogenesis and oxidative stress

Enrique Navarrete de Gálvez, José Aguilera, Alba Solis, María Victoria de Gálvez, José Ramón de Andrés, Enrique Herrera-Ceballos, Alfonso Gago-Calderon. The potential role of UV and blue light from the sun, artificial lighting, and electronic devices in melanogenesis and oxidative stress. J Photochem Photobiol B. 2022 Feb 4;228:112405. doi: 10.1016/j.jphotobiol.2022.112405 article

Highlights

• LED technology is being increasingly used in electronic devices and to provide both indoor and outdoor lighting.
• Normal daily dose of blue light emitted by LED devices is less than 5% compared to sun for inducing skin pigmentation.
• Long time LED overexposure as during the COVID-19 lockdown enhance risk factors for hyperpigmentation.

Abstract

Our exposure to blue light from artificial sources such as indoor lights (mainly light-emitting diodes [LEDs]) and electronic devices (e.g., smartphones, computer monitors, and television screens), has increased in recent years, particularly during the recent coronavirus disease 2019 lockdown. This radiation has been associated to skin damage across its potential in generating reactive oxygen species in both the epidermis and the dermis, skin water imbalances and of potential activating melanin production. These circumstances make it important to determine whether current blue light exposure levels under artificial illumination and electronic devices exposure can cause the previously indicated disorders as compared to solar UV and visible radiation in a typical summer day. Blue light accounted for 25% of the sun's rays, approximately 30% of radiation emitted by electronic devices, and approximately from 6% to 40% of that emitted by indoor lights. The reference equations showed that the sun was the main source of effective irradiance for immediate and persistent pigmentation as well as for potential oxidative stress in our skin. Effective blue light exposure to artificial devices is significantly lower than the solar contribution. However, its contribution must be considered as accumulative dose effect, and especially in people with hypersensitivity promoting skin hyperpigmentation.

Conclusions

Exposure to blue light has health consequences, including photoaging and hyperpigmentation. LED technology is being increasingly used to provide both indoor and outdoor lighting and it emits a considerable proportion of blue light. The effective irradiance for PPD, IPD and oxidative stress emitted by sun and the different artificial light devices calculated for an office worker show that the contribution of sources other than the sun to the effects of PPD and IPD is less than 1% and less than 5% for the case of oxidative stress. Despite the low effective irradiance emitted by electronic devices and artificial light compared to solar radiation, that could lead to think no photo damaging effect of artificial devices, we must consider that the responses of the skin are a consequence of the integration of all daily exposure to light and all sources of radiation. Blue lights are

potentially harmful to our skin in the long terms. In any case, in the absence of sunlight, artificial sources lack the potential to induce photodamage to the skin under normal use conditions, with the exception of photosensitive patients as well as high skin phototypes. These people must protect themselves when exposed to sources of blue light....

Open access paper: https://www.sciencedirect.com/science/article/pii/S1011134422000197

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Magnetotactic advantage in stable sediment by long-term observations of magnetotactic bacteria in Earth's field, zero field and alternating field

Xuegang Mao, Ramon Egli, Xiuming Liu, Lijuan Zhao. Magnetotactic advantage in stable sediment by long-term observations of magnetotactic bacteria in Earth's field, zero field and alternating field. PLoS One. 2022 Feb 24;17(2):e0263593. doi: 10.1371/journal.pone.0263593.

Abstract

Magnetotactic bacteria (MTB) rely on magnetotaxis to effectively reach their preferred living habitats, whereas experimental investigation of magnetotactic advantage in stable sediment is currently lacking. We studied two wild type MTB (cocci and rod-shaped M. bavaricum) in sedimentary environment under exposure to geomagnetic field in the laboratory, zero field and an alternating field whose polarity was switched every 24 hours. The mean concentration of M. bavaricum dropped by ~50% during 6 months in zero field, with no clear temporal trend suggesting an extinction. Cell numbers recovered to initial values within ~1.5 months after the Earth's field was reset. Cocci displayed a larger temporal variability with no evident population changes in zero field. The alternating field experiment produced a moderate decrease of M. bavaricum concentrations and nearby extinction of cocci, confirming the active role of magnetotaxis in sediment and might point to a different magnetotactic mechanism for M. bavaricum which possibly benefited them to survive field reversals in geological periods. Our findings provide a first quantification of magnetotaxis advantage in sedimentary environment.==

Open access paper: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0263593

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Possible health effects on the human brain by various generations of mobile telecommunication: a review based estimation of 5G impact

Hiie Hinrikus, Tarmo Koppel, Jaanus Lass, Hans Orru, Priit Roosipuu, Maie Bachmann. Possible health effects on the human brain by various generations of mobile telecommunication: a review based estimation of 5G impact. Int J Radiat Biol. 2022 Jan 7;1-48. doi: 10.1080/09553002.2022.2026516.

Abstract

Purpose: The deployment of new 5G NR technology has significantly raised public concerns in possible negative effects on human health by radiofrequency electromagnetic fields (RF EMF). The current review is aimed to clarify the differences between possible health effects caused by the various generations of telecommunication technology, especially discussing and projecting possible health effects by 5G. The review of experimental studies on the human brain over the last fifteen years and the discussion on physical mechanisms and factors determining the dependence of the RF EMF effects on frequency and signal structure have been performed to discover and explain the possible distinctions between health effects by different telecommunication generations.

Conclusions: The human experimental studies on RF EMF effects on the human brain by 2G, 3G and 4G at frequencies from 450 to 2500 MHz were available for analyses. The search for publications indicated no human experimental studies by 5G nor at the RF EMF frequencies higher than 2500 MHz. The results of the current review demonstrate no consistent relationship between the character of RF EMF effects and parameters of exposure by different generations (2G, 3G, 4G) of telecommunication technology. At the RF EMF frequencies lower than 10 GHz, the impact of 5G NR FR1 should have no principal differences compared to the previous generations. The radio frequencies used in 5G are even higher and the penetration depths of the fields are smaller, therefore the effect is rather lower than at previous generations. At the RF EMF frequencies higher than 10 GHz, the mechanism of the effects might differ and the impact of 5G NR FR2 becomes unpredictable. Existing knowledge about the mechanism of RF EMF effects at millimeter waves lacks sufficient experimental data and theoretical models for reliable conclusions. The insufficient knowledge about the possible health effects at millimeter waves and the lack of in vivo experimental studies on 5G NR underline an urgent need for the theoretical and experimental investigations of health effects by 5G NR, especially by 5G NR FR2.

https://pubmed.ncbi.nlm.nih.gov/34995145/

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Mobile phone electromagnetic radiation and the risk of headache: a systematic review and meta-analysis

Sajjad Farashi, Saeid Bashirian, Salman Khazaei, Mojtaba Khazaei, Abdollah Farhadinasab. Mobile phone electromagnetic radiation and the risk of headache: a systematic review and meta-analysis. Int Arch Occup Environ Health. 2022 Jan 22. doi: 10.1007/s00420-022-01835-x.

Abstract

Purpose: The effects of electromagnetic fields of mobile phones on headaches have attracted researchers during the last decades. However, contradictory results have been reported so far.

Methods: In this systematic review and meta-analysis, major databases including PubMed, Scopus and Web of Science were searched using suitable search terms and PRISMA guidelines to retrieve eligible studies for the effect of mobile phone use on headache. After the abstract and full-text screening, 33 studies were retrieved and the effect size in terms of odds ratio (OR) was extracted. Between-study heterogeneity was assessed using I2 statistic and Q test, while publication bias was evaluated by funnel plot and Egger's and Begg's tests.

Results: Among 33 eligible studies, 30 eligible studies were included in the meta-analysis. When considering all studies, the pooled effect size of OR = 1.30 (95% CI 1.21-1.39) was obtained, while the heterogeneity between studies was significant. Subgroup analyses by considering the age of participants and EMF exposure duration were performed to find the source of heterogeneity. The odds ratios when the age of participants was the variable were 1.33 (95% CI 1.14-1.53) and 1.29 (95% CI 1.20-1.37), for ages > 18 and age ≤ 18 years, respectively. When EMF exposure duration was considered, subgroup analysis obtained the pooled effect size of OR = 1.41 (95% CI 1.22-1.61) and 1.23 (95% CI 1.12-1.34), for EMF exposure duration > 100 and ≤ 100 minutes per week, respectively. The pooled effect sizes emphasized the effect of mobile phone use on headaches for all ages and exposure durations.

Conclusion: Results revealed that age and exposure duration (mainly call duration), both were the source of heterogeneity between studies. Furthermore, results showed that increasing call duration and mobile phone use in older individuals increased the risk of headache.

Conclusion

Since the mobile phone becomes an indispensable device for many people, its effects on human health have been the center of attention during past decades. The current study focused on the effect of mobile phone-emitted EMFs on headaches as a common problem between children and adults. Results showed the adverse effect of mobile phones on headaches for young and adult individuals. Results showed that increasing EMF exposure (mainly call duration) augmented such effects. Furthermore, the results of studies were more homogeneous for the older population (age > 18 years) as compared with the younger group (age ≤ 18 years). In this study, all types of headaches were considered in a unique category, while their brain mechanisms might be different. In this regard, electromagnetic radiation emitted by mobile phones may influence different types of headaches in different ways. In addition, exposure time (duration in which individuals used mobile phones) is another important factor that is relatively different between included studies in this meta-analysis. These issues might be responsible for between-study heterogeneity observed in the current study.

https://pubmed.ncbi.nlm.nih.gov/35064837/

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Mobile Phone Radiation Deflects Brain Energy Homeostasis and Prompts Human Food Ingestion

Wardzinski EK, Jauch-Chara K, Haars S, Melchert UH, Scholand-Engler HG, Oltmanns KM. Mobile Phone Radiation Deflects Brain Energy Homeostasis and Prompts Human Food Ingestion. Nutrients. 2022 Jan 14;14(2):339. doi: 10.3390/nu14020339.

Abstract

Obesity and mobile phone usage have simultaneously spread worldwide. Radio frequency-modulated electromagnetic fields (RF-EMFs) emitted by mobile phones are largely absorbed by the head of the user, influence cerebral glucose metabolism, and modulate neuronal excitability. Body weight adjustment, in turn, is one of the main brain functions as food intake behavior and appetite perception underlie hypothalamic regulation. Against this background, we questioned if mobile phone radiation and food intake may be related. In a single-blind, sham-controlled, randomized crossover comparison, 15 normal-weight young men (23.47 ± 0.68 years) were exposed to 25 min of RF-EMFs emitted by two different mobile phone types vs. sham radiation under fasting conditions. Spontaneous food intake was assessed by an ad libitum standard buffet test and cerebral energy homeostasis was monitored by ^{31}phosphorus-magnetic resonance spectroscopy measurements. Exposure to both mobile phones strikingly increased overall caloric intake by 22-27% compared with the sham condition. Differential analyses of macronutrient ingestion revealed that higher calorie consumption was mainly due to enhanced carbohydrate intake. Measurements of the cerebral energy content, i.e., adenosine triphosphate and phosphocreatine ratios to inorganic phosphate, displayed an increase upon mobile phone radiation. Our results identify RF-EMFs as a potential contributing factor to overeating, which underlies the obesity epidemic. Beyond that, the observed RF-EMFs-induced alterations of the brain energy homeostasis may put our data into a broader context because a balanced brain energy homeostasis is of fundamental importance for all brain functions. Potential disturbances by electromagnetic fields may therefore exert some generalized neurobiological effects, which are not yet foreseeable.

Conclusions

Our human study demonstrates that the RF-EMFs radiation emitted by mobile phones results in significantly increased food ingestion, particularly carbohydrate intake. Moreover, a deflected cerebral high-energy phosphate metabolism, which is closely related to food intake and body weight, was found after mobile phone use. Therefore, our results identify RF-EMFs as a potential contributing factor to overeating in humans, which underlies the worldwide obesity epidemic. Beyond this, RF-EMF-induced alterations of the brain energy homeostasis, as observed here, may put our data into a broader context because a balanced central nervous energy homeostasis is of fundamental importance, not only for the regulation of food intake and body weight, but also for all brain functions. Therefore, with good cause, the high priority of this research field was already emphasized a long time ago by the WHO Research Agenda for Radiofrequency Fields [65]. Perhaps our data could serve as first step towards deeper insight into this issue and open a new perspective in neurobiological and obesity research.

Open access paper: https://www.mdpi.com/2072-6643/14/2/339/htm

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Effects of radiofrequency electromagnetic fields (RF EMF) on cancer in laboratory animal studies (WHO SR2)

Meike Mevissen, Jerrold M. Ward, Annette Kopp-Schneider, James P. McNamee, Andrew W. Wood, Tania M. Rivero, Kristina Thayer, Kurt Straif. Effects of radiofrequency electromagnetic fields (RF EMF) on cancer in laboratory animal studies. Environment International. Volume 161, 2022. 107106. doi: 10.1016/j.envint.2022.107106.

Abstract

Background The carcinogenicity of radiofrequency electromagnetic fields (RF EMF) has been evaluated by the International Agency for Research on Cancer (IARC) in 2011. Based on limited evidence of carcinogenicity in humans and in animals, RF EMF were classified as possibly carcinogenic to humans (Group 2B). In 2018, based on a survey amongst RF experts, WHO prioritized six major topics of potential RF EMF related human health effects for systematic reviews. In the current manuscript, we present the protocol for the systematic review of experimental laboratory animal studies (cancer bioassays) on exposure to RF fields on the outcome of cancer in laboratory animals.

Objective In the framework of WHO's Radiation Program, the aim of this work is to systematically evaluate effects of RF EMF exposure on cancer in laboratory animals.

Study eligibility and criteria WHO's Handbook (2014) for guideline development will be followed with appropriate adaptation. The selection of eligible studies will be based on Population, Exposures, Comparators, and Outcomes (PECO) criteria. We will include peer-reviewed articles and publicly available reports from government agencies reporting original data about animal cancer bioassays on exposure to RF EMF. The studies are identified by searching the following databases: MEDLINE (PubMed), Science Citation Index Expanded and Emerging Sources Citation Indes (Web of Science), Scopus, and the EMF Portal. No language or year-of-publication restrictions are applied. The methods and results of eligible studies will be presented in accordance with the PRISMA 2020 guidelines.

Study appraisal method Study evaluation of individual studies will be assessed using a risk of bias (RoB) tool developed by the Office of Health Assessment and Translation (OHAT) with appropriate considerations including sensitivity for evaluating RF EMF exposure in animal cancer bioassays. The final evaluation on the certainty of the evidence on a carcinogenic risk of RF EMF exposure in experimental animals will be performed using the OHAT Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach with appropriate considerations. The protocol has been registered in an open-source repository (PROSPERO).

Funding The study is partly financially supported by the World Health Organization. No additional funding was provided outside author salaries through their places of employment.

Declaration of Competing Interest The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: AWW directs a research group, which includes three technical associates who are telecommunications company employees. JM receives employment and research support from The government of Canada related to the topic. KS has been the Head of the IARC Monographs program until his regular retirement (11/2018). Since 10/2019, he is a member of the International Scientific Advisory Committee of the Ramazzini Institute. This involves one 3 h advisory group meeting per year. He does not receive remuneration for his advisory activity. MM is a member of the scientific advisory board of The Swiss Research Foundation for Electricity and Mobile Communication (FSM) that receives research money from commercial entities. She does not receive remuneration for his advisory activity. Her partner does consulting relating to cell phone safety. All remaining authors declare no conflict of interest.

https://www.sciencedirect.com/science/article/pii/S0160412022000320

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iPhone 12 MagSafe technology and cardiac implantable devices: assessment of the actual risk

Federica Censi, Eugenio Mattei, Graziano Onder, Giovanni Calcagnini. iPhone 12 MagSafe technology and cardiac implantable devices: assessment of the actual risk. Pacing Clin Electrophysiol. 2022 Jan 25. doi: 10.1111/pace.14450.

Abstract

Background: Pacemaker (PM) and implantable cardioverter defibrillators (ICD) are equipped with a magnetic sensor activated by external application of magnets to easily manage some functions of these devices. If activated inadvertently or outside a controlled environment and without the supervision of clinical personnel, this magnetic mode introduces a potential risk. In reality, the possibility of a static magnetic field affecting a PM or ICD is remote. However, the presence of the magnet in the iPhone 12 made the possibility of inadvertently activating the magnetic switch of PM and ICD less remote.

Objective: This study investigates the effects of magnetic interference of the iPhone 12 on a large set of cardiac implantable devices representative of the current market and proposes adequate rules of conduct.

Methods: We investigated the risk of the magnetic interference of the iPhone 12 and its MagSafe accessories on a comprehensive set of PMs and ICDs, including the subcutaneous ICD. For the first time, the magnetic interference phenomena were correlated with the magnetic field levels measured all around iPhone 12.

Results: We discovered that the magnets inside iPhone 12 trigger the magnetic mode in the 12 tested devices up to a distance of 1 cm.

Conclusions: Considering the implications related to the activation of the magnetic switch, to date, it is advisable to follow Apple's indications relating to the safety distance of 15 cm, which is widely compatible with the results obtained from this paper and in line with the indications provided by the implantable cardiac device manufacturers.

https://pubmed.ncbi.nlm.nih.gov/35076120/

Excerpts

"Apple also found it appropriate to emphasize in the instructions for use that “Medical devices such as implanted pacemakers and defibrillators may contain sensors capable of reacting to magnets and radio frequencies when in close contact. To avoid potential interactions with these devices, keep your iPhone and MagSafe accessories at a safe distance from the device (more than 15 centimeters away, or more than 30 centimeters if wireless charging is activated). [15]

Considering the implications related to the activation of the magnetic switch of cardiac implantable devices, as a rule of conduct, to date, it is advisable to follow Apple's indications relating to the safety distance of 15 cm, which are widely compatible with the results obtained from this paper and in line with the indications provided

by the manufacturers of the implantable cardiac devices. However, since in real-life scenarios such distance is not always respected, it would be advisable to alert the patient about this specific iPhone 12 concern. Also, it would be important to investigate this question further for the new iPhone models, as long as they still remain MagSafe compatible."

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Interference by Modern Smartphones and Accessories with Cardiac Pacemakers and Defibrillators

Fahd Nadeem, Cao Thach Tran, Estelle Torbey, Daniel Philbin, Carlos Morales, Michael Wu. Interference by Modern Smartphones and Accessories with Cardiac Pacemakers and Defibrillators. Curr Cardiol Rep. 2022 Jan 27. doi: 10.1007/s11886-022-01653-0.

Abstract

Purpose of review: The risk of cardiac implantable electronic device (CIED) interference from cell phones was previously thought to be low based on older studies. Current generation of smartphones have incorporated more magnets for optimization of wireless charging, attachment of accessories, and convenience functionalities. These magnets have the potential to cause CIEDs to inadvertently revert into magnet mode. The purpose of this review is to summarize recent findings on smartphones and their accessories causing interference on CIEDs.

Recent findings: Recent reports have demonstrated that the iPhone 12 series and accessories have the capability to cause CIED magnetic interference. Current generation of smartphones, smartwatches, wireless headphones, and accessories have the potential to cause CIEDs to revert into magnet mode in both in vivo and ex vivo experiments. The risk of a clinically significant event is unlikely as long as the Food and Drug Administration (FDA) recommendations are followed; keeping smartphones and accessories at least six inches away from CIEDs.

https://pubmed.ncbi.nlm.nih.gov/35084671/

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Auditory Effects of Microwave Radiation

James C. Lin. Auditory Effects of Microwave Radiation. Springer, 2021. ISBN 978-3-030-64543-4 ISBN 978-3-030-64544-1 (eBook). doi:10.1007/978-3-030-64544-1

This book examines the human auditory effects of exposure to beams of high-power microwave pulses, which research results have shown can cause a cascade of health events when aimed at a human subject or the subject's head. The book details multidisciplinary investigations using physical theories and models, physiological events and phenomena, and computer analysis and simulation. Coverage includes brain anatomy and physiology, dosimetry of microwave power deposition, microwave auditory effect, interaction mechanisms, and shock/pressure wave induction. The book will be welcomed by scientists, academics, health professionals, and practicing engineers as an important contribution to the continuing study of the effects of microwave pulse absorption on humans.

https://doi.org/10.1007/978-3-030-64544-1

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Exposure Assessment to Radiofrequency Electromagnetic Fields in Occupational Military Scenarios: A Review

Gallucci S, Fiocchi S, Bonato M, Chiaramello E, Tognola G, Parazzini M. Exposure Assessment to Radiofrequency Electromagnetic Fields in Occupational Military Scenarios: A Review. Int J Environ Res Public Health. 2022 Jan 14;19(2):920. doi: 10.3390/ijerph19020920.

Abstract

Background: Radiofrequency radiations are used in most devices in current use and, consequently, the assessment of the human exposure to the radiofrequency radiations has become an issue of strong interest. Even if in the military field there is wide use of radiofrequency devices, a clear picture on the exposure assessment to the electromagnetic field of the human beings in the military scenario is still missing.

Methods: a review of the scientific literature regarding the assessment of the exposure of the military personnel to the RF specific to the military environment, was performed.

Results: the review has been performed grouping the scientific literature by the typology of military devices to which the military personnel can be exposed to. The military devices have been classified in four main classes, according to their intended use: communication devices, localization/surveillance devices, jammers and EM directed-energy weapons.

Discussion and Conclusions: The review showed that in the exposure conditions here evaluated, there were only occasional situations of overexposure, whereas in the majority of the conditions the exposure was below the worker exposure limits. Nevertheless, the limited number of studies and the lack of exposure assessment studies for some devices prevent us to draw definitive conclusions and encourage further studies on military exposure assessment.

Conclusions

In conclusion, this study provides an overview of the current used military devices and of the exposure studies that have been performed to characterize the exposure environment in the military scenario with the aim to analyze the state of the art regarding the interaction between the soldier and the RF-EMFs emitted by military devices. The results include four different typologies of systems, each one for different intended use: communication, localization, jamming, and electronic weaponry.

The reviewed studies about the assessment of the human exposure to the radiation emitted by the above mentioned military devices suggest that in the exposure conditions here evaluated, there were only occasional situations of overexposure, but the large number of variables involved in the description of these scenarios, the wide heterogeneity of the exposure conditions and the absence of exposure evaluation for some specific devices make further studies necessary, also considering upcoming use of other technologies, such as 5G, which will dramatically change the exposure conditions also in military environment, both in terms of the time and conditions exposure and in terms of intrinsic sources characteristics, such as the used frequency ranges.

Open access paper: https://www.mdpi.com/1660-4601/19/2/920/htm

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Numerical Evaluation of Human Body Near Field Exposure to a Vehicular Antenna for Military Applications

Colella Micol, Biscarini Marianna, de Meis Marco, Patrizi Roberto, Ciallella Tino, Ferrante Daniele, De Gaetano Alessandro, Capuano Marco, Pellegrino Giovanni, Martini Emanuele, Cavagnaro Marta, Apollonio Francesca, Liberti Micaela. Numerical Evaluation of Human Body Near Field Exposure to a Vehicular Antenna for Military Applications. Frontiers in Public Health.Vol. 9. 2022. doi:10.3389/fpubh.2021.794564.

Abstract

Background The use of electromagnetic (EM) technologies for military applications is gaining increasing interest to satisfy different operational needs, such as improving battlefield communications or jamming counterpart's signals. This is achieved by the use of high-power EM waves in several frequency bands (e.g., HF, VHF, and UHF). When considering military vehicles, several antennas are present in close proximity to the crew personnel, which are thus potentially exposed to high EM fields.

Methods A typical exposure scenario was reproduced numerically to evaluate the EM exposure of the human body in the presence of an HF vehicular antenna (2–30 MHz). The antenna was modeled as a monopole connected to a 3D polygonal structure representing the vehicle. Both the EM field levels in the absence and in the presence of the human body and also the specific absorption rate (SAR) values were calculated. The presence of the operator, partially standing outside the vehicle, was simulated with the virtual human body model Duke (Virtual Population, V.3). Several exposure scenarios were considered. The presence of a protective helmet was modeled as well.

Results In the area usually occupied by the personnel, E-field intensity radiated by the antenna can reach values above the limits settled by international safety guidelines. Nevertheless, local SAR values induced inside the human body reached a maximum value of 14 mW/kg, leading to whole-body averaged and 10-g averaged SAR values well below the corresponding limits.

Conclusion A complex and realistic near-field exposure scenario of the crew of a military vehicle was simulated. The obtained E-field values radiated in the free space by a HF vehicular antenna may reach values above the safety guidelines reference levels. Such values are not necessarily meaningful for the exposed subject. Indeed, SAR and E-field values induced inside the body remain well below safety limits.

Open access paper: https://www.frontiersin.org/articles/10.3389/fpubh.2021.794564

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A coherent framework for non-ionising radiation protection

Tinker R, Abramowicz J, Karabetsos E, Magnusson S, Matthes R, Moser M, Niu S, O'Hagan J, van Deventer E. A coherent framework for non-ionising radiation protection. J Radiol Prot. 2022 Jan 12;42(1). doi: 10.1088/1361-6498/ac3bc3.

Abstract

A coherent and overarching framework for health protection from non-ionising radiation (NIR) does not currently exist. Instead, many governments maintain different compliance needs targeting only some NIR exposure situations. An international framework developed by the World Health Organization would promote a globally consistent approach for the protection of people from NIR. Designed based on decades of practical experience the framework provides guidance on establishing clear national health and safety objectives and how they should be achieved. It supports multisectoral action and engagement by providing a common language and systematic approach for managing NIR. The framework should allow governments to respond to policy challenges on how to achieve effective protection of people, especially in a world that is rapidly deploying new NIR technologies. In this paper the concepts and key features are presented that underpin the framework for NIR protection, including examples of implementation.

Open access paper: https://iopscience.iop.org/article/10.1088/1361-6498/ac3bc3

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A Monte Carlo Analysis of Actual Maximum Exposure From a 5G Millimeter-Wave Base Station Antenna for EMF Compliance Assessments

Xu Bo, Anguiano Sanjurjo David, Colombi Davide, Törnevik Christer. A Monte Carlo Analysis of Actual Maximum Exposure From a 5G Millimeter-Wave Base Station Antenna for EMF Compliance Assessments. Frontiers in Public Health. Vol 9. 2022. doi:10.3389/fpubh.2021.777759.

Abstract

International radio frequency (RF) electromagnetic field (EMF) exposure assessment standards and regulatory bodies have developed methods and specified requirements to assess the actual maximum RF EMF exposure from radio base stations enabling massive multiple-input multiple-output (MIMO) and beamforming. Such techniques are based on the applications of power reduction factors (PRFs), which lead to more realistic, albeit conservative, exposure assessments. In this study, the actual maximum EMF exposure and the corresponding PRFs are computed for a millimeter-wave radio base station array antenna. The computed incident power densities based on near-field and far-field approaches are derived using a Monte Carlo analysis. The results show that the actual maximum exposure is well below the theoretical maximum, and the PRFs similar to those applicable for massive MIMO radio base stations operating below 6 GHz are also applicable for millimeter-wave frequencies. Despite the very low power levels that currently characterize millimeter-wave radio base stations, using the far-field approach can also guarantee the conservativeness of the PRFs used to assess the actual maximum exposure close to the antenna.

Open access paper: https://www.frontiersin.org/article/10.3389/fpubh.2021.777759

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RF-EMF Exposure Measurement for 5G over mm-Wave Base Station with MIMO Antenna

S. Q. Wali, A. Sali, J. K. Allami, A. F. Osman. RF-EMF Exposure Measurement for 5G over mm-Wave Base Station with MIMO Antenna. *IEEE Access*. 2022. doi: 10.1109/ACCESS.2022.3143805.

Abstract

The fifth-generation (5G) technology offers more capacity and data rates than the previous generations. It provides ultra-low latency and ultra-high dependability, allowing for efficient services in many industries. Using radiofrequency electromagnetic fields (RF-EMF) above 6 GHz in 5G millimeter Wave(mm-Wave) base stations has concerned many people due to the potential health risks caused by EMF exposure. This study aims to measure the maximum exposure emitted by a 5G mm-Wave base station by utilizing international standards in both its assessment methodology and exposure limits. In this study, the R&S®TSMA6 scanner, R&S®ROMES4 software, and R&S®TSME30DC down converter have been used for the measurement campaign; in addition to the user equipment device (UE), GPS, and an omnidirectional antenna. The investigation is based on a code selective method due to the radiated power fluctuations over time with data traffic. To conduct the measurement, six tests are taken based on three different time frames, antenna directions, and user equipment device (UE) to investigate the RF-EMF exposure. The maximum and average exposure from the 5G mm-Wave base station are calculated and compared with the ICNIRP standard. The maximum exposure from the 29.5 GHz base station is found to be 5.71 V/m, and the highest amount of average exposure is 2.02V/m. In this study, it was found that the maximum and average exposure (RF-EMF) produced from a single 5G mm-Wave base station are well within the allowed RF-EMF standard limit.

Excerpts

This section presents the methodology used in performing this work. To conduct the measurement at the base station, different scenarios and tests were chosen. Choosing a location to take the measurement was the second step. After going around the area for a few hours, the location was chosen based on getting the highest received power. The measurement was conducted in the car park of Rekascape Cyberjaya, Selangor at a 5G mm-Wave base station, the distances between the transmitter and receiver were 22 m that the highest amount of power was received. The scenario had been selected in the line of sight (LOS) location; six different tests were selected one of them was measured without connecting the UE device to the base station, while, in the other five tests, the UE device was connected to the base station. The measurement in the LOS scenario had been taken in three different standard times to know when the maximum exposure will be recorded and to illustrate the time effect on the exposure level. Measurement was conducted at 1 minute as a default time, 6 minutes based on the ICNIRP [53]standard, and 30 minutes depending on the IEEE [54] and ICNIRP [55] standard. To analyze the Electrical field strength per channel [V/m] and Electrical field of the 5G mm-Wave base station, the data was extracted from the scanner. Then, the data was sorted in an excel sheet based on the top (n) to normal sorting where every signal synchronization block (SSB) had a fixed column to analyze the electrical field per channel in 5G base station. The maximum electric field strength (Emax) and the average electric-field strength (Avg) were analyzed. Finally, the maximum exposure and average exposure will be compared to ICNIRP [50] standard to ensure the safety of deploying 5G mm-Wave in Malaysia....

In this paper, the RF-EMF exposure for 5G over the mm-Wave base station with a MIMO antenna was investigated. From the literature, no study has been carried out analyzing the exact level of exposure from mmWave base station making it the first of its kind in Malaysia. This study investigated and elaborated on how to take the measurement, sort, extract, and calculate the data. Besides, the effect of time duration on the amount of exposure, various antenna directions, and using UE devices on six different tests was elaborated. For all the tests, the distance between the 5G mm-Wave base station (Tx) and the receiver (Rx) was the same, and the location was chosen based on getting the maximum power. It can be noticed from the data that there is a slight difference in the amount of produced exposure between the first test which is without UE, and the other tests that the UE device was connected to the BS, so the UE does not have a noticeable impact on the measurement results. The experimental results ensure that the time has a modest impact on the level of exposure, in the three-time frames. A high level of Emax from the 5G mm-Wave base station was recorded in the second, third, and fourth tests. The maximum exposure called the worst-case scenario is much higher than the average exposure emitted at the 5G mm-Wave base station. The maximum exposure at the base station among all the tests is 5.71V/m, which is recorded in video streaming from YouTube, and this value is significantly lower than the ICNIRP standard accepted limit of exposure, which is 61V/m [50]. The highest average exposure, which is 2.02V/m at the video call test, is well below the accepted RF-EMF exposure by the ICNIRP standard at the same time, it was found that the level of exposure at the mm-Wave base station is not zero. It was found that the Emax and Eavg from 5G mm-Wave selected base station in this work, are within the limits, indicating that it does not have effects on human health. Nevertheless, there is a need for further investigations on the RF-EMF exposure from 5G mm-Wave in areas that are surrounded by many mm-Wave base stations and for a longer measurement time duration.

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No Alteration Between Intrinsic Connectivity Networks by a Pilot Study on Localized Exposure to the Fourth-Generation Wireless Communication Signals (4G)

Yang Lei, Liu Qingmeng, Zhou Yu, Wang Xing, Wu Tongning, Chen Zhiye. No Alteration Between Intrinsic Connectivity Networks by a Pilot Study on Localized Exposure to the Fourth-Generation Wireless Communication Signals. Frontiers in Public Health. Vol 9. 2022. doi:10.3389/fpubh.2021.734370.

Abstract

Neurophysiological effect of human exposure to radiofrequency signals has attracted considerable attention, which was claimed to have an association with a series of clinical symptoms. A few investigations have been conducted on alteration of brain functions, yet no known research focused on intrinsic connectivity networks, an attribute that may relate to some behavioral functions. To investigate the exposure effect on functional connectivity between intrinsic connectivity networks, we conducted experiments with seventeen participants experiencing localized head exposure to real and sham time-division long-term evolution signal for 30 min. The resting-state functional magnetic resonance imaging data were collected before and after exposure, respectively. Group-level independent component analysis was used to decompose networks of interest. Three

states were clustered, which can reflect different cognitive conditions. Dynamic connectivity as well as conventional connectivity between networks per state were computed and followed by paired sample t-tests. Results showed that there was no statistical difference in static or dynamic functional network connectivity in both real and sham exposure conditions, and pointed out that the impact of short-term electromagnetic exposure was undetected at the ICNs level. The specific brain parcellations and metrics used in the study may lead to different results on brain modulation.

Open access paper: https://www.frontiersin.org/article/10.3389/fpubh.2021.734370

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Compare fabric and brick wall as shielding material dependence on electromagnetic field

M. Pavlík, J. Zbojovský, I. Kolcunová. Compare of fabric and brick wall as shielding material dependence on electromagnetic field*. 2021 IEEE 4th International Conference and Workshop Óbuda on Electrical and Power Engineering (CANDO-EPE)*, 2021, pp. 139-142, doi: 10.1109/CANDO-EPE54223.2021.9667841.

Abstract

The electromagnetic field is a much discussed topic, especially now with the advent of 5G networks. The general public is concerned about the possible impact of the electromagnetic field on human health. By using wireless technologies, we increase the influence of the electromagnetic field on the human body. The basic measures for the protection against electromagnetic radiation are: 1. shielding of the radiation source, 2. shielding of the workplace, 3. personal protective equipment, 4. reduction of radiation in the immediate vicinity of the radiation source. In the household it is possible to shade the “working” environment which is our house. In this paper, we focused on measuring the shielding efficiency of the electromagnetic field. Shielding effectiveness is an indicator of the shielding ability of the material. The measured objects were a brick and a shielding fabric, which can be used practically anywhere. The research focused on the frequency range from 1 GHz to 9 GHz. The results showed the shielding ability achieved by the brick material and the shielding fabric.

Excerpts

A brick wall with 33cm thickness (Fig. 3) and a shielding fabric (Fig. 2) were placed in the middle between the antennas. The shielding fabric was attached to polystyrene. The shielding efficiency of the polystyrene on which the fabric was attached was also measured during the experiment. The shielding efficiency of the polystyrene was subtracted from the total shielding efficiency of the shielding fabric. The composition of the shielding fabric is approximately 68% cotton, 16% polyester, 16% stainless steel....

The current trend of increasing the sources of the electromagnetic field will probably not stop. We can assume that the number of sources of the electromagnetic field will continue to increase. As mentioned in the introduction, the basic measures for the protection against electromagnetic radiation are: 1. shielding of the radiation source, 2. shielding of the workplace, 3. personal protective equipment, 4. reduction of radiation in the immediate vicinity of the radiation source. However, not all are feasible. At present, however, there are many ways to protect yourself from the effects of the electromagnetic field. The basic protection against the external electromagnetic field is provided by buildings, which prevent the penetration of the electromagnetic field into

the interior. However, inside the building, there are many sources of electromagnetic fields that are commonly used. It is therefore possible to additionally protect yourself, for example by using shielding materials which can be commercially purchased. Such a material is, for example, a shielding fabric.

In this paper, we focused on measuring the shielding efficiency, which is an indicator of the shielding ability of the material. The measurement was performed on the basis of [6] IEEE 299–2006 Standard: Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures, EMC Society. The research focused on the frequency range from 1 GHz to 9 GHz. The shielding ability of both materials was monitored. From the results shown in Fig. 4 we can see the shielding ability of both materials. The brick wall shading efficiency gradually increases in the monitored frequency band up to 5.5 GHz. At higher frequencies, the shielding efficiency remains approximately the same. The shielding efficiency of the shielding fabric does not change much in the monitored frequency range. The results of the research show that the shielding fabric is a more suitable material than brick wall, which could be assumed. However, it must be said that brick wall is a material that is commonly available in the house. The shielding fabric can be used to supplement and increase the shielding ability. Since we need an electromagnetic field for the functionality of, for example, a mobile phone, wifi internet, etc., it would be appropriate to use a shielding fabric when these devices are not in use. For example, at night. In futures we could other materials be used to shield the radiation, for example materials used for thermal and acoustic insulation of buildings.

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Assessment of cortisol secretory pattern in workers chronically exposed to ELF-EMF generated by high voltage transmission lines and substation

Yvan Touitou, Brahim Selmaoui, Jacques Lambrozo. Assessment of cortisol secretory pattern in workers chronically exposed to ELF-EMF generated by high voltage transmission lines and substations. Environ Int. 2022 Feb 1;161:107103. doi: 10.1016/j.envint.2022.107103

Abstract

We investigated the effects of extremely-low frequency electromagnetic fields (ELF-EMFs; 50 Hz) on the secretion of cortisol in 14 men (mean age = 38.0 ± 0.9 years) working in extra-high voltage (EHV) substations. The workers dwelt in houses that were close to substations and high-voltage lines. Thus, they had long histories (1-20 years) of long-yerm exposure to ELF-EMFs. Magnetic field strength was recorded using Emdex dosimeters worn by the volunteers day and night for seven days; the one-week geometric mean ranged from 0.1 to 2.6 µT. Blood samples were taken hourly from 20:00 to 08:00 the next morning. Cortisol concentrations and patterns were compared to age-matched, unexposed control subjects whose exposure level was ten times lower. The comparison of the control group (n = 15) and the groups exposed to fields of 0.1-0.3 µT (n = 5) and > 0.3 µT (n = 9), respectively, revealed a significant effect of field intensity on the cortisol secretory pattern. This study strongly suggests that chronic exposure to ELF-EMFs alters the peak-time serum cortisol levels. Studies are required on the effect of this disruption in high-risk populations such as children, elderly people, and patients with cancer.

Highlights

• Health risks, including cancer, are associated with exposure to electric and magnetic fields.
• Most available literature describes biological changes following short-term exposure.
• Additional effects due to long-term exposure cannot be ruled out.
• Hypothalamic-pituitary-adrenal axis and ELF-EMF relationship has been highlighted.
• We report a decline in the peak-time concentration of cortisol in workers exposed for 1 to 20 years.
• Cortisol secretion and the related biological mechanisms should be monitored in long-term exposure to ELF-EMF.

Open access paper: https://www.sciencedirect.com/science/article/pii/S0160412022000290

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Receipt of Electroconvulsive Therapy and Subsequent Development of Amyotrophic Lateral Sclerosis: A Cohort Study

Gabor Mezei, Edmund Lau, Nelson D Pace, Jamie Schenk, Leeka Kheifets. Receipt of Electroconvulsive Therapy and Subsequent Development of Amyotrophic Lateral Sclerosis: A Cohort Study. Bioelectromagnetics. 2022 Feb;43(2):81-89. doi: 10.1002/bem.22389.

Abstract

We investigated the potential relationship between receipt of electroconvulsive therapy (ECT) and development of amyotrophic lateral sclerosis (ALS). We conducted a cohort study using a sample of more than one million beneficiaries enrolled in the U.S. Medicare health insurance program from 1997 to 2017. Using time-varying proportional hazard modeling, we compared ALS occurrence among patients diagnosed with psychiatric conditions who received ECT to ALS occurrence among patients diagnosed with psychiatric conditions but who did not receive ECT. We observed moderately increased, but imprecise, hazard ratios (HR) for ALS following ECT (HR = 1.39, 95% confidence interval [CI]: 0.69-2.80). A statistically significant increase in the HR of ALS was observed among those who received more than 10 ECT treatments (>10 treatments, HR = 2.24, 95% CI: 1.00-5.01), compared to those receiving no ECT, with an even stronger association observed among subjects older than 65 years (HR = 3.03, 95% CI: 1.13-8.10). No monotonic exposure-response relationship was detected in categorical analyses. Our results provide weak support for the hypothesis that receipt of ECT increases the risk of developing ALS. Additional studies in larger populations, or in populations where ECT is more common, will be needed to refute or confirm an association between receipt of ECT and subsequent development of ALS.

https://pubmed.ncbi.nlm.nih.gov/35066895/

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Chain-Like Structures of Biogenic and Nonbiogenic Magnetic Nanoparticles in Vascular Tissues

Svitlana Gorobets, Oksana Gorobets, Yuri Gorobets, Maryna Bulaievska. Chain-Like Structures of Biogenic and

Nonbiogenic Magnetic Nanoparticles in Vascular Tissues. Bioelectromagnetics. 2022 Feb;43(2):119-143. doi: 10.1002/bem.22390.

Abstract

In this paper, slices of organs from various organisms (animals, plants, fungi) were investigated by using atomic force microscopy and magnetic force microscopy to identify common features of localization of both biogenic and nonbiogenic magnetic nanoparticles. It was revealed that both biogenic and nonbiogenic magnetic nanoparticles are localized in the form of chains of separate nanoparticles or chains of conglomerates of nanoparticles in the walls of the capillaries of animals and the walls of the conducting tissue of plants and fungi. Both biogenic and nonbiogenic magnetic nanoparticles are embedded as a part of the transport system in multicellular organisms. In connection with this, a new idea of the function of biogenic magnetic nanoparticles is discussed, that the chains of biogenic magnetic nanoparticles and chains of conglomerates of biogenic magnetic nanoparticles represent ferrimagnetic organelles of a specific purpose. Besides, magnetic dipole-dipole interaction of biogenic magnetic nanoparticles with magnetically labeled drugs or contrast agents for magnetic resonance imaging should be considered when designing the drug delivery and other medical systems because biogenic magnetic nanoparticles in capillary walls will serve as the trapping centers for the artificial magnetic nanoparticles. The aggregates of both artificial and biogenic magnetic nanoparticles can be formed, contributing to the risk of vascular occlusion.

https://pubmed.ncbi.nlm.nih.gov/35077582/

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Effect of the prenatal electromagnetic field exposure on cochlear nucleus neurons and oligodendrocytes in rats

Levent Tümkaya, Orhan Bas, Tolga Mercantepe, Seda Cınar, Abdulkadir Özgür, Zihni Acar Yazici. Effect of the prenatal electromagnetic field exposure on cochlear nucleus neurons and oligodendrocytes in rats. Environ Sci Pollut Res Int. 2022 Feb 3. doi: 10.1007/s11356-021-18325-1.

Abstract

Electromagnetic radiation from elecromagnetic field (EMF) sources has been an important health concern for a long time. The vast majority of this exposure is due to the widespread use of mobile phones, an important source of the EMF. The EMF generated by mobile phones may have adverse effects on the various biological structures that regulate the body system and function. In this study, it was aimed to evaluate histopathologically the effects of 900-megahertz (MHz) EMF application in the prenatal period on the development of the ventral cochlear nucleus, which is the first place of hearing in the brainstem, at various time points of the postnatal period in rats. In the study, Sprague-Dawley pregnant rats were divided randomly into two groups as the control group and the EMF group. The rats in the EMF group were exposed to a 900-MHz EMF every day until birth, while no EMF was applied to the rats in the control group. Auditory brainstem responses of both groups were recorded on the postnatal 13th day, the day the hearing starts. Newborn rats were sacrificed by anesthesia on

days 7, 10, 15, and 30. Contrary to the control group, structural damage in cochlear nuclear neurons and oligodendrocyte cell structures and increased caspase-3 activity were observed in the postnatal period in the EMF groups. However, no significant difference was observed between the groups in terms of structural damage and caspase-3 activity at different stages of the postnatal period when cochlear nucleus development was observed. According to ABS, there was no significant difference between the average latency of waves in both groups. In conclusion, this study shows that 900-MHz electromagnetic waves propagated from mobile phones during the prenatal period have no harmful effects on the development of the ventral cochlear nucleus of rats.

https://pubmed.ncbi.nlm.nih.gov/35112244/

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Effects of mobile phone electromagnetic radiation on rat hippocampus proteome

Kumari Vandana Singh, Rakesh Arya, Jay Prakash Nirala, Debasis Sahu, Ranjan Kumar Nanda, Paulraj Rajamani. Effects of mobile phone electromagnetic radiation on rat hippocampus proteome. Environ Toxicol. 2022 Jan 5. doi: 10.1002/tox.23447.

Abstract

Worldwide, the number of mobile phone users has increased from 5.57 billion in 2011 to 6.8 billion in 2019. However, short- and long-term impact of the electromagnetic radiation emitting from mobile phones on tissue homeostasis with particular to brain proteome composition needs further investigation. In this study, we attempted a global proteome profiling study of rat hippocampus exposed to mobile phone radiation for 20 weeks (for 3 h/day for 5 days/week) to identify deregulated proteins and western blot analysis for validation. As a result, we identified 358 hippocampus proteins, of which 16 showed deregulation (log2 (exposed/sham) ≥ ±1.0, p-value <.05). Majority of these deregulated proteins grouped into three clusters sharing similar molecular pathways. A set of four proteins (Succinate-semialdehyde dehydrogenase: Aldh5a1, Na+ K+ transporting ATPase: Atp1b2, plasma membrane calcium transporting ATPase: PMCA and protein S100B) presenting each functional pathway were selected for validation. Western blot analysis of these proteins, in an independent sample set, corroborated the mass spectrometry findings. Aldh5a1 involve in cellular energy metabolism, both Atp1b2 and PMCA responsible for membrane transport and protein S100B have a neuroprotective role. In conclusion, we present a deregulated hippocampus proteome upon mobile phone radiation exposure, which might influence the healthy functioning of the brain.

https://pubmed.ncbi.nlm.nih.gov/34984797/

Excerpts

Post 1 week of introducing animals to experimental animal house, exposure experiments were undertaken. Each animal in exposure group (n = 5) was subjected to radiofrequency signals from a set of 3G mobile phone (n = 5)

(Samsung Galaxy J2, Korea) kept on the Plexiglass cage (18.5 cm l 8.5 cm w 8.5 cm h) between 10.00 am and 1.00 pm for 20 weeks (3 h/day, 5 days/week)....

The emitted 3G mobile phone radiofrequency signal used for exposure study was 1964.7 MHz. During the experimental period, the average receiving power density of mobile phones measured at different time points (W0, W6, W13, and W20) for exposure group (video calling mode), sham group (switched off mode) and control group (Open field exposure) were 0.06, 6.55 x 10 - 5, and 3.48 x 10 - 7 mW/cm2, respectively (Figure 2A). The average whole-body SAR for animals of MP-RF-EMR exposed, sham and control groups calculated at four-time points (W0, W6, W13, and W20) were 0.015, 1.34 x 10 -5, and 9.15 x 10 - 9 W/kg, respectively (Figure 2B)....

Conclusion

In this study, we report an altered hippocampus proteome in rats exposed to MP-RF-EMR for 20 weeks. We identified a set of important proteins involved in either energy metabolism (Aldh5a1, Idh3b, and ADP/ATP translocase 1), transmembrane ion pumps (Atp1b2, PMCA) or are markers of neurodegeneration or protection (S100B) in MP-RF-EMR exposed groups. At the systemic level, we did not observe stress and did not affect the brain or total body weight gain. MP-RF-EMR exposure may interfere with the nerve signaling causing hyperexcitability in neurons. For meeting energy demand and to restore neuronal resting potential, change in the hippocampal proteome might have provided an adaptive strategy. This study gives a meaningful insight into the possible effect of MP-RF-EMR on rat hippocampus proteome. Clinical significance of these findings with particular emphasis on humans needs focused studies. Elucidating the short- and long-term impact of mobile phone radiation in different biological systems is critical to generate advisory for its healthy usage.

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Effect of electromagnetic radiation on the liver structure and ultrastructure of in utero irradiated rats

Katarína Holovská, Viera Almášiová, Sandra Andrašková, Zuzana Demčišáková, Enikő Račeková, Viera Cigánková. Effect of electromagnetic radiation on the liver structure and ultrastructure of in utero irradiated rats. Acta Vet. Brno 2021, 90: 315-319. doi:10.2754/avb202190030315.

The aim of this study was to observe the influence of electromagnetic radiation (EMR) on the structure and ultrastructure of the rat's liver. The pregnant rats used in the experiment were exposed to a pulsed microwave radiation (frequency of 2.45 GHz; mean power density of 2.8 mW/cm2) daily for 2 h, throughout their pregnancy. After delivery, the offspring was not exposed to EMR. Samples of the liver of 5-week-old offspring were subjected to histopathological evaluation. They were processed for light and transmission electron microscopy. Our results indicated that EMR did not cause pronounced changes in the structure of the liver of the investigated offspring. The size and shape of liver lobuli was preserved and the amount of connective tissue in the liver parenchyma did not increase. However, electron microscopy revealed changes in the shape and number of microvilli at the vascular pole of hepatocytes, and formation of vesicles of various shapes and sizes. The endothelial cells were swollen with larger fenestrations compared to the control group. The spaces of Disse were irregular and dilated. Even though these changes were only mild, further studies are needed to determine the effect of EMR and clarify its potential risk during pregnancy.

Open access paper: https://actavet.vfu.cz/media/pdf/actavet_2021090030315.pdf

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Effects of Acute Exposure to 3500 MHz (5G) Radiofrequency Electromagnetic Radiation on Anxiety-Like Behavior and the Auditory Cortex in Guinea Pigs

Yang H, Zhang Y, Wu X, Gan P, Luo X, Zhong S, Zuo W. Effects of Acute Exposure to 3500 MHz (5G) Radiofrequency Electromagnetic Radiation on Anxiety-Like Behavior and the Auditory Cortex in Guinea Pigs. Bioelectromagnetics. 2022 Jan 23. doi: 10.1002/bem.22388.

Abstract

Numerous studies have shown that radiofrequency electromagnetic radiation (RF-EMR) may negatively affect human health. We detected the effect of 3500 MHz RF-EMR on anxiety-like behavior and the auditory cortex (ACx) in guinea pigs. Forty male guinea pigs were randomly divided into four groups and exposed to a continuous wave of 3500 MHz RF-EMF at an average specific absorption rate (SAR) of 0, 2, 4, or 10 W/kg for 72 h. After exposure, malondialdehyde (MDA) levels, antioxidant enzyme activity, anxiety-like behavior, hearing thresholds, cell ultrastructure, and apoptosis were detected. Our results revealed that hearing thresholds and basic indexes of animal behavior did not change significantly after exposure ($P > 0.05$). However, the MDA levels of ACx were increased ($P < 0.05$), and catalase (CAT), superoxide dismutase (SOD), and glutathione peroxidase (GSH-px) activities were decreased ($P < 0.05$) in the exposure groups compared to the sham group. Ultrastructural changes of ACx, including swollen mitochondria and layered myelin sheaths, were observed. Cytochrome-c relocalization, caspase-9, and cleaved caspase-3 activation were detected in the exposure groups. In conclusion, these results suggest that oxidative stress is an important mechanism underlying the biological effects of RF-EMR, which can induce ultrastructural damage to the ACx and cell apoptosis through a mitochondria-dependent mechanism. Moreover, oxidative stress, apoptosis induction and ultrastructural damage increase in a SAR-dependent manner. However, RF-EMR does not increase hearing thresholds or induce anxiety.

https://pubmed.ncbi.nlm.nih.gov/35066900/

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Potential factors affecting chronic chemical intolerance associated with constitutional predisposition or lifestyle and environment during childhood: From a six-year follow-up study

Kenichi Azuma, Iwao Uchiyama, Naoki Kunugita. Potential factors affecting chronic chemical intolerance associated with constitutional predisposition or lifestyle and environment during childhood: From a six-year follow-up study. J Psychosom Res. 2021 Dec;151:110665. doi: 10.1016/j.jpsychores.2021.110665.

Abstract

Objective: The Japanese chemical intolerance (JCI) study was conducted in January 2012 with a cohort of 7245 adults from population-based sampling. This study aimed to investigate the childhood constitutional and

environmental factors involved in the development of chronic CI from the prospective cohort study.

Methods: In the cohort, 4683 persons were identified after six years. Self-reported questionnaires were administered to the subjects to obtain information on CI status; medical history; constitution, lifestyle, and housing environment during childhood; and recent psychosomatic states. We assessed the differences between individuals with persisting CI status during the follow-up (defined as chronic CI) and controls not having CI status during the follow-up.

Results: A total of 2500 individuals responded. Multiple logistic regression analyses revealed significant associations between chronic CI and motion sickness to car or bus and allergic conjunctivitis during childhood. Significant associations between a possible increased risk of CI and the existence of high-voltage power lines close to housing, the use of vinyl covering in wall material, the use of strong perfume by a family member, and the experience of stinky odor of paint or wax at elementary school were observed. However, the use of carpet in floor material and plaster coating in wall material was associated with a possible decreased risk of CI.

Conclusions: Some potential constitutional predisposition from childhood, including inherent susceptibility in the autonomic nervous system may be involved in the development of CI.

https://pubmed.ncbi.nlm.nih.gov/34763204/

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Association of Excessive Mobile Phone Usage With Sleep Quality and Fatigue Severity: an Epidemiologic Survey in Saudi Population

Al-khlaiwi T, Habib S. Association of Excessive Mobile Phone Usage With Sleep Quality and Fatigue Severity: an Epidemiologic Survey in Saudi Population. KMUJ. 13(2):60-5. 2021. doi: 10.35845/kmuj.2021.20531.

Abstract

OBJECTIVE: To determine the effect of mobile phone usage on sleep quality and fatigue severity through standard questionnaires in Saudi Arabia mobile phone users.

METHODS: This cross-sectional study was conducted in Riyadh, Saudi Arabia on 251 mobile phone users from September 2019 to January 2020. Volunteer mobile phone users aging 15-65 years were selected by nonprobability convenience sampling technique from the Riyadh city community. The subjects were interviewed about the knowledge, attitude and practice of mobile phone use and were assessed through Pittsburg Sleep Quality index (PSQI) and Fatigue severity scale (FSS). Spearman's correlations and Linear regression were applied for statistical analysis through SPSS V.22.

RESULTS: Mean age of study participants was 32.43±12.8 years. There was a significant increase in PSQI and FSS with increase in daily mobile usage. When participants exceeded one-hour daily usage, PSQI (<1h=3.75, 1-2 h=5.78, >2h=6.85, p= 0.001) and FSS (<1h= 2.25, 1-2h= 3.17, >2h= 3.61, p=0.008) exceeded acceptable scores.

Moreover, placing mobile phone inside bedroom was associated with the increase of PSQI (Near Pillow=6.93, Inside Bed=6.16, Outside bed=5.75, p=0.001) and FSS (Near Pillow=3.65, Inside Bed=3.39, Outside Bed=2.58, p= 0.008). There was a significant increase in PSQI (Near Pillow=6.93, Inside Bed=6.16, Outside bed=5.75, p=0.001) and FSS (Near Pillow=3.65, Inside Bed=3.39, Outside Bed=2.58, p= 0.008) its location inside bedrooms. Significant correlation was observed between high PSQI and FSS with daily usage (r=0.213, p=0.001 & r=0.171, p=0.01 respectively).

CONCLUSION: Inappropriate and excessive mobile phone usage is associated with poor sleep quality and excessive fatigue in Saudi Arabian population.

Open access paper: https://www.kmuj.kmu.edu.pk/article/view/20531

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Zinc affects nuclear factor kappa b and DNA methyltransferase activity in C3H cancer fibroblast cells induced by a 2100 MHz electromagnetic field

D Duzgun Ergun, N Pastaci Ozsobaci, T Yilmaz, D Ozcelik, M T Kalkan. Zinc affects nuclear factor kappa b and DNA methyltransferase activity in C3H cancer fibroblast cells induced by a 2100 MHz electromagnetic field. Electromagn Biol Med. 2022 Jan 7;1-8. doi: 10.1080/15368378.2021.2019760.

Abstract

The use of mobile phones is becoming widespread with the development of technology, and as a result, its effects on human health are becoming more and more important every day. Studies have reported that the electromagnetic field (EMF) emitted by mobile phones may have adverse effects on the biological systems. In order to evaluate the effect of zinc (Zn) on C3H cancer fibroblast cells exposed to 2100 MHz EMF, we analyzed cell viability%, nuclear factor kappa b (NF-κB) and DNA methyltransferase (DNMT) activities. Cells were divided to following groups: Control, sham control, 2100 MHz EMF, 50 µM Zn + 2100 MHz EMF, 100 µM Zn + 2100 MHz EMF, and 200 µM Zn + 2100 MHz EMF for 2 h. We measurement cell viability, NF-κB and DNMT activities. There was increased cell viability % in the 2100 MHz EMF group compared to the control group, while the cell viability % was decreased in the 50, 100 and 200 µM Zn + 2100 MHz EMF groups compared to 2100 MHz EMF. NF-κB and DNMT activities were a significant increase in the 2100 MHz EMF group compared to the control group, although were statistically decreased in the 50, 100 and 200 µM Zn + 2100 MHz EMF groups compared to the 2100 MHz EMF group. Our results demonstrate that 2100 MHz EMF exposure in cancer fibroblast cells induce NF-κB and DNMT activities, whereas zinc supplementation reduce NF-κB and DNMT activities-induced 2100 MHz EMF.

https://pubmed.ncbi.nlm.nih.gov/34994293

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Acute and Chronic Exposure to 900 MHz Radio Frequency Radiation Activates p38/JNK-mediated MAPK Pathway in Rat Testis

Hakan Er, Gizem Gamze Tas, Bikem Soygur, Sukru Ozen, Leyla Sati. Acute and Chronic Exposure to 900 MHz Radio Frequency Radiation Activates p38/JNK-mediated MAPK Pathway in Rat Testis. Reprod Sci. 2022 Jan 11. doi: 10.1007/s43032-022-00844-y.

Abstract

The use of electronic devices such as mobile phones has had a long stretch of rapid growth all over the world. Therefore, exposure to radio frequency radiation (RFR) has increased enormously. Here, we aimed to assess the balance between cell death and proliferation and also investigate the involvement of the JNK/p38 MAPK signaling pathway in the testis of rats exposed to 900 MHz RFR in acute and chronic periods (2 h/day, 5 days/week) for 1 or 10 weeks, respectively. The expression of proliferating cell nuclear antigen (PCNA), Bcl-xL, cleaved caspase-3, phosphorylated-JNK (p-JNK), and phosphorylated-p38 (p-p38) was analyzed in line with histopathology and TUNEL analysis in rat testis. There were no histopathological differences between sham and RFR groups in the acute and chronic groups. PCNA expression was not altered between groups in both periods. However, alterations for cleaved caspase-3 and Bcl-xL were observed depending on the exposure period. TUNEL analysis showed a significant increase in the RFR group in the acute period, whereas no difference in the chronic groups for the apoptotic index was reported. In addition, both p-p38 and p-JNK protein expressions increased significantly in RFR groups in both periods. Our study indicated that 900 MHz RFR might result in alterations during acute period exposure for several parameters, but this can be ameliorated in the chronic period in rat testis. Here, we also report the involvement of the p38/JNK-mediated MAPK pathway after exposure to 900 MHz RFR. Hence, this information might shed light in future studies toward detailed molecular mechanisms in male reproduction and infertility.

https://pubmed.ncbi.nlm.nih.gov/35015292/

Excerpts

The carrier frequency was 900 MHz, the modulation frequency was 217 Hz, the pulse width was 0.577 ms, and the power range of the generator was 0–10 W....

During the experiment in the “signal on” situation, the measured electric field strengths over the rats’ heads positioned 3.5 cm away from the antenna were 35.5 V/m for 900 MHz....The electric field background level was between 0.02 and 0.2 V/m in the shielded room. Also, the background magnetic field was measured between 0.01 and 0.03 μT...

The average whole-body SAR value at 900 MHz was 1.159 W/kg. The SAR value for the testes was on the average of 0.107 W/kg. Prior to and after all experimental sessions, the body temperatures of rats were monitored by rectal measurements. The RFR exposure did not lead to any rectal temperature raise....

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A Review of the Effect of the Intermediate Frequency Electromagnetic Fields on Female Reproduction

Stephanie Mohammed. A Review of the Effect of the Intermediate Frequency Electromagnetic Fields on Female Reproduction. Health Phys. 2022 Jan 7. doi: 10.1097/HP.0000000000001516.

Abstract

The use of intermediate frequency (IF) fields in occupational equipment and domestic appliances is increasing dramatically. The World Health Organization consistently points out that there is a lack of scientific evidence to assess the reproductive risk in female species within the exposure limits as stated by the International Commission on Non-Ionizing Radiation Protection. The purpose of this review paper is to review the available literature on the effects of IF EMR on female reproduction in all species and to fully understand these effects. A literature review of experimental, epidemiological, in vivo, and in vitro literature from the 1800s to the present was conducted. Very few studies have been conducted on the effects of IF on female reproduction. The study of women in their workplace, laboratory rats and mice, and chicken embryos has yielded conflicting results on the dangers of IF. Some reports consider IF harmful during pregnancy, while other results show an insignificant ($p < 0.05$) correlation between the exposed group and the unexposed groups. The experiments conducted so far restrict several parameters such as field strength, frequency, and modulation to draw definitive conclusions. In two experiments, this frequency range is considered safe for non-invasive treatment of cancerous and noncancerous ovarian cells in the initial phase. Evaluation of the IF range on reproduction should be a priority for research. This review shows that there are few reports in this field, and they all contradict each other on whether the IF field is harmful or not. Nonetheless, IF is used in medicine to treat cancer and is currently being researched for non-cancerous cells. More comprehensive IF studies should be conducted to address the limitations in these summary studies.

https://pubmed.ncbi.nlm.nih.gov/34999661/

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Electromagnetic Exposure of Personnel Involved in Cardiac MRI Examinations in 1.5T, 3T and 7T Scanners

Katarzyna Sklinda, Jolanta Karpowicz, Andrzej Stępniewski. Electromagnetic Exposure of Personnel Involved in Cardiac MRI Examinations in 1.5T, 3T and 7T Scanners. Int J Environ Res Public Health. 2021 Dec 22;19(1):76. doi: 10.3390/ijerph19010076.

Abstract

(1) Background: It has been hypothesised that a significant increase in the use of cardiac magnetic resonance (CMR), for example, when examining COVID-19 convalescents using magnetic resonance imaging (MRI), has an influence the exposure profiles of medical personnel to static magnetic fields (STmf). (2) Methods: Static exposure to STmf (SEmf) was recorded during activities that modelled performing CMR by radiographers. The

motion-induced time variability of that exposure (TVEmf) was calculated from SEmf samples. The results were compared with: (i) labour law requirements; (ii) the distribution of vertigo perception probability near MRI magnets; and (iii) the exposure profile when actually performing a head MRI. (3) Results: The exposure profiles of personnel managing 42 CMR scans (modelled using medium (1.5T), high (3T) and ultrahigh (7T) field scanners) were significantly different than when managing a head MRI. The majority of SEmf and TVEmf samples (up to the 95th percentile) were at low vertigo perception probability (SEmf < 500 mT, TVEmf < 600 mT/s), but a small fraction were at medium/high levels; (4) Conclusion: Even under the "normal working conditions" defined for SEmf (STmf < 2T) by labour legislation (Directive 2013/35/EC), increased CMR usage increases vertigo-related hazards experienced by MRI personnel (a re-evaluation of electromagnetic safety hazards is suggested in the case of these or similar changes in work organisation).

Open access paper: https://www.mdpi.com/1660-4601/19/1/76

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Exposure of Infants to Gradient Fields in a Baby MRI Scanner

Fangfang Tang, Luca Giaccone, Jiahao Hao, Fabio Freschi, Tongning Wu, Stuart Crozier, Feng Liu. Exposure of Infants to Gradient Fields in a Baby MRI Scanner. Bioelectromagnetics. 2022 Jan 10. doi: 10.1002/bem.22387.

Abstract

In pediatric magnetic resonance imaging (MRI), infants are exposed to rapid, time-varying gradient magnetic fields, leading to electric fields induced in the body of infants and potential safety risks (e.g. peripheral nerve stimulation). In this numerical study, the in situ electric fields in infants induced by small-sized gradient coils for a 1.5 T MRI scanner were evaluated. The gradient coil set was specially designed for the efficient imaging of infants within a small-bore (baby) scanner. The magnetic flux density and induced electric fields by the small x, y, z gradient coils in an infant model (8-week-old with a mass of 4.3 kg) were computed using the scalar potential finite differences method. The gradient coils were driven by a 1 kHz sinusoidal waveform and also a trapezoidal waveform with a 250 μs rise time. The model was placed at different scan positions, including the head area (position I), chest area (position II), and body center (position III). It was found that the induced electric fields in most tissues exceeded the basic restrictions of the ICNIRP 2010 guidelines for both waveforms. The electric fields were similar in the region of interest for all coil types and model positions but different outside the imaging region. The y-coil induced larger electric fields compared with the x- and z- coils.

https://pubmed.ncbi.nlm.nih.gov/35005795/

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Theoretical Concepts in Magnetobiology after 40 Years of Research

Vladimir N. Binhi, Andrei B. Rubin. Theoretical Concepts in Magnetobiology after 40 Years of Research. *Cells* 11, no. 2: 274. 2022. doi:10.3390/cells11020274.

(This article belongs to the Special Issue Magnetic Fields and Cells)

Abstract:

This review contains information on the development of magnetic biology, one of the multidisciplinary areas of biophysics. The main historical facts are presented and the general observed properties of magnetobiological phenomena are listed. The unavoidable presence of nonspecific magnetobiological effects in the everyday life of a person and society is shown. Particular attention is paid to the formation of theoretical concepts in magnetobiology and the state of the art in this area of research. Some details are provided on the molecular mechanisms of the nonspecific action of a magnetic field on organisms. The prospects of magnetobiology for the near and distant future are discussed.

Open access paper: https://www.mdpi.com/2073-4409/11/2/274/htm

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Nonequilibrium, weak-field-induced cyclotron motion: A mechanism for magnetobiology

Ashot Matevosyan, Armen E Allahverdyan. Nonequilibrium, weak-field-induced cyclotron motion: A mechanism for magnetobiology. Phys Rev E. 2021 Dec;104(6-1):064407. doi: 10.1103/PhysRevE.104.064407.

Abstract

There is a long-time quest for understanding physical mechanisms of weak magnetic field interaction with biological matter. Two factors impeded the development of such mechanisms: first, a high (room) temperature of a cellular environment, where a weak, static magnetic field induces a (classically) zero equilibrium response. Second, the friction in the cellular environment is large, preventing a weak field to alter nonequilibrium processes such as a free diffusion of charges. Here we study a class of nonequilibrium steady states of a cellular ion in a confining potential, where the response to a (weak, homogeneous, static) magnetic field survives strong friction and thermal fluctuations. The magnetic field induces a rotational motion of the ion that proceeds with the cyclotron frequency. Such nonequilibrium states are generated by a white noise acting on the ion additionally to the nonlocal (memory-containing) friction and noise generated by an equilibrium thermal bath. The intensity of this white noise can be weak, i.e., much smaller than the thermal noise intensity.

https://pubmed.ncbi.nlm.nih.gov/35030908/

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Human Psychophysiology Is Influenced by Low-Level Magnetic Fields: Solar Activity as the Cause

Michael Hanzelka, Jiří Dan, Pavel Fiala, Přemysl Dohnal. Human Psychophysiology Is Influenced by Low-Level Magnetic Fields: Solar Activity as the Cause. *Atmosphere* 12, no. 12: 1600. 2021. doi: 10.3390/atmos12121600

Abstract

We evaluate the impact of changes in solar activity on three significant human psychophysiological parameters: skin conductance, electromyography (EMG), and the share of abdominal and diaphragmatic breathing in overall ventilation. Variations affecting human psychophysiology due to changes in solar activity directly document the assertion that psychology, behavior, and decision-making all reflect geomagnetic field alterations that stem from variable solar activity. The relevant experiments showed that solar processes, during which the Earth is exposed to electrically charged particles from the Sun (solar wind), exert an impact on the psychophysiological parameters of the body.

Open access paper: https://www.mdpi.com/2073-4433/12/12/1600

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Broadband 75–85 MHz radiofrequency fields disrupt magnetic compass orientation in night-migratory songbirds consistent with a flavin-based radical pair magnetoreceptor

Leberecht, B., Kobylkov, D., Karwinkel, T. *et al.* Broadband 75–85 MHz radiofrequency fields disrupt magnetic compass orientation in night-migratory songbirds consistent with a flavin-based radical pair magnetoreceptor. *J Comp Physiol A* (2022). https://doi.org/10.1007/s00359-021-01537-8

Abstract

The light-dependent magnetic compass sense of night-migratory songbirds can be disrupted by weak radiofrequency fields. This finding supports a quantum mechanical, radical-pair-based mechanism of magnetoreception as observed for isolated cryptochrome 4, a protein found in birds' retinas. The exact identity of the magnetically sensitive radicals in cryptochrome is uncertain in vivo, but their formation seems to require a bound flavin adenine dinucleotide chromophore and a chain of four tryptophan residues within the protein. Resulting from the hyperfine interactions of nuclear spins with the unpaired electrons, the sensitivity of the radicals to radiofrequency magnetic fields depends strongly on the number of magnetic nuclei (hydrogen and nitrogen atoms) they contain. Quantum-chemical calculations suggested that electromagnetic noise in the frequency range 75–85 MHz could give information about the identity of the radicals involved. Here, we show that broadband 75–85 MHz radiofrequency fields prevent a night-migratory songbird from using its magnetic compass in behavioural experiments. These results indicate that at least one of the components of the radical pair involved in the sensory process of avian magnetoreception must contain a substantial number of strong hyperfine interactions as would be the case if a flavin–tryptophan radical pair were the magnetic sensor.

Open access paper: https://link.springer.com/article/10.1007%252Fs00359-021-01537-8

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Magnetoreception and magnetic navigation in fishes: a half century of discovery

Naisbett-Jones LC, Lohmann KJ. Magnetoreception and magnetic navigation in fishes: a half century of discovery. J Comp Physiol A Neuroethol Sens Neural Behav Physiol. 2022 Jan 15. doi: 10.1007/s00359-021-01527-w.

Abstract

As the largest and most diverse vertebrate group on the planet, fishes have evolved an impressive array of sensory abilities to overcome the challenges associated with navigating the aquatic realm. Among these, the ability to detect Earth's magnetic field, or magnetoreception, is phylogenetically widespread and used by fish to guide movements over a wide range of spatial scales ranging from local movements to transoceanic migrations. A proliferation of recent studies, particularly in salmonids, has revealed that fish can exploit Earth's magnetic field not only as a source of directional information for maintaining consistent headings, but also as a kind of map for determining location at sea and for returning to natal areas. Despite significant advances, much about magnetoreception in fishes remains enigmatic. How fish detect magnetic fields remains unknown and our understanding of the evolutionary origins of vertebrate magnetoreception would benefit greatly from studies that include a wider array of fish taxa. The rich diversity of life-history characteristics that fishes exhibit, the wide variety of environments they inhabit, and their suitability for manipulative studies, make fishes promising subjects for magnetoreception studies.

https://pubmed.ncbi.nlm.nih.gov/35031832/

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Magnetic stop signs signal a European songbird's arrival at the breeding site after migration

Joe Wynn, Oliver Padget, Henrik Mouritsen, Joe Morford, Paris Jaggers, Tim Guilford. Magnetic stop signs signal a European songbird's arrival at the breeding site after migration. Science. 2022 Jan 28;375(6579):446-449. doi: 10.1126/science.abj4210.

Abstract

Although it is known that birds can return to their breeding grounds with exceptional precision, it has remained a mystery how they know when and where to stop migrating. Using nearly a century's worth of Eurasian reed warbler (Acrocephalus scirpaceus) ringing recoveries, we investigated whether fluctuations in Earth's magnetic field predict variation in the sites to which birds return. Ringing recoveries suggest that magnetic inclination is learned before departure and is subsequently used as a uni-coordinate "stop sign" when relocating the natal or breeding site. However, many locations have the same inclination angle. Data from populations with different migratory directions indicate that birds solve this ambiguity by stopping at the first place where the right inclination is encountered on an inherited return vector.

https://pubmed.ncbi.nlm.nih.gov/35084979/

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Investigating the impact of weak geomagnetic fluctuations on pigeon races

Petr Jandačka, Hynek Burda, Jiří Ščučka. Investigating the impact of weak geomagnetic fluctuations on pigeon races. J Comp Physiol A Neuroethol Sens Neural Behav Physiol. 2022 Jan 28.doi: 10.1007/s00359-021-01534-x.

Abstract

The existence of avian magnetic orientation has been proved by many experimental studies, however, evidence for the use of magnetic cues by homing pigeons remains controversial. To investigate magnetic orientation by homing pigeons, we analyzed the results of pigeon races relative to weak fluctuations in the geomagnetic field, assuming that such disturbances could impact navigational efficiency if based on magnetoreception. Whereas most of the previous studies recorded and analyzed vanishing bearing of individually released pigeons, we evaluated relative duration of the homeward flight (homing speed, as a proxy of navigational efficiency) and its dependence on specific geomagnetic indices in racing pigeons released collectively. Our analysis of orientation efficiency of about 289 pigeon races over 15 years suggested slight negative correlations between geomagnetic fluctuations and homing time. Although the interpretation of this finding is manifold and not clear, it suggests that natural magnetic variations or disturbances can affect the homing orientation performance of pigeons. We suggest that studying pigeon races may have a heuristic potential and since these races are regularly and frequently organized in many countries all over the globe, examining homing performance relative to a suite of environmental variables may be useful for exploring hypotheses about pigeon navigation.

https://pubmed.ncbi.nlm.nih.gov/35088124/

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Effect of extremely low-frequency magnetic fields on light-induced electric reactions in wheat

Grinberg M, Mudrilov M, Kozlova E, Sukhov V, Sarafanov F, Evtushenko A, Ilin N, Vodeneev V, Price C, Mareev E. Effect of extremely low-frequency magnetic fields on light-induced electric reactions in wheat. Plant Signal Behav. 2022 Jan 7:2021664. doi: 10.1080/15592324.2021.2021664.

Abstract

Magnetic field oscillations resulting from atmospheric events could have an effect on growth and development of plants and on the responsive reactions of plants to other environmental factors. In the current work, extremely low-frequency magnetic field (14.3 Hz) was shown to modulate light-induced electric reactions of wheat (*Triticum aestivum* L.). Blue light-induced electric reaction in wheat leaf comprises depolarization and two waves of hyperpolarization resulting in an increase of the potential to a higher level compared to the dark one. Fluorescent and inhibitory analysis demonstrate a key role of calcium ions and calcium-dependent H^+-ATPase of the plasma membrane in the development of the reaction. Activation of H^+-ATPase by the increased calcium influx is suggested as a mechanism of the influence of magnetic field on light-induced electric reaction.

https://pubmed.ncbi.nlm.nih.gov/34994282/

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Health Safety Guidelines and 5G Wireless Radiation [Health Matters]

James C. Lin. Health Safety Guidelines and 5G Wireless Radiation [Health Matters]. *IEEE Microwave Magazine*. 23(1):10-17. Jan. 2022, doi: 10.1109/MMM.2021.3117307.

Abstract

The rollout of 5G cellular communication technology is well underway worldwide. The advocates of 5G mobile technology hail it as a faster and more secure technology than its predecessor, 3G and 4G systems. The major enabling infrastructure uses millimeter-wave (mm-wave) and phased-array technology to achieve line-of-sight directivity, high data rates, and low latency. A central vulnerability or security threat is that it may allow spying on users. Nevertheless, this is a system architecture and technology or regulatory issue but not a biological effect or health safety matter.

https://ieeexplore.ieee.org/document/9632507

My note: Like several past articles written by James C. Lin in *IEEE Microwave Magazine*, the abstract is biased so read the paper or the following excerpts.

Excerpts

Low-band 5G starts at roughly 400 MHz and uses existing or previous 3G or 4G frequencies or newly opened frequencies to operate; the latter, for example, may overlap with the existing 4G band. The 5G rollout began with midband, which includes popular frequencies between 3 and 4 GHz. However, primary 5G technological advances are associated with high-band 5G, which promises performance bandwidth as high as 20 GHz, and multiple-input, multiple-output strategies using 64–256 antennas at short distances and offering performances up to 10 times better than the current 4G networks."

"For health safety matters, it is not apparent whether the biological responses to high-band 5G radiations would be akin to earlier generations or low-band 5G radiations, given the distinctive characteristics of mm-wave and its interaction with the complex structure and composition of pertinent, superficial biological cells and tissues such as the cornea of the eye and nerve-rich human skin, the large, protective organ of the body."

"The two most widely promulgated RF health safety guidelines or standards have recently published revisions of their respective 1998 and 2005 versions [1], [2]. The updated International Commission on Nonionizing Radiation Protection guidelines and IEEE standards appear to cater to industry wishes; they are strongly linked to thermal effects associated with measurable temperature elevations. Also, the updates seem to have been synchronized to accommodate the 5G rollout."

"To date, there has not been a single reported epidemiological study that investigated mm-waves and their potential health effects.

Thus, although there are roughly 100 published laboratory investigations of all types, and the reported biological responses are inconsistent in their association between biological effects and mm-wave exposure. Indeed, the types of reported laboratory investigations are small, limited, and diverse, considering the wide, 5G,

mm-wave frequency domain. The jury on biological effects or health impacts is still out on 5G mm-waves. Moreover, there is a lack of ongoing, controlled laboratory investigations...."

"If the entities responsible for safety recommendations believe what appears to be their position concerning experimental results from rats from the NIEHS/NTP that a whole-body temperature rise of 1 °C is carcinogenic, then the safety factors of 50 adopted for the public or 10 for workers would be marginal for their stated purpose and practically meaningless from the perspective of “safety” protection (more so above 6 GHz)."

"As shown in Table 1, for mm-waves, the referenced local-tissue-temperature rise in the head, torso, and limbs of humans is 5 °C. This level of temperature rise would bring the tissue temperature from a normal value of 37 °C to a hyperthermic 42 °C. A 42 °C tissue temperature is known to be cytotoxic, with exponential cell-killing capacities. It is used as the basis for clinical cancer therapy in hyperthermia treatment for cancer protocols [14]–[16]. The recently updated safety recommendations provide a reduction factor of 10 for the public’s safety and a reduction factor of two in the case of workers. In this situation, the efficacy of these updated safety recommendations is borderline, and the updated recommendations are meaningless from the perspective of safety protection.

In summary, the safety recommendation updates were based primarily on limiting the tissue-heating potentials of RF radiation to elevate body temperatures. There are significant anomalies in the recently updated safety recommendations. Moreover, aside from the aforementioned anomalies, the existing scientific data are too limited—especially at mm-wavelengths—to make a reliable assessment or conclusion with any certainty. Some of the updated safety recommendations are marginal, questionable, and lack scientific justification from the perspective of safety protection."

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Health Effects of 5G Base Station Exposure: A Systematic Review

Tasneem Sofri, Hasliza A Rahim, Mohamedfareq Abdulmalek, Khatijahhusna Abd Rani, Mohd Hafizi Omar, Mohd Najib Mohd Yasin, Muzammil Jusoh, Ping Jack Soh. Health Effects of 5G Base Station Exposure: A Systematic Review. IEEE Access. Dec 30, 2021. doi: 10.1109/ACCESS.2021.3139385.

Abstract

The Fifth Generation (5G) communication technology will deliver faster data speeds and support numerous new applications such as virtual and augmented reality. The additional need for a larger number of 5G base stations has sparked widespread public concerns about their possible negative health impacts. This review analyzes the latest research on electromagnetic exposure on humans, with particular attention to its effect on cognitive performance, well-being, physiological parameters, and Electroencephalography (EEG). While most of their results indicated no changes in cognitive function, physiological parameters, or overall well-being, the strength of the EEG alpha wave is noticed to vary depending on various aspects of cognitive functions. However, the available studies have not investigated the health effects resulting from exposure from the 5G mobile phone and base station antennas from 700 MHz to 30 GHz on the cognitive performance, well-being subjective symptoms, human physiological parameters, and EEG of adults. There is a need for such research regarding this

current emerging technology. Such studies are significant in determining whether 5G technology is indeed safe for humans.

Conclusion

This work presents an analysis of exposure studies conducted using signals from 400 MHz to 1750 MHz (for 4G). From this analysis, the following conclusions are made:

• Most of the studies in literature using 2G/3G/4G showed no effects and no consistency in how exposure to these signals affected the cognitive, physiological parameters, well-being, and EEG of the volunteers.
• Most research on human cognition, physiological parameters, and well-being so far have focused on the impacts of GSM900/GSM1800/UMTS/4G MPs, GSM900/GSM1800/UMTS BSs, DECT, and Wi-Fi exposures.
• There is an absence of studies reporting the effects of 5G (700 MHz, 3.5 GHz, or 28 GHz) BS signals on adults in terms of cognitive performance, well-being, or physiological markers (heart rate, blood pressure, and body temperature).

Figure 9 and 10 illustrated the possible flowchart and schematic diagram to study the effects of 5G BS exposure signals for sub-6 GHz and mmWave bands (of up to 30 GHz) to human subjects. Data from such a study will be useful in explicitly determining the significance signal exposure from 5G BS on human health, considering their much closer proximity to users.

Open access paper: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9665755

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Wireless phone use in childhood and adolescence and neuroepithelial brain tumours: Results from the international MOBI-Kids study

[My note: Conducting this type of research is a complex endeavor with a high risk of failure. Although the authors made an exemplary effort to salvage the study via supplemental substudies and post-hoc analyses, they were unsuccessful in overcoming the study's methodologic problems. Hence, in my opinion the results seem uninterpretable. See https://www.saferemr.com/2013/05/mobi-kids-childhood-brain-tumor-risk.html for background on the Mobi-Kids study.]

G. Castaño-Vinyals, S. Sadetzki, R. Vermeulen, F. Momoli, M. Kundi, F. Merletti, M. Maslanyj, C. Calderon, J. Wiart, A.-K. Lee, M. Taki, M. Sim, B. Armstrong, G. Benke, R. Schattner, H.-P. Hutter, D. Krewski, C. Mohipp, P. Ritvo, J. Spinelli, B. Lacour, T. Remen, K. Radon, T. Weinmann, E.Th. Petridou, M. Moschovi, A. Pourtsidis, K. Oikonomou, P. Kanavidis, E. Bouka, R. Dikshit, R. Nagrani, A. Chetrit, R. Bruchim, M. Maule, E. Migliore, G. Filippini, L. Miligi, S. Mattioli, N. Kojimahara, N. Yamaguchi, M. Ha, K. Choi, H. Kromhout, G. Goedhart, A. 't Mannetje, A. Eng, C.E. Langer, J. Alguacil, N. Aragonés, M. Morales-Suárez-Varela, F. Badia, A. Albert, G. Carretero, E. Cardis. Wireless phone use in childhood and adolescence and neuroepithelial brain tumours:

Results from the international MOBI-Kids study. Environment International,160, 2022, 107069, doi: 10.1016/j.envint.2021.107069.

Abstract

In recent decades, the possibility that use of mobile communicating devices, particularly wireless (mobile and cordless) phones, may increase brain tumour risk, has been a concern, particularly given the considerable increase in their use by young people. MOBI-Kids, a 14-country (Australia, Austria, Canada, France, Germany, Greece, India, Israel, Italy, Japan, Korea, the Netherlands, New Zealand, Spain) case-control study, was conducted to evaluate whether wireless phone use (and particularly resulting exposure to radiofrequency (RF) and extremely low frequency (ELF) electromagnetic fields (EMF)) increases risk of brain tumours in young people. Between 2010 and 2015, the study recruited 899 people with brain tumours aged 10 to 24 years old and 1,910 controls (operated for appendicitis) matched to the cases on date of diagnosis, study region and age. Participation rates were 72% for cases and 54% for controls. The mean ages of cases and controls were 16.5 and 16.6 years, respectively; 57% were males. The vast majority of study participants were wireless phones users, even in the youngest age group, and the study included substantial numbers of long-term (over 10 years) users: 22% overall, 51% in the 20–24-year-olds. Most tumours were of the neuroepithelial type (NBT; n = 671), mainly glioma. The odds ratios (OR) of NBT appeared to decrease with increasing time since start of use of wireless phones, cumulative number of calls and cumulative call time, particularly in the 15–19 years old age group. A decreasing trend in ORs was also observed with increasing estimated cumulative RF specific energy and ELF induced current density at the location of the tumour. Further analyses suggest that the large number of ORs below 1 in this study is unlikely to represent an unknown causal preventive effect of mobile phone exposure: they can be at least partially explained by differential recall by proxies and prodromal symptoms affecting phone use before diagnosis of the cases. We cannot rule out, however, residual confounding from sources we did not measure. Overall, our study provides no evidence of a causal association between wireless phone use and brain tumours in young people. However, the sources of bias summarised above prevent us from ruling out a small increased risk.

https://www.sciencedirect.com/science/article/pii/S0160412021006942

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Very high radiofrequency radiation at Skeppsbron in Stockholm, Sweden from mobile phone base station antennas positioned close to pedestrians' heads

Tarmo Koppel, Mikko Ahonen, Michael Carlberg, Lennart Hardell. Very high radiofrequency radiation at Skeppsbron in Stockholm, Sweden from mobile phone base station antennas positioned close to pedestrians' heads. Environmental Research. Available online 4 January 2022, 112627 doi: 10.1016/j.envres.2021.112627.

Highlights

- Ambient radiofrequency radiation at Skeppsbron street, Stockholm, Sweden was measured.
- The area with highest average radiation was 12.1 V/m with maximum reading 31.6 V/m.

• Placement of mobile phone base stations at Skeppsbron represents poor radiofrequency infrastructure design yielding high exposure levels to the general public.

Abstract

In urban environment there is a constant increase of public exposure to radiofrequency electromagnetic fields from mobile phone base stations. With the placement of mobile phone base station antennas radiofrequency hotspots emerge. This study investigates an area at Skeppsbron street in Stockholm, Sweden with an aggregation of base station antennas placed at low level close to pedestrians' heads. Detailed spatial distribution measurements were performed with 1) a radiofrequency broadband analyzer and 2) a portable exposimeter. The results display a greatly uneven distribution of the radiofrequency field with hotspots. The highest spatial average across all quadrat cells was 12.1 V $m^{-}1$ (388 mW $m^{-}2$), whereas the maximum recorded reading from the entire area was 31.6 V $m^{-}1$ (2648 mW $m^{-}2$). Exposimeter measurements show that the majority of exposure is due to mobile phone downlink bands. Most dominant are 2600 and 2100 MHz bands used by 4G and 3G mobile phone services, respectively. The average radiofrequency radiation values from the earlier studies show that the level of ambient RF radiation exposure in Stockholm is increasing. This study concluded that mobile phone base station antennas at Skeppsbron, Stockholm are examples of poor radiofrequency infrastructure design which brings upon highly elevated exposure levels to popular seaside promenade and a busy traffic street.

https://www.sciencedirect.com/science/article/pii/S0013935121019289

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Trigger of a migraine headache among Thai adolescents smartphone users: a time series study

Wanna Chongchitpaisan, Phongtape Wiwatanadate, Surat Tanprawate, Assawin Narkpongphan, Nipapon Siripon. Trigger of a migraine headache among Thai adolescents smartphone users: a time series study. Environ Anal Health Toxicol. 2021 Mar;36(1):e2021006-0. doi: 10.5620/eaht.2021006.

Abstract

The study aims to investigate the effect of modern technology in the trigger of migraine headaches in high school students by using generalized estimating equation analysis. The prospective time series study was conducted in one hundred and forty-five smartphones using high school students in Chiang Mai Province who each completed a headache diary giving a total of 12,969 data entries. The smartphone output power was measured and recorded by a smartphone application. Smartphone use, sleep quality, anxiety, and depression also were assessed. Results revealed that the prevalence of repeated headache be 13.4% and migraine 16.9%. The migraine had the strongest association with handfree device use and internet use, followed by age and anxiety. Furthermore, the strongest effect of smartphone output power in triggering a migraine was found at ≤ 1.79×10-5 and 1.80-1.99×10-5 mW ranges. Meanwhile, Lag_6 of daily smartphone output power exposure produced the migraine effect in a reverse dose-response manner. The smartphone electromagnetic radiation

was a primary migraine trigger. The study results led to the recommendation to avoid triggers by use of smartphone talking with hand-free devices to prevent a recurrent migraine.

Conclusions

SOP, which is smartphone electromagnetic radiation, has a non-linear correlation with migraine headaches which has been called a window effect response. The result has also found migraine response to a delayed effect of SOP in the form of reverse dose-response. The delayed effect response on repeated exposure can recover and re-balance itself after exposure to electromagnetic radiation. Additionally, smartphone electromagnetic radiation has effects that fit the criteria for triggers that induce migraines. Finally, younger student, internet use and talking without hand-free devices were risk factors of migraines. It is recommended that limited time for smartphone talking with hand-free device and older age starting using smartphone be suggested in order to prevent migraine attack.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8207005/

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Answers and Questions: Forty Years in Bioelectromagnetics

Ben Greenebaum. Answers and Questions: Forty Years in Bioelectromagnetics. Bioelectromagnetics. 2021 Dec 2. doi: 10.1002/bem.22381.

Abstract

The work began in 1972 when three young assistant professors used a slime mold to see if electromagnetic fields would affect it. The fields did, though the effects were small and hard to tease out of the noise. The cell cycle was lengthened and there were changes in respiration. So, the next question was "how and why?" Further changes were seen using these and then other bacterial and eukaryotic cells in respiration, in ATP, in the protein replication chain, and so forth. Changes occurred even in cell extracts that lacked an intact plasma membrane. Nerve cells showed changes in leakage of neurotransmitters and in neurite outgrowth from excised ganglia. Based on some experiments with nerve cells, I also did some computer calculations, modeling the internal electric and magnetic fields and current densities in simplified representations of bone fractures and also of spinal cords in vertebrae. More recently, I have collaborated on some theoretical models of what fields might be doing at the cellular and molecular level, particularly with reference to the radical model. With each piece of research, my collaborators and I generally found a small piece of information about fields and biological systems; and each answer raised another set of questions, which is the way of science. Though bioelectromagnetic scientists have learned much and can say much at greater depth about what happens when an organism is exposed to a field, the fundamental question still remains: What exactly is going on here?

https://pubmed.ncbi.nlm.nih.gov/34859455/

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What evidence exists on the impact of anthropogenic radiofrequency electromagnetic fields on animals and plants in the environment? A systematic map protocol

Ken Karipidis, Chris Brzozek, Chhavi Raj Bhatt, Sarah Loughran, Andrew Wood. What evidence exists on the impact of anthropogenic radiofrequency electromagnetic fields on animals and plants in the environment? A systematic map protocol. Environmental Evidence. 10(39). 21 December 2021.

Abstract

Background Exposure to radiofrequency (RF) electromagnetic fields (EMF), particularly from telecommunications sources, is one of the most common and fastest growing anthropogenic factors on the environment. In many countries, humans are protected from excessive RF EMF exposure by safety standards that are based on guidelines by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The ICNIRP guidelines are based on knowledge of how RF EMF affects the human body, however, there are currently no recognised international guidelines to specifically protect animals and plants. Whether the ICNIRP guidelines for humans is adequate to provide protection to the environment is a subject of active debate. This systematic map will collate all the available evidence on whether anthropogenic RF EMF has a negative effect on plants and animals in the environment. The map will also identify gaps in knowledge, recommend future research and inform environmental and radiation protection authorities.

Methods The proposed systematic map will include peer-reviewed and grey literature published in English. The EMF—Portal, PubMed and Web of Science databases will be searched using a search string prepared by the review team and tested for comprehensiveness against a list of known relevant reviews. Once duplicates are removed, retrieved articles will be screened in three stages: title, abstract, and full text. Studies will be selected with a subject population of all plants and animals, with exposures to anthropogenic RF EMF (frequency range 100 kHz–300 GHz) compared to no or lower-level exposure, and for all outcomes related to the studied populations. Kappa statistic tests will be conducted at each stage to ensure consistency of decision-making regarding the predefined inclusion/exclusion criteria. Eligible studies will then proceed to the data extraction phase, which will extract meta-data such as bibliographic information, taxonomic information, RF EMF exposure data, outcome(s), sample size, etc. The extracted data will then be organised into a systematic map and the findings summarised by cross-tabulating key meta-data variables in heat maps, charts or other data visualization methods. The systematic map will identify gaps in knowledge, priorities for future research and potential subtopics for further analysis and/or systematic review.
Open access paper: https://environmentalevidencejournal.biomedcentral.com/articles/10.1186/s13750-021-00252-w

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Can the Microwave Auditory Effect Be “Weaponized”?

Foster Kenneth R., Garrett David C., Ziskin Marvin C. Can the Microwave Auditory Effect Be “Weaponized”? Frontiers in Public Health. 9:2142. 2021. doi:10.3389/fpubh.2021.788613.

No abstract.

Open access paper: https://www.frontiersin.org/article/10.3389/fpubh.2021.788613

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The potential adverse effect of 2.45 GHz microwave radiation on the testes of prenatally exposed peripubertal male rats

Andrašková S, Holovská K, Ševčíková Z, Andrejčáková Z, Tóth Š, Martončíková M, Račeková E, Almášiová V. The potential adverse effect of 2.45 GHz microwave radiation on the testes of prenatally exposed peripubertal male rats. Histol Histopathol. 2021 Dec 2:18402. doi: 10.14670/HH-18-402.

Abstract

In utero development of organs is easily influenced by many environmental factors. The aim of this study was to elucidate the effect of microwave radiation (MR) at a frequency of 2.45 GHz and a specific absorption rate of 1.73 W/kg on intrauterine development of testis. Pregnant albino rats were exposed to whole-body MR for 2 hours per day throughout the pregnancy. Male offspring (n=12, age 35 days) were not exposed to MR after birth. The study revealed that MR applied in utero induced apparent structural changes in the testes, such as irregular shape of seminiferous tubules, significant decrease in the diameter of seminiferous tubules ($p<0.05$) and in the height of the germinal epithelium ($p<0.01$), disorganisation of germ cells, desquamations of immature germ cells, formation of giant multinucleated cells, and significant ($p<0.01$) expansion of the interstitium. At the level of transmission electron microscopy, there were observed basement membrane irregularities in seminiferous tubules, vacuolation of the cytoplasm and adversely affected organelles in Sertoli cells, germ cells, Leydig cells, peritubular and endothelial cells. The tight junctions between adjacent Sertoli cells were often incomplete, and necrotizing germ cells were more numerous in experimental animals compared to controls. Enhanced necrotizations of germ cells proved by a Fluoro Jade C method, and declined germ cells proliferation confirmed by proliferating cell nuclear antigen analysis, were detected in MR exposed animals. Our results revealed that the prenatal exposure to MR had an adverse effect on the postnatal testicular development in rats.

https://pubmed.ncbi.nlm.nih.gov/34854072/

Excerpts

The exact cellular pathways mediating the adverse effect of RF-EMR on testicular development and future spermatogenesis are still under investigation and further studies are still required. Many authors suggested that the most likely mechanism of RF-EMR associated testicular tissue injury is oxidative damage (Valko et al., 2006; Höytö et al., 2008; Desai et al., 2009; Tök et al. 2014; Yakymenko et al. 2016). This is in close agreement with our observation of the impaired testicular structure, ultrastructure, and regression of proliferative capacity of spermatogenic elements, accompanied by enhanced degeneration. Given the chosen methodology and the calculated SAR value, we have assumed that the primary source of testicular tissue damage was the non-thermal effect of RF-EMR. However, due to the impossibility of monitoring the hot spot phenomenon in the developing testes of rat foetuses, we cannot exclude the thermal effect.

In conclusion, our data attest to the harmful impact of 2.45 GHz microwave radiation on development of testes during the prenatal period which subsequently compromises the spermatogenic cycle and male reproductive function in the postnatal period of life. To preserve the steady reproductive health, it would be necessary to avoid or minimize exposure to RF-MR, especially in the most vulnerable period of intrauterine development of the individual.

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The Effects of Gum arabic, Curcumin (Curcuma longa) and Garcinia kola on the Rat Hippocampus after Electromagnetic Field Exposure

Abdalla Ahmed Eldaw Elamin, Omur Gulsum Deniz, Suleyman Kaplan. The Effects of Gum arabic, Curcumin (Curcuma longa) and Garcinia kola on the Rat Hippocampus after Electromagnetic Field Exposure: A Stereological and Histological Study. J Chem Neuroanat. 2021 Dec 13;102060. doi: 10.1016/j.jchemneu.2021.102060.

Abstract

The present study was designed to focus on the potential effects of the electromagnetic field (EMF) emitted by mobile phones on hippocampal pyramidal neurons and to investigate the role of curcumin (Cur), Garcinia kola (GK) and Gum arabic (GA) in reducing these adverse effects. Fifty-four 12-week-old male Wistar albino rats were used. These were randomly divided into nine groups of six rats each. The control, Cur, GK and GA groups were not exposed to EMF, while the sham group was kept in the EMF exposure system without being exposed to EMF. The EMF+Cur, EMF+GK, EMF+GA and EMF groups were exposed to 900MHz EMF for one hour a day for 28 days. The number of the pyramidal neurons in the cornu ammonis (CA) of the hippocampus was estimated using the optical fractionator technique. Histopathological changes were evaluated under light and electron microscopes. The activities of the superoxide dismutase (SOD) and catalase (CAT) enzymes were also evaluated from serum samples. Significant levels of CAT and SOD activities were observed in the EMF group compared to the control group (p=0.000; p=0.001) respectively. Microscopic observations showed that dark-coloured nuclei with unclear neuron boundaries were frequently observed in the EMF group. Stereological data analysis revealed a significant decrease in the CA's total number of pyramidal neurons in the EMF group compared to the control and sham groups (p=0.000; p=0.000) respectively. Cur and GK were observed to provide significant protection in the EMF+Cur and EMF+GK groups compared to the EMF group (p=0.000; p=0.000) respectively. No significant difference was observed between the EMF+GA group and EMF group (p=0.989). Exposure to 900MHz EMF causes severe alterations in the number and structure of hippocampal pyramidal neurons. Cur and GK exhibit a protective effect against these deleterious effects, but GA showed no protective effect.

https://pubmed.ncbi.nlm.nih.gov/34915150/

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[Exposure of the scrotum to 4G cellphone radiofrequency radiation affects spermatogenesis and blood-testis barrier of adult male rats]

Qing Cheng, Gang Yu, Gang Wang, Zhi-Ming Bai. [Exposure of the scrotum to 4G cellphone radiofrequency electromagnetic radiation affects the spermatogenesis and blood-testis barrier of adult male rats] [Article in Chinese]. Zhonghua Nan Ke Xue. 2021 Aug;27(8):680-684.

Abstract

Objective: To investigate the direct impact of exposure of the scrotum to 4G cellphone radiofrequency electromagnetic radiation (RF-EMR) on the testis of adult rats.

Methods: We equally randomized 30 adult male SD rats into a control and an exposure group, the latter exposed to 4G cellphone RF-EMR 6 hours a day for 150 days. Then, we analyzed the changes in semen quality and seminiferous epithelia, and measured the levels antioxidant enzyme-peroxide and the expressions of blood-testis barrier proteins in the testis of the rats.

Results: Compared with the controls, the rats in the exposure group showed significantly decreased sperm concentration (［6.39 ± 0.82］ vs ［4.74 ± 0.87］ ×107/ml, P < 0.05), viability (62.11 ± 8.82］ % vs ［41.44 ± 7.33］ %, P < 0.05), motility (［55.71 ± 7.39］ vs ［36.22 ± 6.36］ %, P < 0.05), the percentage of morphologically normal sperm (［84.89 ± 5.11］ % vs ［70.78 ± 8.11］ %, P < 0.05) and Johnsen's score (8.38 ± 0.98 vs 6.11 ± 1.56, P < 0.05), increased Coentino's score (1.36 ± 0.21 vs 1.81 ± 0.34, P < 0.05) and MDA level (P < 0.05), reduced levels of SOD, GSH and CAT (P < 0.05), and down-regulated expressions of occludin, ZO-1, CAR and N-Cadherin (P < 0.05).

Conclusions: Exposure of the scrotum to 4G cellphone RF-EMR directly causes injury of the testis, disorder of the blood-testis barrier, reduction of semen quality and consequently decline in the fertility of male rats.

https://pubmed.ncbi.nlm.nih.gov/34914238/

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3.5-GHz radiofrequency electromagnetic radiation promotes the development of Drosophila melanogaster

Yahong Wang, Zhihao Jiang, Lu Zhang, Ziyan Zhang, Yanyan Liao, Peng Cai. 3.5-GHz radiofrequency electromagnetic radiation promotes the development of Drosophila melanogaster. Environ Pollut. 2021 Dec 8;294:118646. doi: 10.1016/j.envpol.2021.118646.

Highlights

- Simulating the most representative 3.5 GHz RF-EMF band of 5G in China.
- We study the long-term effects of 3.5 GHz RF-EMF on flies' development.
- The microbial community may participate in the development under long-term RF-EMF.
- It provides a reference for the hidden health effects of RF-EMF.

Abstract

With the rapidly increasing popularity of 5G mobile technology, the effect of radiofrequency radiation on human health has caused public concern. This study explores the effects of a simulated 3.5 GHz radiofrequency electromagnetic radiation (RF-EMF) environment on the development and microbiome of flies under intensities of 0.1 W/m2, 1 W/m2 and 10 W/m2. We found that the pupation percentages in the first 3 days and eclosion rate in the first 2 days were increased under exposure to RF-EMF, and the mean development time was shortened. In a study on third-instar larvae, the expression levels of the heat shock protein genes hsp22, hsp26 and hsp70 and humoral immune system genes AttC, TotC and TotA were all significantly increased. In the oxidative stress system, DuoX gene expression was decreased, sod2 and cat gene expression levels were increased, and SOD and CAT enzyme activity also showed a significant increase. According to the 16S rDNA results, the diversity and species abundance of the microbial community decreased significantly, and according to the functional prediction analysis, the genera Acetobacter and Lactobacillus were significantly increased. In conclusion, 3.5 GHz RF-EMF may enhance thermal stress, oxidative stress and humoral immunity, cause changes in the microbial community, and regulate the insulin/TOR and ecdysteroid signalling pathways to promote fly development.

https://pubmed.ncbi.nlm.nih.gov/34896224/

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Abnormal Expression of Connexin43 in Cardiac Injury Induced by S-Band and X-Band Microwave Exposure in Rats

Yin Y, Xu X, Gao Y, Wang J, Yao B, Zhao L, Wang H, Wang H, Dong J, Zhang J, Peng R. Abnormal Expression of Connexin43 in Cardiac Injury Induced by S-Band and X-Band Microwave Exposure in Rats. J Immunol Res. 2021 Dec 17;2021:3985697. doi: 10.1155/2021/3985697.

Abstract

Although the effects of microwave exposure on the heart have gradually become the focus of domestic and foreign scholars, the biological effects caused by different doses and different frequency bands of exposure are still unclear. In this study, we will investigate the damaging effect of S-band and X-band microwave composite exposure on cardiac structure and function, as well as the pathophysiological significance of Cx43 in cardiac conduction dysfunction after exposure. We used S- and X-band radiation sources with the average power density of 5 and 10 mW/cm^2 to expose Wistar rats to single or composite exposure. At the 6th hour, on the 7th, 14th, and 28th days after exposure, ECG was used to detect the electrical conduction of the heart, and the myocardial enzyme was measured by the automatic biochemical analyzer. We selected the observation time points and groups with severe damage to observe the changes of myocardial structure and ultrastructure with an optical microscope and TEM; and to detect the expression and distribution of Cx43 by western blotting and immunohistochemistry. After exposure, the heart rate increased, the P wave amplitude decreased, and the R wave amplitude increased; the content of the myocardial enzyme in serum increased; the structure and ultrastructure of cardiac tissue were damaged. The damage was dose-dependent and frequency-dependent. The expression of Cx43 in myocardial tissue decreased, and distribution was abnormal. Taken together, these findings suggested that the mechanism of abnormal electrical conduction in the heart of rats by S- and X-band microwave exposure might be related to the decreased expression and disordered distribution of Cx43 after microwave exposure.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8709747/

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Methodology of Studying Effects of Mobile Phone Radiation on Organisms: Technical Aspects

Katerina Bartosova, Marek Neruda, Lukas Vojtech. Methodology of Studying Effects of Mobile Phone Radiation on Organisms: Technical Aspects. Int J Environ Res Public Health. 2021 Nov 30;18(23):12642. doi: 10.3390/ijerph182312642

Abstract

The negative influence of non-ionizing electromagnetic radiation on organisms, including humans, has been discussed widely in recent years. This paper deals with the methodology of examining possible harmful effects of mobile phone radiation, focusing on in vivo and in vitro laboratory methods of investigation and evaluation and their main problems and difficulties. Basic experimental parameters are summarized and discussed, and recent large studies are also mentioned. For the laboratory experiments, accurate setting and description of dosimetry are essential; therefore, we give recommendations for the technical parameters of the experiments, especially for a well-defined source of radiation by Software Defined Radio.

Excerpt

Moreover, we emphasize that the dosimetry should always be clearly set and observed in the laboratory tests. This includes using a radiofrequency radiation source where the frequency, time, and intensity of the radiation, including placement of the radiation source, can be precisely set and controlled. To comply with the above-mentioned criteria—precisely defined radiofrequency radiation on the one hand, and unpredictable changes of the signal on the other hand—we suggest using the Software Defined Radio (SDR) approach available for 2G, 3G [44,45], 4G, and 5G [46] instead of a signal vector generator or undefined cell phone. The SDR transceiver enables the generation of high-frequency multichannel/wideband power signals in repeatable scenarios (recorded signal or artificial signal), with respect to timing, modulation methods, waveform, transmission power, and its time changes, etc., of real mobile phone radio channel parameters and for different xG mobile generations, unlike a standard signal generator. In order to be able to repeat the experiments in a controlled manner, it is necessary to use a standardized antenna adapter for radiating high-frequency power, i.e., an antenna structure for near/far EM field. The SDR enables the creation of a new base transceiver station (2G), Node B (3G), eNode B (4G), or gNode B (5G), which directly communicates with mobile phones, i.e., it can generate a real unpredictable mobile phone signal (i.e., signal changing in an irregular, unpredictable way), as suggested by Panagopoulos [24]. In addition, the SDR also enables the creation of a mobile phone phantom, i.e., specific hardware solution, e.g., OsmocomBB [44], with a well-defined mobile phone phantom (antenna, controlled radiofrequency signal radiation setup, etc., in standardized measurement environment, i.e., measurement cell), which can facilitate the reproducibility of future experiments. All necessary parameters of individual mobile technologies, including time intervals, frequency, modulation, intensity, etc., can be precisely controlled. Using the SDR and standardized measurement cell could substantially help to avoid problems of the

replication of studies. In addition, one of the advantages of this approach is the possibility of sharing a specific scenario between laboratories in order to ensure the repeatability of the radiation source.

Conclusions

The paper reviews laboratory methods studying the effects of radiofrequency radiation on organisms, focusing on technical aspects of the experiments. As can be concluded from many works, the effects of radiofrequency radiation can differ under different conditions and settings. Therefore, we emphasize that the methodology should be clearly and precisely set to ensure the results can be verified and reproduced. Very important is the choice of a suitable source of radiation, here we recommend the SDR, which can simulate a real mobile phone signal in a controlled and repeatable way. The influence of radiofrequency radiation is a multidisciplinary topic and includes many fields, such as medicine, biology, toxicology, physics, electrical and electronic engineering, telecommunication, and statistics. The future research requires close cooperation of scientists from all these fields. Following the given recommendations should increase the overall quality of the experiments and publications and give the possibility to compare, reproduce, and verify the results.

Open access paper: https://www.mdpi.com/1660-4601/18/23/12642

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Multi-hop D2D Communication in Cellular Networks to Minimize EMR

Avirup Das, Nabanita Das, Abhirup Das Barman. Multi-hop D2D Communication in Cellular Networks to Minimize EMR. IEEE Transactions on Green Communications and Networking. 30 December 2021. doi: 10.1109/TGCN.2021.3139286.

Abstract

With the advent of IoT, and the growing demand of infotainment, the number of data sources transmitting at high data rates for long duration is increasing rapidly. It results an ever increasing level of associated Electromagnetic Radiation (EMR) in our surroundings. The transmission powers from the near-field sources like mobile phones along with the duration of sessions are the crucial factors to accurately assess the harmful effects of EMR exposure from these devices. In order to limit and balance the EMR exposure from these sources, this paper, proposes short-range multi-hop packet forwarding technique with cognitive channel allocation for newer technologies of LTE. Theoretical analysis presented here, establishes bounds on the permissible channels and matching data rates to be used by the nodes to balance the duration of transmission maintaining the safe limit of Specific Absorption Rate (SAR). Based on this strategy, algorithm is developed for multi-hop packet routing with channel selection using cognitive radio. Extensive simulation studies on 5G New Radio (NR) band show significant improvement in energy efficiency with nearly balanced transmission duration and SAR reducing the near-field heating effect throughout the network.

https://ieeexplore.ieee.org/document/9666462

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Effect of Magnetic Fields during Pregnancy on Fetal Growth and Preterm Labor: A Review Article

Zahra Khojastehfard, Somayeh Ghahremani, Maryam Sabaghian, Samaneh Ghalebizadeh, Zoleykha Asgarlou, Soheil Mohammadi Yazdi, Mahla Salarfard. Effect of Magnetic Fields during Pregnancy on Fetal Growth and Preterm Labor: A Review Article. Intl J Pediatrics. 10.22038/ijp.2020.48094.3874

Abstract

Background Low birth weight is one of the most important health indicators in evaluating pregnancy care worldwide. We aimed to evaluate the effect of cell phones used in pregnancy on fetal growth and preterm labor.

Materials and Methods The search process included screening the relevant articles on electronic databases of Scopus, EMBASE, Cochrane, Web of Science, and Medline to analyze the association of maternal exposure to magnetic fields with fetal growth, birth weight, small-for-gestational-age (SGA), and preterm labor.

Results In the first study, the duration of pregnancy was shorter for mothers using cell phones for more than one hour per day than those use shorter than one hour. In the second study, the intermediate use of cell phones by mothers indicated an increased risk of preterm birth. In the third study, the birth weight were lower in excessive cell phone users than normal status. In the fourth study, low, medium, and high cell phone exposure during the six months before conception had no effect on low birth weight, preterm birth, and SGA.In the fifth study, a negative correlation was observed between magnetic fields expose during pregnancy and the birth week, birth weight, and birth length of the newborn. In the sixth study, the risk of low birth weight, preterm birth, and SGA was close to null. In the seventh study, dental radiography during pregnancy was associated with low birth weight, specifically with term low birth weight.

Conclusion In general, there are contradictory findings on the impact of cell phone exposure during pregnancy. These results should be interpreted with caution because of the small sample size and recall bias.

Open access paper: https://ijp.mums.ac.ir/article_15508_d1291b56392c9b107f6f008380ca99d1.pdf

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Motor neuron disease risk and magnetic field exposures

Tom Sorahan, Linda Nichols. Motor neuron disease risk and magnetic field exposures. Occup Med (Lond). 2021 Dec 23; kqab180. doi: 10.1093/occmed/kqab180.

Abstract

Background: Many studies have investigated magnetic field exposure and the risks of motor neuron disease (MND). Meta-analyses have found positive associations but a causal relationship has not been established.

Aims: To investigate the risks of MND and occupational exposure to magnetic fields in a large UK cohort.

Methods: Mortality of 37 986 employees of the former Central Electricity Generating Board of England and Wales was investigated for the period 1987-2018. Employees were first employed in the period 1942-82 and were still in employment on the 1 November, 1987. Detailed calculations enabled estimates to be made of magnetic field exposures. Observed deaths were compared with expected numbers based on mortality rates for the general population of England and Wales and Poisson regression was used to calculate rate ratios (relative risks) for categories of lifetime, lagged (distant) and lugged (recent) magnetic field exposure.

Results: Mortality from MND in the total cohort was similar to national rates (observed 69, expected 71.3, SMR 97, 95% CI 76-122). There were no statistically significant trends of risks increasing with lifetime, recent or distant magnetic field exposure, although positive associations were observed for some categories of recent exposure.

Conclusions: The study did not find that the cohort had elevated risks of MND as a consequence of occupational lifetime exposure to magnetic fields, although a possible role for recent exposures could usefully be investigated in other datasets.

Funding: This work was supported by the Energy Networks Association (ENA). [The Energy Networks Association is the industry body funded by UK gas and electricity transmission and distribution licence holders.]

https://pubmed.ncbi.nlm.nih.gov/34940878/

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Influence of Geomagnetic Disturbances at Different Times of Day on Locomotor Activity in Zebrafish (Danio Rerio)

Viacheslav V Krylov. Influence of Geomagnetic Disturbances at Different Times of Day on Locomotor Activity in Zebrafish (Danio Rerio). Clocks Sleep. 2021 Nov 29;3(4):624-632. doi: 10.3390/clockssleep3040045.

Abstract

The influence of magnetic fields and natural geomagnetic storms on biological circadian rhythms are actively studied. This study reveals an impact of local natural perturbations in the geomagnetic field that occurred at different times of the day on circadian patterns of locomotor activity of zebrafish. A decrease in zebrafish swimming speed was observed during the geomagnetic disturbances before or after the fluctuations of diurnal geomagnetic variation. However, if the geomagnetic perturbations coincided with the fluctuations of diurnal geomagnetic variation, the decrease in zebrafish swimming speed was insignificant. This result suggests that the biological effects of geomagnetic disturbances may depend on synchronization with the diurnal geomagnetic variation. It implies that the previously published correlations between geomagnetic activity and medical or biological parameters could result from a disruption in circadian biorhythms.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8700499/

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Effect of electromagnetic field on abortion: A systematic review and meta-analysis

Masumeh Ghazanfarpour, Zahra Atarodi Kashani, Reza Pakzad, Fatemeh Abdi , Fatemeh Alsadat Rahnemaei, Pouran Akhavan Akbari, Nasibeh Roozbeh. Effect of electromagnetic field on abortion: A systematic review and meta-analysis. Open Medicine. doi: 10.1515/med-2021-0384

Abstract

Background The increasing use of new technologies by pregnant women inevitably exposes them to the risks of the electromagnetic fields (EMFs). According to the World Health Organization, EMFs are the major sources of pollutants which harm human health. This study was aimed to evaluate the effects of EMF exposure on abortion.

Methods Web of Science, Cochrane Library, MEDLINE, PubMed, EMBASE, Scopus, and Google Scholar were searched until 2021. Pooled odds ratio (OR) with 95% confidence interval (CI) was estimated using a random-effects model. Heterogeneity was explored using Cochran's Q test and I 2 index. A meta-regression method was employed to investigate the factors affecting heterogeneity between the studies. The Newcastle-Ottawa scale was used to assess the credibility of the studies.

Results Eligible studies (N = 17) were analyzed with a total of 57,693 participants. The mean maternal age (95% CI) was 31.06 years (27.32–34.80). Based on meta-analysis results, the pooled estimate for OR of EMF with its effects was 1.27 (95% CI: 1.10–1.46). According to the results of meta-regression, sample size had a significant effect on heterogeneity between studies (p: 0.030), but mother's age and publication year had no significant effect on heterogeneity (p-value of both were >0.05). No publication bias was observed.

Conclusion Exposure to EMFs above 50 Hz or 16 mG is associated with 1.27× increased risk of abortion. It may be prudent to advise women against this potentially important environmental hazard. Indeed, pregnant women should receive tailored counselling.

Open access paper: https://www.degruyter.com/document/doi/10.1515/med-2021-0384/html

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Estimated all-day and evening whole-brain radiofrequency electromagnetic fields doses, and sleep in preadolescents

Cabré-Riera A, van Wel L, Liorni I, Koopman-Verhoeff ME, Imaz L, Ibarluzea J, Huss A, Wiart J, Vermeulen R, Joseph W, Capstick M, Vrijheid M, Cardis E, Röösli M, Eeftens M, Thielens A, Tiemeier H, Guxens M. Estimated

all-day and evening whole-brain radiofrequency electromagnetic fields doses, and sleep in preadolescents. Environ Res. 2021 Oct 29:112291. doi: 10.1016/j.envres.2021.112291.

Highlights

- We estimated whole-brain RF-EMF doses (mJ/kg/day) for several RF-EMF sources.
- We estimated all-day and evening whole-brain RF-EMF doses.
- We assessed subjective and objective sleep measures in preadolescents.
- No association between all-day whole-brain RF-EMF doses and sleep.
- Evening whole-brain RF-EMF dose from phone calls related to shorter total sleep time.

Abstract

Objective: To investigate the association of estimated all-day and evening whole-brain radiofrequency electromagnetic field (RF-EMF) doses with sleep disturbances and objective sleep measures in preadolescents.

Methods: We included preadolescents aged 9-12 years from two population-based birth cohorts, the Dutch Generation R Study (n = 974) and the Spanish INfancia y Medio Ambiente Project (n = 868). All-day and evening overall whole-brain RF-EMF doses (mJ/kg/day) were estimated for several RF-EMF sources including mobile and Digital Enhanced Cordless Telecommunications (DECT) phone calls (named phone calls), other mobile phone uses, tablet use, laptop use (named screen activities), and far-field sources. We also estimated all-day and evening whole-brain RF-EMF doses in these three groups separately (i.e. phone calls, screen activities, and far-field). The Sleep Disturbance Scale for Children was completed by mothers to assess sleep disturbances. Wrist accelerometers together with sleep diaries were used to measure sleep characteristics objectively for 7 consecutive days.

Results: All-day whole-brain RF-EMF doses were not associated with self-reported sleep disturbances and objective sleep measures. Regarding evening doses, preadolescents with high evening whole-brain RF-EMF dose from phone calls had a shorter total sleep time compared to preadolescents with zero evening whole-brain RF-EMF dose from phone calls [-11.9 min (95%CI -21.2; -2.5)].

Conclusions: Our findings suggest the evening as a potentially relevant window of RF-EMF exposure for sleep. However, we cannot exclude that observed associations are due to the activities or reasons motivating the phone calls rather than the RF-EMF exposure itself or due to chance finding.

https://pubmed.ncbi.nlm.nih.gov/34757029/

Excerpts

Preadolescents spend 48.9 min/day using mobile communication devices for screen activities and 2.5 min/day making phone calls (Supplementary Table S3). The median of the overall estimated all-day whole-brain RF-EMF dose was 60 (interquartile range (IQR) 20; 118) mJ/kg/day and the main contributor to the all-day whole-brain

RF-EMF dose were phone calls (78%) (Table 2).... Preadolescents who spent more time with console/computer gaming or television watching were more likely to have higher evening whole-brain RF-EMF dose from screen activities....

Objective total sleep time was on average 7.5 h, sleep efficiency was 84%, and wake after sleep onset was 71.4 min in the study sample (Table 3)....

Preadolescents with high evening whole-brain RF-EMF dose from phone calls had a shorter total sleep time and longer sleep latency compared to preadolescents with zero evening whole-brain RF-EMF dose from phone calls [−11.9 min (95%CI -21.2; −2.5) and) 0.3 min (95%CI 0.0; 0.7), respectively] (Table 6). However, the latter association did not survive correction for multiple testing. Overall evening whole-brain RF-EMF dose, and evening dose from screen activities were not associated with objective sleep measures (Table 6) and with sleep quality and restfulness (data not shown)....

This study investigated the association of overall and source-specific all-day and evening whole-brain RF-EMF doses with sleep parameters in preadolescents. We found that the all-day whole-brain RF-EMF doses were not associated with sleep disturbances and objective sleep measures. Regarding evening doses, preadolescents with a high evening whole-brain RF-EMF dose from phone calls had shorter total sleep time....

All-day and evening whole-brain RF-EMF dose from screen activities were not associated with subjective or objective sleep measures....

A more comprehensive study needs to be designed to disentangle between all the potential factors related to the use of mobile communication devices that might affect sleep, including RF-EMF exposure. Also, of note, preadolescents are reducing the use of phones for calling and those who make phone calls use hands-free devices or mobile phone applications that allow voice or video calls. This changing pattern might decrease the overall RF-EMF dose the brain receives but increase the amount of RF-EMF dose from screen activities with mobile communication devices....

The levels of RF-EMF exposure from far-field sources are low and do not produce peak and high intensity exposures to the brain such as those from personal use of mobile communication devices for phone calls or screen activities (Birks et al., 2018, 2021). In our study, RF-EMF dose from far-field sources was not related to subjective or objective sleep measures. Previous studies assessing the association between RF-EMF exposure from far-field sources and sleep showed mixed results....

Conclusion

Overall all-day whole-brain RF-EMF dose and all-day dose from phone calls were not associated with sleep, though evening whole-brain RF-EMF dose from phone calls were associated with less favourable sleep characteristics as objectively measured by actigraphy. These findings suggest the evening as a potentially relevant window of exposure. Since this is the first study investigating the association between RF-EMF dose and sleep and there is not known biological mechanism explaining the observed associations, our results should be interpreted with caution. Studies exploring the relationship of RF-EMF exposure to the brain and sleep should

assess the amount of RF-EMF dose absorbed by the brain in the evening or at night which might be more relevant for adolescents' sleep.

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Original Findings Confirmed in Replication Study: Provocation with 2.4 GHz Cordless Phone affects Autonomic Nervous System as measured by Heart Rate Variability

Magda Havas, Jeffrey Marrongelle. Original Findings Confirmed in Replication Study: Provocation with 2.4 GHz Cordless Phone affects the Autonomic Nervous System (ANS) as measured by Heart Rate Variability (HRV). Medical Research Archives. 9(11). Nov. 2021. doi: 10.18103/mra.v9i11.2605.

Abstract

This is a double-blind, placebo-controlled replication of a study that we previously conducted in Colorado with 25 subjects designed to test the effect of radio frequency radiation (RFR) generated by the base station of a cordless phone on heart rate variability (HRV). In this study, we analyzed the response of 69 subjects between the ages of 26 and 80 in both Canada and the USA. Subjects were exposed to radiation for 3-min intervals generated by a 2.4-GHz cordless phone base station (3–8 microW/cm^2). Prior to provocation we conducted an orthostatic test to assess the state of adrenal exhaustion, which interferes with a person's ability to mount a response to a stressor. A few participants had a severe reaction to the RFR with an increase in heart rate and altered HRV indicative of an alarm response to stress. Based on the HRV analyses of the 69 subjects, 7% were classified as being "moderately to very sensitive", 29% were "little to moderately sensitive", 30% were "not to a little sensitive" and 6% were "unknown". These results are not psychosomatic and are not due to electromagnetic interference. Twenty-five percent of the subjects' self-proclaimed sensitivity corresponded to that based on the HRV analysis, while 32% overestimated their sensitivity and 42% did not know whether or not they were electrically sensitive. Of the 39 participants who claimed to experience some electrical hypersensitivity, 36% claimed they also reacted to a cordless phone and experienced heart symptoms and, of these, 64% were classified as having some degree of electrohypersensitivity (EHS) based on their HRV response. Novel findings include documentation of a delayed response to radiation. This protocol underestimates the reaction to electromagnetic radiation and may provide a false negative for those with a delayed reaction and/or with adrenal exhaustion. Orthostatic HRV testing combined with provocation testing may provide a useful diagnostic tool for some sufferers of EHS when they are exposed to electromagnetic radiation. It can be used to confirm EHS but not to reject EHS as a diagnosis since not everyone with EHS has an ANS reaction to electromagnetic radiation.

Conclusions

Our results show that 36% of the individuals tested reacted via altered heart rate variability (HRV) to the non-ionizing radiation generated by a cordless phone base station in this double-blind, placebo-controlled study. These reactions were not psychosomatic. In this study, we document an increased heart rate (HR), altered HRV and changes in the sympathetic and parasympathetic control of the autonomic nervous system (ANS) typical of a fight-or-flight stress response. These results are similar to our previous study. The results are not due to electromagnetic interference (EMI), since we have examples of a delayed response after the radiation was turned off and have tested EMI with much higher exposure using the same technology with no reactions noted. Our results demonstrate that the radiation from a 2.4-GHz cordless phone affects the ANS and may put some individuals with pre-existing heart conditions at risk when exposed to electromagnetic frequencies to which they

are sensitive. Individuals fell into 3 categories: those who had a healthy ANS and were able to tolerate the stress without reactions; those who reacted; and those who had a compromised ANS with adrenal exhaustion and were unable to mount a response leading, in some cases, to a false negative result. Although documenting a response is relatively simple, determining the degree of EHS is quite complex and requires further study especially for those with a compromised ANS.

Open access paper: https://esmed.org/MRA/mra/article/view/2605

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Micronucleus Assay in Cell Phone Users: Importance of Oral Mucosa Screening

Melika Ghandehari, Donia Sadri, Sareh Farhadi. Micronucleus Assay in Cell Phone Users: Importance of Oral Mucosa Screening. Int J Prev Med. 2021 Sep 29;12:125. doi: 10.4103/ijpvm.IJPVM_489_19.

Abstract

Background: One of the concerns of cell phone users is prolonged exposure to harmful and potentially carcinogenic waves. This study was aimed to investigate the correlation between amount of cell phone use and related factors with percentage of micronucleus containing cells.

Methods: This descriptive study was conducted on selected patients referring to Islamic Azad University Faculty of Dentistry using cell phones regarding related inclusion and exclusion criteria. Papanicolaou staining method was approached for mucosal smears of samples and frequency of micronucleus containing cells and also, frequency of micronucleus in each cell were recorded for each sample; then, correlation of these findings with amount of daily cell phone usage was statistically analyzed using the calculation of Pearson correlation coefficient and preparation of regression analysis (backward) with significant level of lower than 0.05.

Results: Of 100 samples, the frequency of micronucleus containing cells was 2.94% ± 1.89% and the frequency of micronucleus in each cell was 1.02% ± 1.68%. The amount of cell phone usage was significantly correlated with the frequency of micronucleus containing cells ($r = 0.70$, $P = 0.0001$) and also with the frequency of micronucleus in each cell ($r = 0.57$, $P = 0.0001$). Also, age and sex were not significantly correlated with the frequency of micronucleus containing cells ($P = 0.47$ and 0.32) and also with the frequency of micronucleus in each cell, respectively ($P = 0.16$ and 0.27).

Conclusions: The present study showed that the increased amount of cell phone usage had a strong and significant correlation with the higher frequency of the micronucleus containing cells and the higher frequency of micronucleus in each cell in the buccal mucosa. Also, the related factors as age and sex were not significantly correlated with the frequency of micronucleus containing buccal mucosa cells.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8551792/

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The biological effects of electromagnetic exposure on immune cells and potential mechanisms

Chuanfu Yao, Li Zhao, Ruiyun Peng. The biological effects of electromagnetic exposure on immune cells and potential mechanisms. Electromagn Biol Med. 2021 Nov 9;1-10. doi: 10.1080/15368378.2021.2001651.

Abstract

Anxiety about potential health hazards of electromagnetic exposure has been growing in the past decades, with their widely application in many fields. The immune system plays pivotal role in maintaining body's homeostasis. Importantly, immune system is also a sensitive target for electromagnetic fields. In recent years, the biological effects of electromagnetic fields on immune cells have been attracting more and more attentions. Accumulated data suggested that electromagnetic exposure could affect the number and function of immune cells to some extent, including cell proportion, cell cycle, apoptosis, killing activity, cytokines contents and so on. The research objects basically covered all types of immune cells, mainly on PBMC, T lymphocytes, B lymphocytes, NK cells and macrophages. Meanwhile, there also are negative reports of electromagnetic fields on immune cells. This article reviews the results of epidemiological investigation, the progresses in animal studies and in vitro experiments, and the current attempts to explore potential mechanisms. Knowledge of the biological effects on immune cells associated with electromagnetic fields is critical for proper health hazard evaluation, development of safety standards, and safe exploitation of new electromagnetic devices and applications.

https://pubmed.ncbi.nlm.nih.gov/34753364/

Outlook

In an organism, the role of the defence system against external stressors is played by the immune system consisting of various cell types. The immune cells are engaged in many physiological processes and responsible for the proper function of the whole organism. Any factor with an ability to cause immunomodulatory effects may weaken or enhance the response of the immune system (Piszczek et al. 2021). The biological effects of electromagnetic fields on immune cells have been attracting more and more attention in recent years. Researchers from numerous groups focused on both epidemiological investigations and experimental studies. Accumulated data suggested that electromagnetic exposure could affect the number and function of immune cells to some extent, including cell proportion, cell cycle, apoptosis, killing activity, cytokines contents and so on. The research objects basically covered all types of immune cells, mainly on PBMC, T lymphocytes, B lymphocytes, NK cells and macrophages. Meanwhile, there also are negative reports of electromagnetic fields on immune cells. Electromagnetic fields-induced biological effects on immune cells are influenced by two general factors: the exposure parameters (i.e., frequency, power density, exposure duration, etc.) and the composition and/or properties of the cell target. Any deviation from the two general factors will lead to inconsistent results. This may be the reason why the results are inconsistent and no comparability between different laboratories. Therefore, it is extremely difficult to find out a mechanism which could play a dominant role in the effects of various types of immune cells under electromagnetic exposure in a wide range of parameters. However, ROS, NF-κB signaling pathway, intracellular Ca^{2+} emerged as the potential mechanisms involved in electromagnetic field-induced activation and inhibition of immune cells; nevertheless, the specific mechanisms underlying the observed bio-effects in these cells remain unknown.

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Evidence for a connection between coronavirus disease-19 and exposure to radiofrequency radiation from wireless communications including 5G

My comments: If there is a connection between the Covid-19 pandemic and wireless communication radiation (WCR) due to impaired immune system response, it is likely attributable to the population's total EMF exposure including ELF EMF as well as WCR (e.g., 2G-5G, Wi-Fi, and Bluetooth). 5G is not universally available and is only partially deployed in locations that have this infrastructure. Moreover, since 5G operates a fraction of the time and depends heavily on 4G communication now, I suspect that densification of 4G via small cell deployment is more likely to be problematic than 5G.

Beverly Rubik, Robert R Brown. Evidence for a connection between coronavirus disease-19 and exposure to radiofrequency radiation from wireless communications including 5G. J Clin Transl Res. 2021 Sep 29;7(5):666-681.

Abstract

Background and aim: Coronavirus disease (COVID-19) public health policy has focused on the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus and its effects on human health while environmental factors have been largely ignored. In considering the epidemiological triad (agent-host-environment) applicable to all disease, we investigated a possible environmental factor in the COVID-19 pandemic: ambient radiofrequency radiation from wireless communication systems including microwaves and millimeter waves. SARS-CoV-2, the virus that caused the COVID-19 pandemic, surfaced in Wuhan, China shortly after the implementation of city-wide (fifth generation [5G] of wireless communications radiation [WCR]), and rapidly spread globally, initially demonstrating a statistical correlation to international communities with recently established 5G networks. In this study, we examined the peer-reviewed scientific literature on the detrimental bioeffects of WCR and identified several mechanisms by which WCR may have contributed to the COVID-19 pandemic as a toxic environmental cofactor. By crossing boundaries between the disciplines of biophysics and pathophysiology, we present evidence that WCR may: (1) cause morphologic changes in erythrocytes including echinocyte and rouleaux formation that can contribute to hypercoagulation; (2) impair microcirculation and reduce erythrocyte and hemoglobin levels exacerbating hypoxia; (3) amplify immune system dysfunction, including immunosuppression, autoimmunity, and hyperinflammation; (4) increase cellular oxidative stress and the production of free radicals resulting in vascular injury and organ damage; (5) increase intracellular Ca2+ essential for viral entry, replication, and release, in addition to promoting pro-inflammatory pathways; and (6) worsen heart arrhythmias and cardiac disorders.

Relevance for patients: In short, WCR has become a ubiquitous environmental stressor that we propose may have contributed to adverse health outcomes of patients infected with SARS-CoV-2 and increased the severity of the COVID-19 pandemic. Therefore, we recommend that all people, particularly those suffering from SARS-CoV-2 infection, reduce their exposure to WCR as much as reasonably achievable until further research better clarifies the systemic health effects associated with chronic WCR exposure.

Excerpts

Epidemiologists, including those at the CDC, consider multiple causal factors when evaluating the virulence of an agent and understanding its ability to spread and cause disease. Most importantly, these variables include environmental cofactors and the health status of the host. Evidence from the literature summarized here suggests a possible connection between several adverse health effects of WCR exposure and the clinical course of COVID-19 in that WCR may have worsened the COVID-19 pandemic by weakening the host and exacerbating COVID-19 disease. However, none of the observations discussed here prove this linkage. Specifically, the

evidence does not confirm causation. Clearly COVID-19 occurs in regions with little wireless communication. Furthermore, the relative morbidity caused by WCR exposure in COVID-19 is unknown....

Another shortcoming of this paper is that we do not have access to experimental data on 5G exposures. In fact, little is known about population exposure from real-world WCR, which includes exposure to WCR infrastructure and the plethora of WCR emitting devices. In relation to this, it is difficult to accurately quantify the average power density at a given location, which varies greatly, depending on the time, specific location, time-averaging interval, frequency, and modulation scheme. For a specific municipality it depends on the antenna density, which network protocols are used, as, for example, 2G, 3G, 4G, 5G, Wi-Fi, WiMAX (Worldwide Interoperability for Microwave Access), DECT (Digitally Enhanced Cordless Telecommunications), and RADAR (Radio Detection and Ranging). There is also WCR from ubiquitous radio wave transmitters, including antennas, base stations, smart meters, mobile phones, routers, satellites, and other wireless devices currently in use. All of these signals superimpose to yield the total average power density at a given location that typically fluctuates greatly over time. No experimental studies on adverse health effects or safety issues of 5G have been reported, and none are currently planned by the industry, although this is sorely needed....

This paper points to the need for further research on nonthermal WCR exposure and its potential role in COVID-19. Moreover, some of the WCR exposure bioeffects that we discuss here — oxidative stress, inflammation, and immune system disruption — are common to many chronic diseases, including autoimmune disease and diabetes. Thus, we hypothesize that WCR exposure may also be a potential contributing factor in many chronic diseases....

Conclusion

There is a substantial overlap in pathobiology between COVID-19 and WCR exposure. The evidence presented here indicates that mechanisms involved in the clinical progression of COVID-19 could also be generated, according to experimental data, by WCR exposure. Therefore, we propose a link between adverse bioeffects of WCR exposure from wireless devices and COVID-19.

Specifically, evidence presented here supports a premise that WCR and, in particular, 5G, which involves densification of 4G, may have exacerbated the COVID-19 pandemic by weakening host immunity and increasing SARS-CoV-2 virulence by (1) causing morphologic changes in erythrocytes including echinocyte and rouleaux formation that may be contributing to hypercoagulation; (2) impairing microcirculation and reducing erythrocyte and hemoglobin levels exacerbating hypoxia; (3) amplifying immune dysfunction, including immunosuppression, autoimmunity, and hyperinflammation; (4) increasing cellular oxidative stress and the production of free radicals exacerbating vascular injury and organ damage; (5) increasing intracellular Ca^{2+} essential for viral entry, replication, and release, in addition to promoting pro-inflammatory pathways; and (6) worsening heart arrhythmias and cardiac disorders.

WCR exposure is a widespread, yet often neglected, environmental stressor that can produce a wide range of adverse bioeffects. For decades, independent research scientists worldwide have emphasized the health risks and cumulative damage caused by WCR [42,45]. The evidence presented here is consistent with a large body of established research. Healthcare workers and policymakers should consider WCR a potentially toxic environmental stressor. Methods for reducing WCR exposure should be provided to all patients and the general population.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8580522/

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The association between mobile phones and the risk of brain cancer mortality: A 25-year cross-country analysis

Mialon HM, Nesson ET. The association between mobile phones and the risk of brain cancer mortality: A 25-year cross-country analysis. Contemporary Economic Policy. December 4, 2019. doi:10.1111/coep.12456.

Abstract

We investigate the relationship between cell phones and brain cancer using brain cancer death rates for 88 countries between 1990 and 2015 from the World Health Organization and country-level mobile phone subscription rates from the World Bank. We estimate difference-in-difference models including country and year fixed effects and time-varying country covariates. We find that mobile phone subscription rates are positively and statistically significantly associated with death rates from brain cancer 15–20 years later. In falsification tests, we find few positive associations between mobile phone subscription rates and deaths from rectal, pancreatic, stomach, breast or lung cancer or ischemic heart disease. Finally, differential effects models suggest that mobile phone subscription rates are associated with brain cancer deaths 15–19 years later relative to deaths from other causes.

Excerpts

The link between mobile phones and brain tumors has received much attention in the media (e.g., Hakim 2016; Knutson 2016; Storrs 2016), although previous evidence has not yielded conclusive results (Hardell and Carlberg 2014; Hardell, Carlberg, and Hansson Mild 2011; Hardell et al. 2013; M. Little et al. 2012; Myung et al. 2009).

...We find a positive association between mobile phone subscriptions and brain cancer death rates. Specifically, one more mobile phone subscription per 100 people is associated with 0.003 and 0.02 additional brain cancer deaths per 100,000 people 15 and 20 years later, respectively. This result is robust to a number of specification tests, although it is sensitive to the exclusion of country-specific linear time trends. We run a number of falsification tests where we examine the relationship between mobile phone subscription rates and mortality rates from five other common forms of cancer, rectal cancer, pancreatic cancer, stomach cancer, lung cancer, and breast cancer, as well as ischemic heart disease. We find much smaller coefficients with much larger standard errors for these other mortality outcomes, although we do find a few positive and statistically significant coefficients. Given that we find some sensitivity to country-specific linear trends and some significant effects of mobile phone subscriptions on other cancers, we estimate a differential effects model where we compare the association between mobile phone subscription rates and brain cancer mortality relative to other disease mortality. In these models, we additionally find statistically significant, positive coefficients, suggesting that mobile phone prevalence is associated with brain cancer mortality about 15–20 years later relative to other disease mortality.

Our study is the first to analyze the potential link between brain cancer and mobile phone use on the aggregate, across multiple countries, and over a period spanning more than 20 years....

We collect information on annual mobile cellular subscriptions per 100 people from the World Bank (The World Bank 2016). The first mobile cellular phones were introduced in the Nordic countries in the early 1980s, and by 1990, Iceland, Norway, and Sweden had more than three mobile phone subscriptions per 100 people. Additionally, the United States, Hong Kong, Singapore, Kuwait, and New Zealand were relatively early adopters, with more than one subscription per 100 people by 1990. By 1995, the European Union had an average of over four subscriptions per 100 people, growing to over 53 subscriptions per 100 people in 2000. North American and high income Asian and Middle Eastern countries followed similar patterns.

Table 1 shows summary statistics for all variables in our sample over the period from 1990 to 2015. On average, the annual brain cancer death rate is about 3.7 individuals per 100,000. There are about 62 mobile phone subscriptions per 100 people on average. However, there is a lot of temporal variation in mobile phone subscriptions, which we detail more below....

Results from Table 2:

... one more mobile phone subscription per 1,000 people is associated with 0.00012 more brain cancer deaths per 1,000 people 15 years later and 0.00073 more brain cancer deaths per 1,000 people 20 years later.

In the first column of Table 4, we find very similar effects to Table 2, and we again find that mobile phone subscriptions are related to increases in brain cancer mortality starting about 15–25 years later. The next four columns show results from differential effects models. In these models, we again find a positive and statistically significant association between mobile phone subscription rates and brain cancer mortality 15–19 years later relative to mortality from the other diseases studied. Our results here are robust to specification changes, with the exception that we lose statistical significance when not using country weights. 3 However, we do note that the mobile phone coefficient is much larger for the 15–19 year lag compared to other lags.

We find a statistically significant relationship between mobile phone subscriptions and brain cancer death rates 15–20 years later. Our estimated effect sizes are small but statistically significant. The implications of our findings are potentially very large. Almost 16,000 people died from brain cancer in the United States in 2014. If our findings are correct, the number of brain cancer deaths will continue to rise as the number of mobile phone users rose rapidly in the early part of the century. To err on the side of caution, individuals may want to make greater use of the speaker phone and/or texting options on their cell phones or investigate cell phone cases that may deflect radiation away from their ears.

Some caveats to our analysis are warranted. First, we cannot make an unambiguous claim of causality based on our results. Although we control for other characteristics likely to affect brain cancer death rates and find limited statistically significant relationships between mobile phone subscriptions and other mortality outcomes, there may be yet other factors that are correlated with mobile phone subscriptions and are also drivers of changes in brain cancer death rates. For example, ionizing radiation from computed tomography (CT) scans is an established risk factor for brain cancer (Pearce et al. 2012), and if the use of CT scans is correlated with mobile phone use, our estimates may be biased. We include controls for health spending, which should control for the

number of X-rays to some degree, and moreover, if X-rays and mobile phone adoption were truly correlated, we would expect mobile phones to have an effect on cancer mortality rates in other sites. But, omitted variables do remain a concern in our analysis.

Second, our measure of mobile phone use, mobile phone subscriptions per 100 people, may not be perfectly accurate....

Third, long lags between mobile phone subscriptions and brain cancer death rates mean that, depending on the specified lag between mobile phone subscriptions and mortality, the large recent variations in mobile phone adoption may not be part of our analysis. Additionally, the recent innovations in mobile phone technology, for example switching from 2G to 3G and 4G have resulted in changes in the radiation emitted from mobile phones (Croft et al. 2010; Leung et al. 2011). Moreover, the transition of peoples' use of mobile phones as predominantly phones to the rise of texting and other forms of social media may also change the relationship between mobile phones and brain cancer in the future.

https://onlinelibrary.wiley.com/doi/abs/10.1111/coep.12456

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Effect of cell phone use on salivary components; a review of literature

Fateme Arbabi Kalati, Tahereh Nosratzehi. Effect of cell phone use on salivary components; a review of literature. J Complement Integr Med. 2021 Nov 25. doi: 10.1515/jcim-2021-0397.

Abstract

Mobile phones have been increasingly used in the past decade and have become a cultural instrument. There is a great concern over the harmful effects of electromagnetic and radiofrequency waves as well as microwaves generated by mobile phones and their telecommunication stations on health. The saliva plays an important role in preserving oral homeostasis as the first defensive line against the microbial invasion which protects oral mucosa mechanically and immunologically. A search was run in Pub med, Goggle Scholar, Medline, and Web of Science databases using the following keywords: cell phone, mobile phone, antioxidant profile, saliva, oxidative stress, interleukin, and inflammation. Sixty-five published articles were identified. Studies on the use of cell phones as educational aids, the use of immune histochemistry on salivary glands, or the evaluation of saliva in individuals with specific conditions, such as the use of orthodontic brackets, were excluded. In addition, duplicate articles are eliminated, and finally, 14 articles were included in the present study. Nowadays mobile phone is very popular, causing concern about the effect it has on people's health. Parotid salivary glands are in close contact with a cell phone while talking with the phone and the possibility of being affected by them; so this study was designed to investigate the effect of cell phone use on salivary components.

https://pubmed.ncbi.nlm.nih.gov/34821111/

Excerpt

The above studies show that using cell phones affects the antioxidative system, immune system, and inflammatory system of saliva. Although to date, no specific medical condition has been attributed to these changes, decreasing the frequency and duration of cellphone use is advisable.

Thus, based on these findings, it is recommended that a long-term/or excessive use of mobile phones, especially by young individuals, should be avoided. This goal can be accomplished by telehealth technology promotion activities targeting the more sensitive ages, children, and adolescents since their developing brains absorb more EMR from a mobile phone. Such activities include group discussions, public presentations, and mass communication through available electronic and print media sources.

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Occupational exposure to radiofrequency electromagnetic fields (review)

Rianne Stam. Occupational exposure to radiofrequency electromagnetic fields. Ind Health. 2021 Nov 16. doi: 10.2486/indhealth.2021-0129.

Abstract

High exposures to radiofrequency electromagnetic fields (RF EMF) are possible in workplaces involving sources used for broadcasting, telecommunication, security and identification, remote sensing and the heating and drying of goods. A systematic literature review of occupational RF EMF exposure measurements could help to clarify where more attention to occupational safety may be needed. This review identifies specific sources of occupational RF EMF exposure and compares the published maximum exposures to occupational exposure limits. A systematic search for peer-reviewed publications was conducted via PubMed and Scopus. Relevant grey literature was collected via web searches. For each publication, the highest measured electric field strength, magnetic flux density or power density was extracted. Maximum exposures exceeding the limits were reported for dielectric heating, scanners for security and radiofrequency identification, plasma devices and broadcasting and telecommunication transmitters. Occupational exposure exceeding the limits was rare for microwave heating and radar applications. Some publications concerned case studies of occupational accidents followed by a medical investigation of thermal health effects. These were found for broadcasting antennas, radar installations and a microwave oven and often involved maintenance personnel. New sources of occupational exposure such as those in fifth generation telecommunication systems or energy transition will require further assessment.

Open access paper: https://www.jstage.jst.go.jp/article/indhealth/advpub/0/advpub_2021-0129/_article

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Magnetic Field-Induced Interactions between Phones Containing Magnets and Cardiovascular Implantable Electronic Devices - Flip it to be Safe?

Lacour P, Dang PL, Heinzel FR, Parwani AS, Bähr F, Kucher A, Hohendanner F, Niendorf T, Rahimi F, Saha N, Han H, Rubarth K, Sherif M, Boldt LH, Pieske B, Blaschke F. Magnetic Field-Induced Interactions between Phones

Containing Magnets and Cardiovascular Implantable Electronic Devices - Flip it to be Safe? Heart Rhythm. 2021 Nov 9:S1547-5271(21)02334-1. doi: 10.1016/j.hrthm.2021.11.010.

Abstract

Background: Recent case reports and small studies have reported activation of the magnet-sensitive switches in cardiovascular implantable electronic devices (CIED) by the new iPhone 12 series, initiating asynchronous pacing in pacemakers and suspension of anti-tachycardia therapies in ICDs.

Objective and methods: We performed a prospective single-center observational study to quantify the risk of magnetic field interactions of the iPhone 12 with CIEDs. A representative model of each CIED series from all manufacturers was tested ex vivo. Incidence and minimum distance necessary for magnet mode triggering were analyzed in 164 CIED patients with either the front or the back of the phone facing the device. The magnetic field of the iPhone 12 was analyzed using a 3-axis hall probe.

Results: Ex vivo, magnetic interferences occurred in 84.6% with the back compared to 46.2% with the front of the iPhone 12 facing the CIED. In vivo, activation of the magnet-sensitive switch occurred in 30 CIED patients (18.3%; 21 pacemaker, 9 ICDs) when the iPhone 12 was placed in close proximity over the CIED pocket and the back of the phone was facing the skin. Multiple binary logistic regression analysis identified the implantation depth (95% confidence interval [CI], 0.02 to 0.24) as independent predictor of magnet-sensitive switch activation.

Conclusion: Magnetic field interactions occur only in close proximity, and with precise alignment of the iPhone 12 and CIEDs. It is important to advise CIED patients to not put the iPhone 12 directly on the skin above the CIED. Further recommendations are not necessary.

Open access paper: https://www.heartrhythmjournal.com/article/S1547-5271(21)02334-1/fulltext

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Compact Exposimeter Device for the Characterization and Recording of Electromagnetic Fields from 78 MHz to 6 GHz with Several Narrow Bands (300 kHz)

Marco Xavier Rivera González, Nazario Félix González, Isabel López, Juan Sebastián Ochoa Zambrano, Andrés Miranda Martínez, Ceferino Maestú Unturbe. Compact Exposimeter Device for the Characterization and Recording of Electromagnetic Fields from 78 MHz to 6 GHz with Several Narrow Bands (300 kHz). Sensors (Basel). 2021 Nov 7;21(21):7395. doi: 10.3390/s21217395.

Abstract

A novel compact device with spectrum analyzer characteristics has been designed, which allows the measuring of the maximum power received in multiple narrow frequency bands of 300 kHz, recording the entire spectrum from 78 MHz to 6 GHz; the device is capable of measuring the entire communications spectrum and detecting

multiple sources of electromagnetic fields using the same communications band. The proposed device permits the evaluation of the cross-talk effect that, in conventional exposimeters, generates a mistake estimation of electromagnetic fields. The device was calibrated in an anechoic chamber for far-fields and was validated against a portable spectrum analyzer in a residential area. A strong correlation between the two devices with a confidence higher than 95% was obtained; indicating that the device could be considered as an important tool for electromagnetic field studies.

Conclusions

A compact exposimeter system has been proposed, which has similar characteristics to a spectrum analyzer, without losing the advantages of conventional exposimeters, and can be a useful tool for electromagnetic field studies analyzing a far-field. The proposed exposimeter measures the received power in the spectrum between 78 MHz and 6 GHz with a resolution bandwidth of 300 KHz, measuring approximately 19,500 narrow bands; the proposed exposimeter has passed the testing phase compared with spectrum analyzers with a significant factor of 0.948 for Student's t-test and a correlation factor of 0.9682 between the measurements of both devices.

The proposed exposimeter requires one second to measure the entire radioelectric spectrum; therefore, it has less sensitivity to variations in electromagnetic fields. This could be improved by restricting the measurements to the communication bands of interest; however, information from the rest of the radio spectrum is lost. It is important to define the relationship between the communication bands to be measured and the sensitivity to electromagnetic field variations with respect to time.

In future work, it is expected to use several of the proposed devices in electromagnetic field surveys to cover residential areas and provide information as an electromagnetic field sensor network to be used in epidemiological studies in the deployed area.

Open access paper: https://www.mdpi.com/1424-8220/21/21/7395/htm

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Computational modeling investigation of pulsed high peak power microwaves and the potential for traumatic brain injury

Amy M Dagro, Justin W Wilkerson, Thaddeus P Thomas, Benjamin T Kalinosky, Jason A Payne. Computational modeling investigation of pulsed high peak power microwaves and the potential for traumatic brain injury. Sci Adv. 2021 Oct 29;7(44):eabd8405. doi: 10.1126/sciadv.abd8405.

Amy Dagro and Thaddeus Thomas are with the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD; Benjamin Kalinosky is with General Dynamics Information Technology, JBSA Fort Sam Houston, San Antonio, TX; and Jason Payne is with U.S, Air Force Research Laboratory, 711th Human Performance Wing, Airman Systems Directorate, Bioeffects Division, Radio Frequency Bioeffects Branch, JBSA Fort Sam Houston, San Antonio, TX.

Abstract

When considering safety standards for human exposure to radiofrequency (RF) and microwave energy, the dominant concerns pertain to a thermal effect. However, in the case of high-power pulsed RF/microwave energy, a rapid thermal expansion can lead to stress waves within the body. In this study, a computational model is used to estimate the temperature profile in the human brain resulting from exposure to various RF/microwave incident field parameters. The temperatures are subsequently used to simulate the resulting mechanical response of the brain. Our simulations show that, for certain extremely high-power microwave exposures (permissible by current safety standards), very high stresses may occur within the brain that may have implications for neuropathological effects. Although the required power densities are orders of magnitude larger than most real-world exposure conditions, they can be achieved with devices meant to emit high-power electromagnetic pulses in military and research applications.

Excerpts

"The bulk of scientific literature uses continuous waves and moderate field strengths (typical of real-life scenarios), with less emphasis on pulsed fields of very high peak strength that may occur with ultrawideband pulse generators or EM pulse simulators (4). It is worth investigating whether extremely high peak power sources applied with a slow repetition frequency, or low duty cycle, can induce injurious effects without thermal buildup greater than a few degrees Celsius."

"With the exception of low intracranial absorption at 1400 MHz, the highest ratio of peak average intracranial SAR* to peak average skin SAR* occurs between 1 to 1.8 GHz."

"The MAE, also referred to as “microwave hearing” or the “Frey effect” due to its discovery by Allan Frey in 1961 (7, 8), was initially observed when subjects standing up to hundreds of feet away from a radar transponder could hear an audible tonal noise (e.g., chirping, buzzing, or clicking). The scientific underpinnings of the MAE were controversial for the first several years (9–11). After more than a decade of investigations, it became generally accepted that the perceived sound is due to the cochlea detecting stress waves that result from a rapid temperature rise in tissues within the head due to pulsed RF/microwave exposure (11, 12)."

"Typically, relatively low-average powers and small temperature changes (10^{-6}°C) are required to elicit the MAE (12). Although adverse health effects from the MAE have not been previously established, one study on rodents suggests that very high–peak power pulsed microwaves can result in cognitive deficits (13)."

"This study uses a two-simulation approach to investigate whether an HPM source could theoretically induce adverse mechanical responses within the brain."

"This study has shown that, by applying a small temperature increase (<0.0005°C) in a very short amount of time (less than several microseconds), potentially injurious stress waves are created."

"For frequencies between 400 MHz to 2 GHz, the IEEE C95.1 RF exposure guidelines limit the exposure reference limit (ERL) to fmhz/200 (W/m2) over an averaging time of 30 min. For 1-GHz exposures, the IEEE C95.1 ERL of 5 W/m2 over 30 min would equate to an average energy density of 9000 J/m2. Our computational model shows that, for sufficiently high incident power densities, a single pulse could potentially result in biologically meaningful pressures. For example, large pressures may occur following 1-GHz frequency, a pulse duration of 5 μs, and incident power densities of at least 1.5 × 107 W/m2. The energy density associated with such a pulse would be equal to PIN×τd or 75 J/m2 (significantly less than the ERL standard)."

" Note that the proposed HPM power densities in this study are extremely large and several orders of magnitude larger than power densities typically experienced by the public. As an illustrative example, at around 200 feet from a cell phone base station, a person will be exposed to a power density of only 0.001 mW/cm^2 or less (36). This study establishes a testable hypothesis between potential neurocognitive effects and the thermoelastic mechanism from HPM systems. To date, however, adverse effects from HPM systems have not been established in the scientific literature."

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8555891/

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Assessment of Human Exposure in Iasi-City using Data Provided by the (Romanian) National Autonomous RF-EMF Monitoring System

M. Ursachianu, O. Bejenaru, C. Lazarescu, A. Salceanu and M. Paulet. The Assessment of Human Exposure in Iasi-City using Data Provided by The National Autonomous RF-EMF Monitoring System throughout 2020. *2021 International Conference on Electromechanical and Energy Systems (SIELMEN)*, 2021, pp. 225-230, doi: 10.1109/SIELMEN53755.2021.9600350.

Abstract

In the last decades, we are all witnessed to an explosive increase and development of applications that integrate the electromagnetic environment in our day-by-day life. The principal and delicate problem of the human exposure to a various types of electromagnetic field (EMF) sources is very challenging and up to date one, being considered to have a higher level of importance especially from the safety point of view. The population has always been reluctant and ambiguous about the introduction of new technologies, like the actual case of the implementation around the world of the new 5G NR mobile communications technology for example. For that, the responsible authorities from different countries must conduct studies to ensure and to track the fact that the exposure at new technology is safe or not. So, that being said, the process of monitoring the EMF produce by a diversity of different sources of radiofrequency electromagnetic fields (RF-EMFs) should be a priority in our days. In the study presented in this paper, using the National Autonomous Broadband EMF Monitoring System, a continuous 24/365(hours/days) monitoring system, we analyze real-time monitoring data for all months of the year 2020 for all EMF monitoring fixed station installed at that time in Iasi-city giving a special attention for the last month of the year, December 2020. It was made also an analysis and comparison off the measured data with those imposed by international organizations and national regulatory bodies. At the final a set of preliminary conclusions have been taken.

https://ieeexplore.ieee.org/document/9600350

Conclusions

Evaluation the levels of the electromagnetic fields generated by a diversity of communication systems and other sources of RF-EMFs should be a priority in our days. An Autonomous Continuous and Intelligent Broadband EMF monitoring system with multiband frequency sensors represent an important step in this area. The network of

tri-axials sensors from EMF monitoring system measures the total levels of electromagnetic field from all surrounding sources and can also do a real-time measure of the assessment results to the public.

The continuous monitoring of the electromagnetic field is very important to realize to reassure the population who is in an area of ambiguity regarding the exposure to electromagnetic radiation generated by various sources of radio frequency electromagnetic fields in our country. The exposure to RF-EMFs is an actual problem of concern for many people in nowadays and should be a priority area of investigation, especially regarding the emergence of new communication technologies, like 5G NR.

The present study offers an insight view into the EMF exposure levels recorded by the national EMF real-time monitoring system, for a full month of the year 2020. The results of our analysis indicate that the exposure levels to radio electromagnetic fields are much more below the reference levels values adopted by the national legislation for population.

The E-field values of different transmitters may vary over the time. In the case of base stations of cellular mobile services, the transmitted power depends highly on the actual traffic load and user behavior. During a monitoring of 24h the electric field values was well below the limits. Traffic load may also depend on the time of the day, day of the week, and even in season as we will see in a future study. Monitoring the E-Field values from mobile base station antenna may also depend on the distance from the source.

An EMF monitoring station with a tri-axial electric field probe who can measured the electric field in a broadband frequency range like one of those used in the national EMF monitoring system could be also use for providing a good assessment of human exposure to EMF generated by new types of mobile communication services. 5G NR (NR – New Radio).

Further research can be directed on the study of EMF monitoring values in case of extending the evaluation study over more EMF monitoring stations from different cities of the country, eventually for a long period of time, in order to obtain a better assess of the coverage and the temporal evolution over the problem of the exposure to different electromagnetic field sources.

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5G Base Station Deployment Review for RF Radiation

M. S. Elbasheir, R. A. Saeed, S. Edam. 5G Base Station Deployment Review for RF Radiation. 2021 International Symposium on Networks, Computers and Communications (ISNCC), 2021, pp. 1-5, doi: 10.1109/ISNCC52172.2021.9615689.

Abstract

The 5G is expected to make great change for Mobile network and technology in the coming years. there is extensive discussion about the electromagnetic radiation that the 5G will contribute and its impact to the human and other technologies. The aggressive deployment of the technology associated with the new massive

Internet of Things (IoT) devices, all are indicator to the great electromagnetic radiation and exposure that 5G may cause. This problem considered as a challenge constrain for deployment of massive 5G base stations especially in residential areas. This paper reviews the recent works on the Electromagnetic Fields (EMF) radiation assessment for 5G base stations (BS) on human evaluation and analysis from different perspectives. The review covers the international standard exposure limits adopted by some of the regulatory bodies. The reviewed cases are classified into two main categories, assessment based on model simulation, and on field measurement, where both categories have the same objective to assess and evaluate the EMF radiation exposure from BSs.

Conclusions

EMF exposure has increasingly earned attention in the community and media. Recently the 5G has been proposed to be deployed under the 3GPP released 18. One of the main challenges for 5G deployment is the EMF exposure, especially when accumulated with the other deployed technologies i.e., 4G, 3G and low-power wide-area network (LPWAN) technologies. This paper reviewed the EMF radiation assessment from 5G BSs, where we reviewed some recent related work recently done through measurement and simulations. Various results were discussed, analyzed and compared with the regulation bodies like ICNIRP and FCC. there are many EMF assessment methodologies and techniques were presented and discussed. Most of the recommendations were to conduct more investigations with different perspectives, parameters, assumptions and scenarios

https://ieeexplore.ieee.org/document/9615689

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Magnetite Particle Presence in the Human Brain: A Computational Dosimetric Study to Emphasize the Need of a Complete Assessment of the Electromagnetic Power Deposition at 3.5 GHz

D. Vatamanu, S. Miclaus. Magnetite Particle Presence in the Human Brain: A Computational Dosimetric Study to Emphasize the Need of a Complete Assessment of the Electromagnetic Power Deposition at 3.5 GHz. *Eng. Technol. Appl. Sci. Res.*, 11(5): 7720–7729, Oct. 2021.

Abstract

The growing evidence of increased magnetite nanoparticles (both endo- and exo-genic) in the human brain raises the importance of assessing the entire power deposition when electromagnetic waves at GHz frequencies propagate in such tissues. This frequency range corresponds to many popular portable communication devices that emit radiation close to a human's head. At these frequencies, the current dosimetric numerical codes can not accurately compute the magnetic losses part. This is due to the lack of an implemented computational algorithm based on solving the coupled Maxwell and Landau-Lifshitz-Gilbert equations, in the case of magneto-dielectrics, considering eddy currents losses and specific properties of magnetic sub-millimetric particles. This paper focuses on analyzing the limits and the inconsistencies when using commercial dosimetric numerical software to analyze the total absorbed power in brain models having ferrimagnetic content and being exposed to 3.5GHz electromagnetic waves. Magnetic losses computed using Polder’s permeability tensor as constitutive relation lead to unreliable results. However, using such software can provide a preliminary view of the electromagnetic impact of ultra- and super-high frequencies on magnetic-dielectric tissues.

Open access paper: https://www.etasr.com/index.php/ETASR/article/view/4466

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1,800 MHz RF Electromagnetic Irradiation Impairs Neurite Outgrowth With a Decrease in Rap1-GTP in Primary Mouse Hippocampal Neurons and Neuro2a Cells

Li Yanqi, Deng Ping, Chen Chunhai, Ma Qinlong, Pi Huifeng, He Mindi, Lu Yonghui, Gao Peng, Zhou Chao, He Zhixin, Zhang Yanwen, Yu Zhengping, Zhang Lei. 1,800 MHz Radiofrequency Electromagnetic Irradiation Impairs Neurite Outgrowth With a Decrease in Rap1-GTP in Primary Mouse Hippocampal Neurons and Neuro2a Cells. Frontiers in Public Health. Vol. 9:1854. 2021. doi: 10.3389/fpubh.2021.771508

Abstract

Background: With the global popularity of communication devices such as mobile phones, there are increasing concerns regarding the effect of radiofrequency electromagnetic radiation (RF-EMR) on the brain, one of the most important organs sensitive to RF-EMR exposure at 1,800 MHz. However, the effects of RF-EMR exposure on neuronal cells are unclear. Neurite outgrowth plays a critical role in brain development, therefore, determining the effects of 1,800 MHz RF-EMR exposure on neurite outgrowth is important for exploring its effects on brain development.

Objectives: We aimed to investigate the effects of 1,800 MHz RF-EMR exposure for 48 h on neurite outgrowth in neuronal cells and to explore the associated role of the Rap1 signaling pathway.

Material and Methods: Primary hippocampal neurons from C57BL/6 mice and Neuro2a cells were exposed to 1,800 MHz RF-EMR at a specific absorption rate (SAR) value of 4 W/kg for 48 h. CCK-8 assays were used to determine the cell viability after 24, 48, and 72 h of irradiation. Neurite outgrowth of primary hippocampal neurons (DIV 2) and Neuro2a cells was observed with a 20 × optical microscope and recognized by ImageJ software. Rap1a and Rap1b gene expressions were detected by real-time quantitative PCR. Rap1, Rap1a, Rap1b, Rap1GAP, and p-MEK1/2 protein expressions were detected by western blot. Rap1-GTP expression was detected by immunoprecipitation. The role of Rap1-GTP was assessed by transfecting a constitutively active mutant plasmid (Rap1-Gly_Val-GFP) into Neuro2a cells.

Results: Exposure to 1,800 MHz RF-EMR for 24, 48, and 72 h at 4 W/kg did not influence cell viability. The neurite length, primary and secondary neurite numbers, and branch points of primary mouse hippocampal neurons were significantly impaired by 48-h RF-EMR exposure. The neurite-bearing cell percentage and neurite length of Neuro2a cells were also inhibited by 48-h RF-EMR exposure. Rap1 activity was inhibited by 48-h RF-EMR with no detectable alteration in either gene or protein expression of Rap1. The protein expression of Rap1GAP increased after 48-h RF-EMR exposure, while the expression of p-MEK1/2 protein decreased. Overexpression of constitutively active Rap1 reversed the decrease in Rap1-GTP and the neurite outgrowth impairment in Neuro2a cells induced by 1,800 MHz RF-EMR exposure for 48 h.

Conclusion: Rap1 activity and related signaling pathways are involved in the disturbance of neurite outgrowth induced by 48-h 1,800 MHz RF-EMR exposure. The effects of RF-EMR exposure on neuronal development in infants and children deserve greater focus.

Open access paper: https://www.frontiersin.org/article/10.3389/fpubh.2021.771508

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Solar and geomagnetic activity enhance the effects of air pollutants on atrial fibrillation

Zilli Vieira CL, Link MS, Garshick E, Peralta AA, Luttmann-Gibson H, Laden F, Liu M, Gold DR, Koutrakis P. Solar and geomagnetic activity enhance the effects of air pollutants on atrial fibrillation. Europace. 2021 Nov 13:euab269. doi: 10.1093/europace/euab269.

Abstract

Aims: Cardiac arrhythmias have been associated with intense solar and geomagnetic activity (SGA) and exposures to air pollution.

Methods: We examined whether oscillations of SGA can modify the effect of hourly exposures to air pollutants on atrial fibrillation ≥30 s (AF) risk in patients with dual-chamber implantable cardioverter-defibrillators. The effects of SGA on ambient particulate matter <2.5 μm (PM2.5), black carbon (BC), ultrafine particles (PN), and associations with AF were assessed. Measures of SGA included solar wind proton density (SW), total interplanetary magnetic field strength (IMF), and Kp index, a measure of global geomagnetic activity.

Results: Overall time lags between 0 and 24 h, periods of increased SGA (>50th percentile in IMF, SW, and Kp index) enhanced the effects of all three air pollutants on AF, while during periods of reduced SGA the associations were considerably weaker or absent. During periods of intense SW 6 h prior to an AF event, the odds ratio (OR) for PM2.5 exposure per interquartile range (IQR) of 5.6 μg/m3 was 1.7 [95% confidence interval (CI) 1.3-2.3, P = 0.0001]. For periods of reduced SW, the OR for PM2.5 exposure per IQR was 1.2 (95% CI 0.9-1.5; P = 0.27). There were similar effects for PN and BC exposures. In patients with multiple AF events per hour, the associations with air pollutants during intense SGA were even greater.

Conclusion: The effects of air pollutants up to 24 h before AF events were enhanced during periods of increased SGA. Our results suggest that these effects may account for variation in AF risk.

https://pubmed.ncbi.nlm.nih.gov/34791174/

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Human resting-state EEG and radiofrequency GSM mobile phone exposure: The impact of the individual alpha frequency

Jasmina Wallace, Lydia Yahia-Cherif, Christophe Gitton, Laurent Hugueville, Jean-Didier Lemaréchal, Brahim

Selmaoui. Human resting-state EEG and radiofrequency GSM mobile phone exposure: The impact of the individual alpha frequency. Int J Radiat Biol. 2021 Nov 19;1-29. doi: 10.1080/09553002.2021.2009146.

Abstract

Purpose. With the extensive use of mobile phone (MP) several studies have been realized to investigate the effects of radiofrequency electromagnetic fields (RF-EMF) exposure on brain activity at rest via electroencephalography (EEG), and the most consistent effect has been seen on the alpha band power spectral density (PSD). However, some studies reported an increase or a decrease of the PSD, while others showed no effect. It has been suggested that these differences might partly be due to a variability of the physiological state of the brain between subjects. So, the aim of this study was to investigate the alpha band modulation, exploring the impact of the alpha band frequency ranges applied in the PSD analysis.

Materials & Methods. Twenty-one healthy volunteers took part in the study with a double-blind, randomized and counterbalanced crossover design, during which eyes-open (EO) and eyes-closed (EC) resting-state EEG was recorded. The exposure system was a sham or a real GSM (global system for mobile) 900 MHz MP (pulse modulated at 217 Hz, mean power of 250 mW and 2 W peak, with a maximum specific absorption rate of 0.70 W/kg on 1 g tissue). The experimental protocol presented a baseline recording phase without MP exposure, an exposure phase during which the exposure system was placed against the left ear, and the post-exposure phase without MP. EEG data from baseline and exposure phases were analyzed and PSD was computed for the alpha band in the fixed range of 8-12 Hz and for the individual alpha band frequency range (IAF).

Results. Results showed a trend in decrease or increase of EEG power of both alpha oscillations during exposure in relation to EC and EO recording conditions, respectively, but not reaching statistical significance. Findings did not provide evidence for a different sensitivity to RF-EMF MP related to individual variability in the frequency of the alpha band.

Conclusion. In conclusion, these results did not show alpha band activity modulation during resting-state under RF-EMF. It might be argued the need of a delay after the exposure in order to appreciate an EEG spectral power modulation related to RF-EMF exposure.

https://pubmed.ncbi.nlm.nih.gov/34797205/

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The effects of radiofrequency exposure on male fertility and adverse reproductive outcomes: A protocol for two systematic reviews of human observational studies with meta-analysis

Ryan P.W. Kenny, Evelyn Barron Millar, Adenike Adesanya, Catherine Richmond, Fiona Beyer, Carolina Calderon, Judith Rankin, Mireille Toledano, Maria Feychting, Mark S Pearce, Dawn Craig, Fiona Pearson. The effects of radiofrequency exposure on male fertility and adverse reproductive outcomes: A protocol for two systematic reviews of human observational studies with meta-analysis. Environment International. 158, 2022, 106968. doi:

10.1016/j.envint.2021.106968.

Abstract

Background The World Health Organization (WHO) is bringing together evidence on radiofrequency electromagnetic field (RF-EMF) exposure in relation to health outcomes, previously identified as priorities for evaluation by experts in the field, to inform exposure guidelines. A suite of systematic reviews are being undertaken by a network of topic experts and methodologists in order to collect, assess and synthesise data relevant to these guidelines. Here, we present the protocol for the systematic review on the effect of exposure to RF on adverse reproductive outcomes (human observational studies), also referred to as Systematic Review (SR) 3 within the series of systematic reviews currently being commissioned.

Objectives Following the WHO handbook for guideline development and the COSTER conduct guidelines, we will systematically review the effect of RF-EMF exposure on both male fertility (SR3A) and adverse pregnancy outcomes (SR3B) in human observational studies. Herein we adhere to the PRISMA-P reporting guidelines.

Data sources We will conduct a broad search for potentially relevant records relevant for both reviews within the following bibliographic databases: MEDLINE; Embase; and EMF Portal. We will also conduct searches of grey literature through relevant databases and organisational websites. RF-EMF experts will also be consulted. We will hand search citation and reference lists of included study records.

Study eligibility criteria We will include quantitative human observational studies on the effect of RF-EMF exposure: (in SR3A) in adult male participants on infertility, sperm morphology, concentration or total sperm count or motility; and (in SR3B) in preconception adults or pregnant women on preterm birth, small for gestational age (associated with intrauterine growth restriction), miscarriage, stillbirth and congenital anomalies.

Study appraisal and synthesis methods Titles, abstracts and then full texts will be screened in blinded duplicate against eligibility criteria with input from a third reviewer as required. Data extraction from included studies will be completed by two reviewers as will risk of bias assessment using the Office of Health Assessment and Translation (OHAT) tool. If appropriate we will undertake meta-analysis to pool effect measures and explore heterogeneity using sub-group analyses or meta-regression as feasible. We will conduct sensitivity analysis to assess the impact of any assumptions made throughout the review process. The OHAT methodology, based on the GRADE guidelines for evidence assessment, will be used to evaluate the certainty of evidence per outcome and to conclude the level of evidence of a health effect.

Conclusion This manuscript details the protocols for two systematic reviews. The aims of publishing details of both protocols are to: pre-specify their scope and methods; reduce the impact of reviewer bias; promote transparency and replicability; and improve the review process.

Prospero registration CRD42021265401 (SR3A), CRD42021266268 (SR3B).

Open access paper: https://www.sciencedirect.com/science/article/pii/S0160412021005936

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The effects of radiofrequency electromagnetic fields exposure on human self-reported symptoms: A protocol for a systematic review of human experimental studies

Xavier Bosch-Capblanch, Ekpereonne Esu, Stefan Dongus, Chioma Moses Oringanje, Hamed Jalilian, John Eyers, Gunnhild Oftedal, Martin Meremikwu, Martin Röösli. The effects of radiofrequency electromagnetic fields exposure on human self-reported symptoms: A protocol for a systematic review of human experimental studies. Environment International. 158,

2022, 106953. doi: 10.1016/j.envint.2021.106953.

Abstract

Background The technological applications of radiofrequency electromagnetic fields (RF-EMF) have been steadily increasing since the 1950s across multiple sectors exposing large proportions of the population. This fact has raised concerns related to the potential consequences to people's health. The World Health Organization (WHO) is assessing the potential health effects of exposure to RF-EMF and has carried out an international survey amongst experts, who have identified six priority topics to be further addressed through systematic reviews, whereof the effects on symptoms is one of them. We report here the systematic review protocol of experimental studies in humans assessing the effects of RF-EMF on symptoms.

Objective Our objectives are to assess the effects of exposure to electromagnetic fields (compared to no or lower exposure levels) on symptoms in human subjects. We will also assess the accuracy of perception of presence of exposure in volunteers with and without idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF).

Eligibility criteria We will search relevant literature sources (e.g. the Web of Science, Medline, Embase, Epistemonikos) for randomized trials (comparing at least two arms) and randomised crossover trials of RF-EMF exposure that have assessed the effects on symptoms. We will also include studies that have measured the accuracy of the perception of the presence or absence of exposure. We will include studies in any language.

Study appraisal and synthesis Studies will be assessed against inclusion criteria by two independent reviewers. Data on study characteristics, participants, exposure, comparators and effects will be extracted using a specific template for this review, by two independent reviewers. Discrepancies will be solved by consensus. Risk of bias (ROB) will be assessed using the ROB Rating Tool for Human and Animal Studies and the level of confidence in the evidence of the exposure-outcome relations will be assessed using the GRADE approach. For the perception studies, we will use adapted versions of the ROB tool and GRADE assessment. Where appropriate, data will be combined using meta-analytical techniques.

Open access paper: https://www.sciencedirect.com/science/article/pii/S016041202100578X

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The effect of radiofrequency electromagnetic fields (RF-EMF) on biomarkers of oxidative stress in vivo and in vitro: A protocol for a systematic review

Bernd Henschenmacher, Annette Bitsch, Tonia de las Heras Gala, Henry Jay Forman, Athanassios Fragoulis, Pietro Ghezzi, Rupert Kellner, Wolfgang Koch, Jens Kuhne, Dmitrij Sachno, Gernot Schmid, Katya Tsaioun, Jos Verbeek, Robert Wright. The effect of radiofrequency electromagnetic fields (RF-EMF) on biomarkers of oxidative stress in vivo and in vitro: A protocol for a systematic review. Environment International. 158, 2022, 106932. doi: 10.1016/j.envint.2021.106932.

Abstract

Background Oxidative stress is conjectured to be related to many diseases. Furthermore, it is hypothesized that radiofrequency fields may induce oxidative stress in various cell types and thereby compromise human and animal health. This systematic review (SR) aims to summarize and evaluate the literature related to this hypothesis.

Objectives The main objective of this SR is to evaluate the associations between the exposure to radiofrequency electromagnetic fields and oxidative stress in experimental models (in vivo and in vitro).

Methods The SR framework has been developed following the guidelines established in the WHO Handbook for Guideline Development and the Handbook for Conducting a Literature-Based Health Assessment). We will include controlled in vivo and in vitro laboratory studies that assess the effects of an exposure to RF-EMF on valid markers for oxidative stress compared to no or sham exposure. The protocol is registered in PROSPERO.

We will search the following databases: PubMed, Embase, Web of Science Core Collection, Scopus, and the EMF-Portal. The reference lists of included studies and retrieved review articles will also be manually searched.

Study appraisal and synthesis method Data will be extracted according to a pre-defined set of forms developed in the DistillerSR online software and synthesized in a meta-analysis when studies are judged sufficiently similar to be combined. If a meta-analysis is not possible, we will describe the effects of the exposure in a narrative way.

Risk of bias The risk of bias will be assessed with the NTP/OHAT risk of bias rating tool for human and animal studies.

We will use GRADE to assess the certainty of the conclusions (high, moderate, low, or inadequate) regarding the association between radiofrequency electromagnetic fields and oxidative stress.

Funding This work was funded by the World Health Organization (WHO).

Registration The protocol was registered on the PROSPERO webpage on July 8, 2021.

Open access paper: https://www.sciencedirect.com/science/article/pii/S0160412021005572

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The toxic effect of mobile phone radiation on rabbit organs

Shudong Zhu, Yan Zhu, Hao Li, Doudou Zhang, Dianzheng Zhang. The toxic effect of mobile phone radiation on rabbit organs. All Life. 252-258. 19 May 2020. https://doi.org/10.1080/26895293.2020.1763481

Abstract

Whether electromagnetic radiation (EMR) emitted from mobile phones is hazardous to human health is largely unknown. We investigated the effects of mobile phone radiation on critical organs in a rabbit model by exposing the animals to mobile phone radiation with sub-thermal specific absorption rate (SAR) of 1.0 and 0.7 W/kg for the head and the body, respectively, for 16 weeks (6 h/day, 6 days/week). There is no apparent change at the organ level. However, H&E staining showed that radiation-exposure significantly increased inflammatory cell infiltration in the liver and the lungs with a lesser degree of myocardial cell cytoplasmic vacuolation. In addition, results from γ-H2AX staining suggest that radiation can also cause DNA damage in the brain. Of note, no apparent activation of Caspase-3 in the organs examined. Our data altogether suggest that mobile phone radiation may be more hazardous to both the liver and the lungs, and less toxic to the brain and heart.

https://www.tandfonline.com/doi/full/10.1080/26895293.2020.1763481

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Does exposure to radiation emitted from mobile jammers influence spatial memory?

A. Shahi, F. Shahnazar, S. Nematolahi, A. Dehghan, M.B. Shojaeifard. Does exposure to radiation emitted from mobile jammers influence the spatial memory? Int J Radiat Res 2021, 19(4): 993-1000.

Abstract

Background: The central nervous system is sensitive to radiation exposure as environmental pollution. This project aimed to evaluate the influence of jammer exposure radiation on spatial learning and memory.

Materials and Methods: 50 adult male Sprague-Dawley rats were divided into five groups. The experimental groups were exposed to jammer radiation for 2h/day once or 2h/day for two weeks. Sham groups were similar to the experimental groups which were exposed to switch-off. The distance from the jammer router to the animals' cages was 30 cm. In the second phase, using Morris Water Maze, the effect of jammer exposure radiation on spatial learning and memory was studied.

Results: Data showed that radiation exposure once a day for 2h caused a significant increase in the learning procedure in the experimental group1, but we observed an increase in the parameters of distance and escape latency in finding the platform for two weeks' exposure in the experimental group 2.

Conclusion: Results indicated that probably the motivation of escape and use of the different cues led to learning in the animals, while disrupting mobile performance through jammer router from animal environment caused a better brain performance in the spatial learning and memory in short term jammer radiation-treated animals group. However, with the same test conditions, in long term jammer the radiation-treated animals' motivation reduced, which affected the responses and performance and reduced the learning. Moreover, environmental conflicts such as radiofrequency waves lead to behavioral alternations.

Exposure set up

The animals were placed in Plexiglas cages individually and exposed to radiation. The electromagnetic field measurements were done using an Aaronia Spectran HF-4060 device (Euscheid, Germany) with the frequency range 100 MHz -6 GHz. The frequency band, power output, and power density measured from electromagnetic fields of Jammer router were 1052-1979(MHz), -32±3 (dB mw), 86.18000 (µw/m2), and ICNIRP 0.31(%) respectively. Jammer router (MB06Mobile Blocker) works in four different frequency ranges (Global System for Mobile Communications [GSM], digital cellular service, code division multiple access, third generation). Shielding radii for this jammer are up to 40m.

Open access paper: http://ijrr.com/article-1-3981-en.html

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Electromagnetic field exposure-induced depression features could be alleviated by heat acclimation based on remodeling the gut microbiota

Luo X, Huang X, Luo Z, Wang Z, He G, Tan Y, Zhang B, Zhou H, Li P, Shen T, Yu X, Yang X. Electromagnetic field exposure-induced depression features could be alleviated by heat acclimation based on remodeling the gut microbiota. Ecotoxicol Environ Saf. 2021 Nov 15;228:112980. doi: 10.1016/j.ecoenv.2021.112980.

Highlights

- EMF exposure induced depression features.
- EMF cause gut microbiota and metabolites disturbance similar to depression model.
- HA alleviated depression caused by EMF.
- HA alleviated depression by gut microbiota, might be mechanism of cross-tolerance.

Abstract

Background: Electromagnetic pollution cannot be ignored. Long-term low-dose electromagnetic field (EMF) exposure can cause central nervous system dysfunction without effective prevention.

Materials/methods: Male C57BL/6J mice (6-8 weeks, 17-20 g) were used in this study. Depression-like and anxiety-like behaviors detected by behavioral experiments were compared among different treatments. 16S rRNA gene sequencing and non-targeted liquid chromatography-mass spectrometry (LC-MS) metabolomics were used to explore the relationship between EMF exposure and heat acclimation (HA) effects on gut microbes and serum metabolites.

Results: Both EMF and HA regulated the proportions of p_Firmicutes and p_Bacteroidota. EMF exposure caused the proportions of 6 kinds of bacteria, such as g_Butyricicoccus and g_Anaerotruncus, to change significantly ($p < 0.05$). HA restored the balance of gut microbes that was affected by EMF exposure and the proportion of probiotics (g_Lactobacillus) increased significantly ($p < 0.01$). Serum metabolite analysis suggested that HA alleviated the disturbance of serum metabolites (such as cholesterol and D-mannose) induced by EMF exposure. Both the metabolic KEGG pathways and PICRUSt functional analysis demonstrated that tryptophan metabolism, pyrimidine metabolism and amino acid biosynthesis were involved.

Conclusions: EMF exposure not only led to depression-like neurobehavioral disorders, but also to gut microbiota imbalance. HA alleviated the depression features caused by EMF exposure. Based on the analysis of gut microbiota associated with serum metabolites, we speculated that gut microbiota might play a vital role in the cross-tolerance provided by HA.

https://pubmed.ncbi.nlm.nih.gov/34794024/

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The effects of different herbals on the rat hippocampus exposed to electromagnetic field for one hour during the prenatal period

Ömür Gülsüm Deniz, Süleyman Kaplan. The effects of different herbals on the rat hippocampus exposed to electromagnetic field for one hour during the prenatal period. J Chem Neuroanat. 2021 Nov 19;102043. doi: 10.1016/j.jchemneu.2021.102043.

Highlights
• 900 MHz electromagnetic field exposure can cause adverse effects on the hippocampus.
• Garcinia kola, Momordica charantia, thymoquinone may reduce deleterious effects of electromagnetic field.
• It was revealed that the protective effect of Momordica charantia is stronger than other antioxidant substances used in the present study.

Note: Momordica charantia is commonly called bitter melon.

Abstract

The purpose of this study was to highlight the possible effects on the hippocampus of the electromagnetic field (EMF) emitted by mobile phones, and to investigate whether these potential effects can be reduced using various antioxidant substances. Twenty-seven female Wistar albino rats were divided into nine equal groups, each containing three pregnant rats aged 8-10 weeks and weighing 200-250 gr. The EMF groups were exposed to 900 Megahertz (MHz) EMF for 1hour (hr) a day for 21 days. No EMF exposure was applied to the Cont and also the groups given only Garcinia kola (GK), Momordica charantia (MC), and thymoquinone (TQ). The Sham group was kept in the polycarbonate EMF exposure system, but was not exposed to EMF. Four weeks after birth, rat pups were subjected to behavioural tests. Brain tissue samples were evaluated using histological, stereological, functional, and immunohistochemical methods. The numbers of pyramidal neurons in the rat

cornu ammonis (CA) were determined using the optical fractionator method. Superoxide dismutase (SOD) and catalase (CAT) enzyme activities in the blood samples were also evaluated. The analysis data indicated that total pyramidal neuron numbers were decreased significantly in the CA of the EMF (1hr) group ($p<0.01$). Our results also showed that the protective effect of MC was more potent than that of the other antioxidant substances ($p<0.01$). A 900MHz EMF can cause deleterious changes in the brain. It can also be suggested that GK, MC and TQ are capable of reducing these adverse effects.

https://pubmed.ncbi.nlm.nih.gov/34808256/

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Environmental factors and risks of cognitive impairment and dementia: A systematic review and meta-analysis

Yong-Li Zhao, Yi Qu, Ya-Nan Ou, Ya-Ru Zhang, Lan Tan, Jin-Tai Yu. Environmental factors and risks of cognitive impairment and dementia: A systematic review and meta-analysis. Ageing Res Rev. 2021 Oct 29;72:101504. doi: 10.1016/j.arr.2021.101504.

Highlights
- Air pollution, tobacco smoke and pesticides could elevate the risks of dementia.
- Exposure to electromagnetic fields was found positive associated with dementia.
- Solvents and aluminum were found hazard for dementia, while silicon might be benefit.
- Living in rural area and more deprived neighborhood were adverse for dementia.
- Residential greenness and social contacts were proposed as beneficial factors.

Abstract

Background: Dementia is a challenging neurodegenerative disease. This systematic review aimed to summarize natural, physical, and social environmental factors that are associated with age-related cognitive impairment and dementia.

Methods: We systematically searched PubMed, EMBASE, Web of Science, and PsychINFO till January 11, 2021 for observational studies. The hazard ratio (HR), relative risk (RR), and odds ratio (OR) with 95% confidence interval (CI) were aggregated using random-effects methods. The quality of evidence for each association was evaluated.

Results: Of the 48,399 publications identified, there were 185 suitable for review across 44 environmental factors. Meta-analyses were performed for 22 factors. With high-to-moderate quality of evidence, risks were suggested in exposure to PM2.5 (HR=1.24, 95%CI: 1.17-1.31), NO2 (HR=1.07, 95%CI: 1.02-1.12), aluminum (OR=1.35, 95%CI: 1.14-1.59), solvents (OR=1.14, 95%CI: 1.07-1.22), road proximity (OR=1.08, 95%CI: 1.04-1.12) and other air pollution, yet more frequent social contact (HR=0.82, 95%CI: 0.76-0.90) and more greenness (OR=0.97, 95%CI: 0.95-0.995) were protective. With low-to-very low quality, electromagnetic fields, pesticides, SO2, neighborhood socioeconomic status, and rural living were suggested risks, but more community cultural engagement might be protective. No significant associations were observed in exposure to PM10, NOx, noise, silicon, community group, and temperature. For the remaining 22 factors, only a descriptive analysis was undertaken as too few studies or lack of information.

Conclusions: This review highlights that air pollution, especially PM2.5 and NO2 play important role in the risk for age-related cognitive impairment and dementia.

https://pubmed.ncbi.nlm.nih.gov/34755643/

Excerpts

3.2.2. Electromagnetic fields (EMFs)

From 27 studies, we found electromagnetic fields exposure was associated with dementia (OR=1.27, 95% CI: 1.13–1.43, I2 =76.7%, S- grade, Fig. 3) with low-quality evidence, and among them, 11 were cohort studies and 16 were case-control studies (Appendix Figure 1.7). The result was robust via sensitivity analysis (Appendix Figure 3.8). Moreover, 23 studies focused on the outcome of AD, and 4 focused on VaD. Subgroup analysis displayed a significant association between EMFs with AD, but not with VaD (Fig. 3). In addition, the correlation with AD was observed in both females (OR=2.33, 95% CI: 1.19–4.57, I2 =49.8%) and male (OR=1.51, 95% CI: 1.21–1.89, I2 =46.4%, Appendix Figure 1.7.4). EMFs Exposure was mostly from occupation according to job-exposure information, and living next to the power line in life was not linked to dementia or AD (Fig. 3).

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The ecology of electricity and electroreception

Sam J. England, Daniel Robert. The ecology of electricity and electroreception. Biological Reviews. 12 October 2021. https://doi.org/10.1111/brv.12804

Abstract

Electricity, the interaction between electrically charged objects, is widely known to be fundamental to the functioning of living systems. However, this appreciation has largely been restricted to the scale of atoms, molecules, and cells. By contrast, the role of electricity at the ecological scale has historically been largely neglected, characterised by punctuated islands of research infrequently connected to one another. Recently, however, an understanding of the ubiquity of electrical forces within the natural environment has begun to grow, along with a realisation of the multitude of ecological interactions that these forces may influence. Herein, we provide the first comprehensive collation and synthesis of research in this emerging field of electric ecology. This includes assessments of the role electricity plays in the natural ecology of predator–prey interactions, pollination, and animal dispersal, among many others, as well as the impact of anthropogenic activity on these systems. A detailed introduction to the ecology and physiology of electroreception – the biological detection of ecologically relevant electric fields – is also provided. Further to this, we suggest avenues for future research that show particular promise, most notably those investigating the recently discovered sense of aerial electroreception.

Open access paper: https://onlinelibrary.wiley.com/doi/full/10.1111/brv.12804

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Assessment of Human Exposure (Including Interference to Implantable Devices) to Low-Frequency Electromagnetic Field in Modern Microgrids, Power Systems and Electric Transports

Andrea Mariscotti. Assessment of Human Exposure (Including Interference to Implantable Devices) to Low-Frequency Electromagnetic Field in Modern Microgrids, Power Systems and Electric Transports. Energies 2021. 14(20): 6789. doi:10.3390/en14206789.

Abstract

Electromagnetic field emissions of modern power systems have increased in complexity if the many power conversion forms by means of power electronics and static converters are considered. In addition, the installed electric power has grown in many everyday applications such as wireless charging of vehicles, home integrated photovoltaic systems, high-performance electrified transportation systems, and so on. Attention must then be shifted to include harmonics and commutation components on one side, as well as closer interaction with humans, that concretizes in impact on physiological functions and interference to implantable medical devices and hearing aids. The panorama is complex in that standards and regulations have also increased significantly or underwent extensive revisions in the last 10 years or so. For assessment, the straightforward application of the limits of exposure is hindered by measurement problems (time or frequency domain methods, positioning errors, impact of uncertainty) and complex scenarios of exposure (multiple sources, large field gradient, time-varying emissions). This work considers thus both the clarification of the principles of interaction for each affected system (including humans) and the discussion of the large set of related normative and technical documents, deriving a picture of requirements and constraints. The methods of assessment are discussed in a metrological perspective using a range of examples.

Open access paper: https://www.mdpi.com/1996-1073/14/20/6789/htm

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On the Power Lines—Electromagnetic Shielding Using Magnetic Steel Laminates

Tatiana Damatopoulou, Spyros Angelopoulos, Christos Christodoulou, Ioannis Gonos, Evangelos Hristoforou and Antonios Kladas. On the Power Lines—Electromagnetic Shielding Using Magnetic Steel Laminates.Energies 2021, 14(21): 7215. 2 November 2021. doi:10.3390/en14217215

(This article belongs to the Special Issue Advanced Electrical Measurements Technologies)

Abstract

Protection against the electromagnetic fields around high-voltage transmission lines is an issue of great importance, especially in the case of buildings near power lines. Indeed, the developed fields can be harmful for the habitants and electrical/electronic devices, so the implementation of appropriate measures to address the above electromagnetic interference issue is necessary in order to ensure the safety of both human beings and equipment. Several practices have been proposed to reduce the electric and the magnetic fields around

overhead and underground transmission lines (minimum distance, shielded cables, anechoic chamber etc.). In this context, the scope of the current paper is the use of highly permeable magnetic sheets for shielding purposes, along with the development of an appropriate procedure, based on finite element analysis (FEA) for the efficient design of passive shielding. The simulation results are compared with laboratory measurements in order to confirm the adequacy of the proposed methodology. The good agreement between the FEA outcomes and the experimental results confirms that the developed FEA tool can be trustfully used for the design of the shielding means in the case of overhead or underground power lines.

Open access paper: https://www.mdpi.com/1996-1073/14/21/7215/htm

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Influence of Materials, Windows &Shielding Layers on Low-Frequency Electromagnetic Environment of Subway Vehicle & Human Exposure Research

Zhiyuan Wang, Weinan Liu. Influence of Materials, Windows and Shielding Layers on Low-Frequency Electromagnetic Environment of Subway Vehicle and Human Exposure Research. Progress In Electromagnetics Research M, 105:151-160, 2021. doi:10.2528/PIERM21080403.

Abstract

The numerous high-power devices and cables gathered around the subway vehicle will aggravate the deterioration of the electromagnetic environment, which may cause the train to fail to operate normally or threaten the health of passengers with a pacemaker or defibrillator. In order to study the distribution characteristics of low-frequency magnetic field of the subway in complex electromagnetic environment and the influence of various factors on human electromagnetic exposure, the magnetic flux density nephograms of the subway train with different vehicle body materials, with or without windows and with the shielding layer are calculated and analyzed. Specific energy absorption rate (SAR) values have been calculated in a standing voxel model from exposure to electromagnetic fields at 2.4 GHz, frequencies commonly used by Wi-Fi devices. The numerical results show that the average value of magnetic flux density in the stainless-steel carriage is less than that in the aluminum alloy carriage and the carbon fiber reinforce plastic (CFRP) carriage. Compared with the vehicle with windows, the average value of magnetic flux density in the vehicle without windows is less. The added shielding layer decreases the average value of magnetic flux density from 10.5 uT to 3 uT. The maximum value of magnetic flux density in the carriage under different factors is about 10 uT, which is far less than the magnetic flux density reference limit of 0.1 mT of the International Commission of Non-Ionizing Radiation Protection (ICNIRP) standard. When the Wi-Fi device is closest to the human body, the highest Specific Absorption Ratio (SAR) value of human tissue is 0.00749 W/kg, which is far less than the electromagnetic exposure limit of 1.6 W/kg of IEEE standard.

http://www.jpier.org/PIERM/pier.php?paper=21080403

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Effectiveness of Omega-3 Fatty Acid in Protection from Magnetic Field Exposure During Pregnancy: An Experimental Rat Study

Ugurkan Erkayiran, Tufan Arslanca. Effectiveness of Omega-3 Fatty Acid in Protection from Magnetic Field Exposure During Pregnancy: An Experimental Rat Study. Journal of Reproductive Medicine. Nov 2021.

OBJECTIVE: Magnetic fields (MFs) can have several negative effects on the human body. This study aimed to reveal the relationship of adenosine deaminase enzyme (ADA), thyroid-stimulating hormone (TSH), and fetal neural degeneration (FND) with the curative effect of omega-3 fatty acids.

STUDY DESIGN: Pregnant Wistar Albino rats (n=30) were separated into 3 groups: Group 1 (sham group), Group 2 (rats exposed to 20 microteslas [μT] for 1 h/day for 10 days), and Group 3 (rats exposed to 20 μT for 4 h/day for 10 days). Blood samples were taken on days 1, 10, and 17 to examine ADA and TSH. Neurodegeneration scores were ana-lyzed with microscopic examination.

RESULTS: FND was determined to be greater in the rats exposed to the long-term MFs as compared to short-term MFs ($p<0.05$). There was a significant difference in terms of ADA and TSH in the rats that received short- and long-term MF as compared to the sham group ($p<0.05$). The mean scores were higher in the short- and long-term MF groups than in the sham group ($p<0.05$). ADA activity was found to be higher and TSH was lower in the short- and long-term MF groups ($p<0.05$). With the use of omega-3, positive alterations in myelin degeneration were observed in the groups exposed to short- and long-term MF ($p<0.05$).

CONCLUSION: While both ADA and TSH increased in both short- and long-term MF exposure, long-term MFs affected FND more than short-term exposure. Although using omega-3 showed a protective effect on the MF-induced FND, it was only protective against short-term exposure.

https://www.reproductivemedicine.com/toc/auto_abstract.php?id=24943

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Exposure to 10 Hz Pulsed Magnetic Fields Do Not Induce Cellular Senescence in Human Fetal Lung Fibroblasts

Sun Chuan, Huang Zheng, Qin Houbing, Zhang Jing, Wang Sanying, Xu Xiaogang, Ying Shibo, Mao Genxiang. Exposure to 10 Hz Pulsed Magnetic Fields Do Not Induce Cellular Senescence in Human Fetal Lung Fibroblasts. Frontiers in Public Health. 9:1657. 2021. doi: 10.3389/fpubh.2021.761069.

Abstract

Rapid population aging has led to a global burden of late-life diseases. As the largest risk factor for a multitude of age-related diseases, aging is not only the result of genotype but also closely related to external factors. With the rapid expansion in the usage of electromagnetic fields (EMFs), the effect of EMFs on aging has also attracted attention. Cells are the basic unit of organs and body tissues, and cellular senescence plays an important role in the aging process. The effect of EMFs on cellular senescence has been investigated in a few studies, but the information is limited, and the results are inconsistent; thus, further investigation is required. In this study, we

investigated the effect of 10 Hz pulsed magnetic fields (MFs) on cellular senescence in a 2BS cell line, isolated from human fetal lung fibroblasts, and found that intermittent (1 d on/1 d off) exposure to 10 Hz pulsed MFs at 1.0 mT for 2 weeks induced DNA damage, but no other significant phenotype of cellular senescence in 2BS cells.

Open access paper: https://www.frontiersin.org/article/10.3389/fpubh.2021.761069

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The Impact of Intraspecies Variability on Growth Rate and Cellular Metabolic Activity of Bacteria Exposed to Rotating Magnetic Field

Woroszyło M, Ciecholewska-Juśko D, Junka A, Pruss A, Kwiatkowski P, Wardach M, Fijałkowski K. The Impact of Intraspecies Variability on Growth Rate and Cellular Metabolic Activity of Bacteria Exposed to Rotating Magnetic Field. Pathogens. 2021 Nov 4;10(11):1427. doi: 10.3390/pathogens10111427.

Abstract

Majority of research on the influence of magnetic fields on microorganisms has been carried out with the use of different species or different groups of microorganisms, but not with the use of different strains belonging to one species. The purpose of the present study was to assess the effect of rotating magnetic fields (RMF) of 5 and 50 Hz on the growth and cellular metabolic activity of eight species of bacteria: *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Proteus mirabilis*, *Klebsiella pneumoniae*, *Enterococcus faecalis*, *Enterobacter cloacae*, *Moraxella catarrhalis*, and *Bacillus cereus*. However, contrary to the research conducted so far, each species was represented by at least four different strains. Moreover, an additional group of *S. aureus* belonging to a single clonal type but representing different biotypes was also included in the experiment. The results showed a varied influence of RMF on growth dynamics and cellular metabolic activity, diversified to the greatest extent in dependence on the bacterial strain exposed to the RMF and to a lesser extent in dependence on the frequency of the generated magnetic field. It was found that, with regard to the exposed strain of the same species, the effect exerted by the RMF may be positive (i.e., manifests as the increase in the growth rate or/and cellular metabolic activity) or negative (i.e., manifests as a reduction of both aforementioned features) or none. Even when one clonal type of *S. aureus* was used, the results of RMF exposure also varied (although the degree of differentiation was lower than for strains representing different clones). Therefore, the research has proven that, apart from the previously described factors related primarily to the physical parameters of the magnetic field, one of the key parameters affecting the final result of its influence is the bacterial intraspecies variability.

Open access paper: https://www.mdpi.com/2076-0817/10/11/1427

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The conspiracy of Covid-19 and 5G: Spatial analysis fallacies in the age of data democratization

Eoin Flaherty, Tristan Sturm, Elizabeth Farries. The conspiracy of Covid-19 and 5G: Spatial analysis fallacies in the age of data democratization. Social Science & Medicine. 2021, 114546. 2021. doi: 10.1016/j.socscimed.2021.114546.

Abstract

In a context of mistrust in public health institutions and practices, anti-COVID/vaccination protests and the storming of Congress have illustrated that conspiracy theories are real and immanent threat to health and wellbeing, democracy, and public understanding of science. One manifestation of this is the suggested correlation of COVID-19 with 5G mobile technology. Throughout 2020, this alleged correlation was promoted and distributed widely on social media, often in the form of maps overlaying the distribution of COVID-19 cases with the instillation of 5G towers. These conspiracy theories are not fringe phenomena, and they form part of a growing repertoire for conspiracist activist groups with capacities for organised violence. In this paper, we outline how spatial data have been co-opted, and spatial correlations asserted by conspiracy theorists. We consider the basis of their claims of causal association with reference to three key areas of geographical explanation: (1) how social properties are constituted and how they exert complex causal forces, (2) the pitfalls of correlation with spatial and ecological data, and (3) the challenges of specifying and interpreting causal effects with spatial data. For each, we consider the unique theoretical and technical challenges involved in specifying meaningful correlation, and how their discarding facilitates conspiracist attribution. In doing so, we offer a basis both to interrogate conspiracists' uses and interpretation of data from elementary principles and offer some cautionary notes on the potential for their future misuse in an age of data democratization. Finally, this paper contributes to work on the basis of conspiracy theories in general, by asserting how – absent an appreciation of these key methodological principles – spatial health data may be especially prone to co-option by conspiracist groups.

https://www.sciencedirect.com/science/article/pii/S0277953621008789

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Solar Activity Is Associated With Diastolic and Systolic Blood Pressure in Elderly Adults

Veronica A Wang, Carolina L Zilli Vieira, Eric Garshick, Joel D Schwartz, Michael S Garshick, Pantel Vokonas, Petros Koutrakis. Solar Activity Is Associated With Diastolic and Systolic Blood Pressure in Elderly Adults. J Am Heart Assoc. 2021 Nov 2;10(21):e021006. doi: 10.1161/JAHA.120.021006.

Abstract

Background Since solar activity and related geomagnetic disturbances modulate autonomic nervous system activity, we hypothesized that these events would be associated with blood pressure (BP).

Methods We studied 675 elderly men from the Normative Aging Study (Boston, MA) with 1949 BP measurements between 2000 and 2017. Mixed-effects regression models were used to investigate the association of average 1-day (ie, day of BP measurement) to 28-day interplanetary magnetic field intensity, sunspot number, and a dichotomized measure of global geomagnetic activity (Kp index) in 4-day increments with diastolic and systolic BP. We adjusted for meteorological conditions and other covariates associated with BP, and in additional models adjusted for ambient air pollutants (particulate matter with an aerodynamic diameter ≤2.5 μm, black carbon, and particle number) and ambient particle radioactivity.

Results There were positive associations between interplanetary magnetic field, sunspot number, and Kp index and BP that were greatest with these exposures averaged over 16 through 28 days before BP measurement. An interquartile range increase of 16-day interplanetary magnetic field and sunspot number and higher Kp index were associated with a 2.5 (95% CI, 1.7–3.2), 2.8 (95% CI, 2.1–3.4), and 1.7 (95% CI, 0.8–2.5) mm Hg increase, respectively, for diastolic BP as well as a 2.1 (95% CI, 0.7–3.6), 2.7 (95% CI, 1.5–4.0), and 0.4 (95% CI, -1.2 to 2.1) mm Hg increase, respectively, for systolic BP. Associations remained after adjustment for ambient air pollutants and ambient particle radioactivity.

Conclusions Solar activity and solar-driven geomagnetic disturbances were positively associated with BP, suggesting that these natural phenomena influence BP in elderly men.

Clinical Perspective

What Is New?

- Solar and geomagnetic activity were associated with increases in blood pressure in a large cohort of predominantly White, elderly men.
- The association with blood pressure was similar to or greater than that of particulate pollution and of radioactivity associated with ambient particles.
- The association of solar and geomagnetic activity with blood pressure was independent of these pollutants.

What Are the Clinical Implications?

- These findings suggest that natural phenomena linked to the solar cycle contributes to increases in blood pressure and, therefore, may influence hypertension management.

The Earth's magnetic field protects living organisms from long-term, harmful extra-terrestrial radiation. Despite this protective shield, solar activity can cause geomagnetic disturbances (GMD), disruptions to the Earth's natural magnetic field oscillations, and can impact autonomic nervous system activities,1, 2 which can, in turn, directly and indirectly play a role in initiating and sustaining high blood pressure (BP).3 Numerous pathogenic risk factors such as genetic predisposition,4 physical activity,5 and diet6 have been identified to play key roles in the development of hypertension. A recent review7 highlighted the role of environmental factors, such as temperature, altitude, latitude, and air pollutants, in elevating BP, but few studies considered solar activity and GMD as risk factors for the development of hypertension or transient increases in BP. In those that have,8, 9 the findings suggest that individuals have elevated BP several days before and after magnetic storms.

To gain insight and provide awareness into the association between solar activity and BP in elderly men, a vulnerable population at high risk for cardiovascular disease,10 we conducted a repeated measures analysis to examine the association of average 1-day (ie, day of BP measurement) to 28-day solar activity and GMD with BP among elderly men in Boston, MA who had between 1 and 8 health assessments over 17 years. We hypothesized that solar and geomagnetic activity is positively associated with systolic blood pressure (SBP) and diastolic blood pressure (DBP).

Open access paper: **https://www.ahajournals.org/doi/10.1161/JAHA.120.021006**

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Assessment of Human Exposure to Electromagnetic Fields: Review and Future Directions

Akimasa Hirata, Yinliang Diao, Teruo Onishi, Kensuke Sasaki, Seunyoung Ahn, Davide Colombi, Valerio De Santis, Ilkka Laakso, Luca Giaccone, Wout Joseph, Essam A. Rashed, Wolfgang Kainz, Ji Chen. Assessment of Human Exposure to Electromagnetic Fields: Review and Future Directions. IEEE Transactions on Electromagnetic Compatibility, doi: 10.1109/TEMC.2021.3109249.

Wolfgang Kainz, Center for Devices and Radiological Health, Food and Drug Administration, Silver Spring, MD 20852 USA (e-mail: wolfgang.kainz@fda.hhs.gov).

Abstract

This article reviews recent standardization activities and scientific studies related to the assessment of human exposure to electromagnetic fields (EMF). The differences of human exposure standards and assessment of consumer products and medical applications are summarized. First, we reviewed human body modeling and tissue dielectric properties. Then, we explain the rationale of current exposure standards from the viewpoint of EMF and the standardization process for product compliance based on these exposure standards. The assessment of wireless power transfer, as an example of emerging wireless devices, and environmental EMFs in our daily lives are reviewed. Safety in magnetic resonance systems, where the EMF exposure is much larger than from typical consumer devices, is also reviewed. Finally, we summarize future research directions and research needs for EMF safety.

Excerpts

The overall improvement in human model accuracy is an important topic as mentioned in Section II-A and B. This may include an intersubject variability study using different models or an analysis of the population level. In addition, the accurate measurement of dielectric human tissue properties is essential for evaluating the induced field strength. Recent studies suggest that the conductivity of skin and brain tissues may be significantly higher than those commonly used in LF dosimetry (e.g., [31]). Recent publications reported a novel approach for dielectric measurements that allows the estimation of dielectric human tissue properties in vivo using MRI [137]. These and other novel medical imaging and measurement technologies will help to further improve human body modeling.

Research needs in the areas of human EMF safety (Section III) are summarized by various international standardization bodies [4], [138], [139]. The topics listed therein relate to human body modeling, as well as the necessity of more accurate dosimetry, which includes reductions of uncertainties, and multiphysics or multiscale methods for correlating the field quantities with substantiated biological effects (e.g., [140]). The assessments of exposure to emerging LF and RF technologies and simultaneous exposure (local and whole-body) to multiple sources will also prove useful for identifying potential changes in the dominant factors affecting EM safety. Additional research on human EM safety will provide more scientific data and improve the justifications for exposure limits, especially at frequencies higher than 6 GHz, and in the intermediate frequency range.

New mobile wireless technologies, such as 5G/6G and beyond, are being developed continuously. Their safe use demands not only conservative short- and long-term exposure limits for the new frequencies, but also adequately standardized compliance methods. Therefore, additional relevant exposure evaluation methods are needed to support frequencies from 100 to 300 GHz within the next 10 years. As the complexity of new wireless technologies has substantially increased over the years, further development and standardization of novel and more efficient EMF compliance testing methodologies are needed. International standardization will continue to play a key role in harmonizing global test procedures to establish compliance with current and future wireless technologies. One challenge faced by standardization will be to define test conditions that provide conservative, but realistic exposure conditions based on real-life situations, rather than relying on theoretical or unreasonable assumptions and simplifications. The assessment methods by the computation may become more common for emerging wireless systems, and thus further research is needed for verification of its effectiveness in different scenarios.

Future work for the environmental spectral measurement (see Section V) will focus on measurement procedures to assess worst-cases and realistic exposure to EMF from 5G New Radio (NR)—Ma-MIMO with a focus on sub-6 GHz and millimeter wave bands. The literature scarcely documents in situ assessment of 5G Ma-MIMO signals at millimeter waves and the proper adjustment of measurement settings. For personal exposimeter studies, protocols for 5G personal exposure assessment will need to include active and inactive users. In contrast to legacy technologies, Ma-MIMO base station exposure strongly depends on the activity of the individual user (e.g., streaming data, downloading files, and web browsing). Involving millimeter waves for personal exposure assessment is a significant challenge.

Also, in RF-MR safety, it is necessary to develop clinically relevant human body models for measurements in addition to developing new computational methods for multiscale and multiphysics applications. Most computational human body models use over 30 different types of tissue. However, below 500 MHz dielectric human tissues properties are not significantly different from each other. Some preliminary studies provided evidence that simplified human body models can still achieve accurate EM simulation results. This leads to the possibility of developing simplified computational and experimental models for different RF-MR safety measurement needs for PIMDs, AIMDs, and high-field MR systems (e.g., [141]). Furthermore, simple and equivalent test methods/equipment those are based on the physics principles should be developed (e.g., [142]).

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9557785&isnumber=4358749

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Accurately assessing exposure to radio frequency electromagnetic fields from 5G networks

Accurately assessing exposure to radio frequency electromagnetic fields from 5G networks. Ericsson white paper. GFTL-21:001105 Uen. October 2021.

No abstract.

Excerpts

"Measurements were recently taken in a large number of street-level locations around base stations in a commercial 5G network with massive MIMO base stations operating in the 3.5GHz band [9]. It was found that the contribution from the 5G network to the total environmental RF EMF exposure was less than 10 percent even in the case of 100 percent induced traffic and that the maximum exposure levels from the 5G base stations were 150 to 200 times below the international limits set by the ICNIRP."

Conclusion

"The high spectrum efficiency and the advanced antenna technologies used by 5G NR lead to lower levels of RF EMF exposure than from earlier generations of mobile networks for comparable services. The base stations in 5G NR networks need to comply with the same RF EMF safety regulations as other radio equipment, and the limits cover all frequency bands used by 5G, including those in the millimeter-wave range. International RF EMF exposure guidelines have recently been published based on the latest available scientific research, with conservative limits that have been or will be adopted in national regulations. Assessing compliance with RF EMF limits may be a challenge for massive MIMO 5G base stations due to dynamic beam steering, but solutions such as envelope beam pattern files together with recommended power reduction factors are available to enable accurate evaluations. The typical overall environmental RF EMF exposure will remain at a small fraction of international limits even with 5G being deployed since the contribution from 5G is relatively small."

Open access report: https://www.ericsson.com/en/reports-and-papers/white-papers/accurately-assessing-exposure-to-radio-frequency-electromagnetic-fields-from-5g-networks

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Physical units to report intensity of electromagnetic wave

R Ramirez-Vazquez, I Escobar, T Franco, E Arribas. Physical units to report intensity of electromagnetic wave. Environ Res. 2021 Nov 2;112341. doi: 10.1016/j.envres.2021.112341.

Abstract

The aim of this work is to propose a consensus to scientific community that handles personal exposimeters, which measure intensity of an electromagnetic wave (W/m2). To express the intensity of an electromagnetic wave there is a duality in the way of expressing it. Some scientists prefer to use W/m2 while others use V/m, which is a unit of the electric field. There is also a duality in the name, sometimes it is called it power flux density and some other times, wave intensity. We believe that this second name is more appropriate from the point of view of physics. We suggest expressing intensity of an electromagnetic wave in W/m2 instead of giving the value of their electric field which is measured in V/m. There is a quadratic relation between electric field and intensity of the wave, and it is necessary to do a mathematical operation, so in our opinion, it is preferable to use W/m2 which directly gives us the value of the measured intensity. Furthermore, if the intensity is very low, it may be expressed in μW/m2 and with only three significant figures, due to sensitivity of the current exposimeters used.

https://pubmed.ncbi.nlm.nih.gov/34740620/

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The effects of radiofrequency exposure on male fertility and adverse reproductive outcomes: A protocol for two systematic reviews of human observational studies with meta-analysis

Kenny RPW, Millar EB, Adesanya A, Richmond C, Beyer F, Calderon C, Rankin J, Toledano M, Feychting M, Pearce MS, Craig D, Pearson F. The effects of radiofrequency exposure on male fertility and adverse reproductive outcomes: A protocol for two systematic reviews of human observational studies with meta-analysis. Environ Int. 2021 Nov 1;158:106968. doi: 10.1016/j.envint.2021.106968.

Abstract

Background: The World Health Organization (WHO) is bringing together evidence on radiofrequency electromagnetic field (RF-EMF) exposure in relation to health outcomes, previously identified as priorities for evaluation by experts in the field, to inform exposure guidelines. A suite of systematic reviews are being undertaken by a network of topic experts and methodologists in order to collect, assess and synthesise data relevant to these guidelines. Here, we present the protocol for the systematic review on the effect of exposure to RF on adverse reproductive outcomes (human observational studies), also referred to as Systematic Review (SR) 3 within the series of systematic reviews currently being commissioned.

Objectives: Following the WHO handbook for guideline development and the COSTER conduct guidelines, we will systematically review the effect of RF-EMF exposure on both male fertility (SR3A) and adverse pregnancy outcomes (SR3B) in human observational studies. Herein we adhere to the PRISMA-P reporting guidelines.

Data sources: We will conduct a broad search for potentially relevant records relevant for both reviews within the following bibliographic databases: MEDLINE; Embase; and EMF Portal. We will also conduct searches of grey literature through relevant databases and organisational websites. RF-EMF experts will also be consulted. We will hand search citation and reference lists of included study records.

Study eligibility criteria: We will include quantitative human observational studies on the effect of RF-EMF exposure: (in SR3A) in adult male participants on infertility, sperm morphology, concentration or total sperm count or motility; and (in SR3B) in preconception adults or pregnant women on preterm birth, small for gestational age (associated with intrauterine growth restriction), miscarriage, stillbirth and congenital anomalies.

Study appraisal and synthesis methods: Titles, abstracts and then full texts will be screened in blinded duplicate against eligibility criteria with input from a third reviewer as required. Data extraction from included studies will be completed by two reviewers as will risk of bias assessment using the Office of Health Assessment and Translation (OHAT) tool. If appropriate we will undertake meta-analysis to pool effect measures and explore heterogeneity using sub-group analyses or meta-regression as feasible. We will conduct sensitivity analysis to assess the impact of any assumptions made throughout the review process. The OHAT methodology, based on the GRADE guidelines for evidence assessment, will be used to evaluate the certainty of evidence per outcome and to conclude the level of evidence of a health effect.

Conclusion: This manuscript details the protocols for two systematic reviews. The aims of publishing details of both protocols are to: pre-specify their scope and methods; reduce the impact of reviewer bias; promote transparency and replicability; and improve the review process.

Prospero registration: CRD42021265401 (SR3A), CRD42021266268 (SR3B).

https://pubmed.ncbi.nlm.nih.gov/34735951/

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The effects of radiofrequency electromagnetic fields exposure on human self-reported symptoms: A protocol for a systematic review of human experimental studies

Bosch-Capblanch X, Esu E, Dongus S, Oringanje CM, Jalilian H, Eyers J, Oftedal G, Meremikwu M, Röösli M. The effects of radiofrequency electromagnetic fields exposure on human self-reported symptoms: A protocol for a systematic review of human experimental studies. Environ Int. 2021 Nov 1;158:106953. doi: 10.1016/j.envint.2021.106953.

Abstract

Background: The technological applications of radiofrequency electromagnetic fields (RF-EMF) have been steadily increasing since the 1950s across multiple sectors exposing large proportions of the population. This fact has raised concerns related to the potential consequences to people's health. The World Health Organization (WHO) is assessing the potential health effects of exposure to RF-EMF and has carried out an international survey amongst experts, who have identified six priority topics to be further addressed through systematic reviews, whereof the effects on symptoms is one of them. We report here the systematic review protocol of experimental studies in humans assessing the effects of RF-EMF on symptoms.

Objective: Our objectives are to assess the effects of exposure to electromagnetic fields (compared to no or lower exposure levels) on symptoms in human subjects. We will also assess the accuracy of perception of presence of exposure in volunteers with and without idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF).

Eligibility criteria: We will search relevant literature sources (e.g. the Web of Science, Medline, Embase, Epistemonikos) for randomized trials (comparing at least two arms) and randomised crossover trials of RF-EMF exposure that have assessed the effects on symptoms. We will also include studies that have measured the accuracy of the perception of the presence or absence of exposure. We will include studies in any language.

Study appraisal and synthesis: Studies will be assessed against inclusion criteria by two independent reviewers. Data on study characteristics, participants, exposure, comparators and effects will be extracted using a specific template for this review, by two independent reviewers. Discrepancies will be solved by consensus. Risk of bias

(ROB) will be assessed using the ROB Rating Tool for Human and Animal Studies and the level of confidence in the evidence of the exposure-outcome relations will be assessed using the GRADE approach. For the perception studies, we will use adapted versions of the ROB tool and GRADE assessment. Where appropriate, data will be combined using meta-analytical techniques.

https://pubmed.ncbi.nlm.nih.gov/34735955/

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Radio-frequency exposure of the yellow fever mosquito (A. aegypti) from 2 to 240 GHz

De Borre E, Joseph W, Aminzadeh R, Müller P, Boone MN, Josipovic I, et al. (2021) Radio-frequency exposure of the yellow fever mosquito (A. aegypti) from 2 to 240 GHz. PLoS Comput Biol 17(10): e1009460. doi: 10.1371/journal.pcbi.1009460.

Abstract

Fifth generation networks (5G) will be associated with a partial shift to higher carrier frequencies, including wavelengths of insects. This may lead to higher absorption of radio frequency (RF) electromagnetic fields (EMF) by insects and could cause dielectric heating. The yellow fever mosquito (Aedes aegypti), a vector for diseases such as yellow and dengue fever, favors warm climates. **Being exposed to higher frequency RF EMFs causing possible dielectric heating, could have an influence on behavior, physiology and morphology, and could be a possible factor for introduction of the species in regions where the yellow fever mosquito normally does not appear.** In this study, the influence of far field RF exposure on A. aegypti was examined between 2 and 240 GHz. Using Finite Difference Time Domain (FDTD) simulations, the distribution of the electric field in and around the insect and the absorbed RF power were found for six different mosquito models (three male, three female). The 3D models were created from micro-CT scans of real mosquitoes. The dielectric properties used in the simulation were measured from a mixture of homogenized A. aegypti. For a given incident RF power, the absorption increases with increasing frequency between 2 and 90 GHz with a maximum between 90 and 240 GHz. The absorption was maximal in the region where the wavelength matches the size of the mosquito. For a same incident field strength, the power absorption by the mosquito is 16 times higher at 60 GHz than at 6 GHz. The higher absorption of RF power by future technologies can result in dielectric heating and potentially influence the biology of this mosquito.

Author summary

Radio Frequency (RF) exposure of the A. aegypti mosquito can lead to absorption and dielectric heating. We used Finite Difference Time Domain (FDTD) simulations between 2 and 240 GHz to study the RF power absorbed by the insect and the distribution of the electric field (EF) in and around it. For this, three male and three female mosquito 3D models were constructed from micro-CT scans. We used high resolution models and dielectric properties, both retrieved from real insects, to gain realistic outputs. For increasing frequency up to 90 GHz, the absorbed power increases for all models. At 90–120 GHz, the wavelength is comparable to the body size, and the increase in absorbed powers reaches a maximum. Therefore, moving to higher frequencies in 5G, implies higher absorbed power and possibly higher dielectric heating of the insect.

Excerpt

The insect of interest in this paper is the yellow fever mosquito, Aedes aegypti, it is known as a vector for diseases such as yellow fever, dengue fever and zika virus infections [14, 15]. According to the Centers of Disease Control and Prevention in the U.S., yellow fever cases and deaths worldwide are estimated at 200,000 and 30,000 each year [16], respectively. The yellow fever mosquito is a tropical species favouring a hot and humid environment. Temperature affects the life cycle and feeding behaviour of the mosquito and the reproduction of the viruses [14, 15]. RF power absorption and dielectric heating can cause disturbance in for example the behaviour or development of the mosquito. Another interesting consequence of dielectric heating and higher body temperature, may be the spread of the mosquito to areas that are normally unfavorable for them. Be that as it may, the focus in this paper is on the RF power absorption, the dielectric heating or other consequences are not considered.

Open access paper: https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1009460

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The detrimental effect of cell phone radiation on sperm biological characteristics in normozoospermic

Mohammadmehdi Hassanzadeh-Taheri, Mohammad Ali Khalili, Ali Hosseininejad Mohebati, Mahmood Zardast, Mehran Hosseini, Maria Grazia Palmerini, Mohammad Reza Doostabadi. The detrimental effect of cell phone radiation on sperm biological characteristics in normozoospermic. Andrologia. 10 October 2021. doi: 10.1111/and.14257.

Abstract

Radiofrequency electromagnetic radiation emitted from cell phone has harmful effects on some organs of the body, such as the brain, heart, and testes. This study aimed to assess the effects of cell phones on sperm parameters, DNA fragmentation, and apoptosis in normozoospermic. Normal sperm samples were divided into two groups of control and case. The samples from the case were placed for 60 min at a distance of approximately 2.5 cm from the cell phone set in the active antenna position. Control samples were exposed to cell phones without active antennas. All specimens were analysed by World Health Organization criteria. Sperm viability, sperm with chromatin abnormality and maturity, DNA fragmentation, and apoptosis were examined. Viability and motility in the case were significantly lower than the control ($p < .001$, $p = .004$ respectively). The percentage of apoptotic sperms and DNA fragmentation were significantly higher in the case when compared with the control ($p = .031$, $p < .001$ respectively). The other parameters studied such as morphology, chromatin abnormality, and maturity showed no significant difference between the case and control groups. Cell phone waves had a detrimental effect on human sperm's biological features. Therefore, it is recommended to keep the cell phone away from the pelvis as much as possible.

Conclusion

The cell phone waves can reduce the sperm's biological characteristics, such as morphology, motility, viability, DNA integrity, and an increase in apoptosis in normozoospermic men. Therefore, it is recommended for men to keep the cell phone away from their pelvic.

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Prenatal chronic exposure to electromagnetic fields modulated adenosine deaminase activity in serum and brain of Wistar rats' offspring

Behrooz Mohammadi, Mahdi Sadegh & Homa Soleimani. Prenatal chronic exposure to electromagnetic fields modulated adenosine deaminase activity in serum and brain of Wistar rats' offspring, Journal of Microwave Power and Electromagnetic Energy. 2021. DOI: 10.1080/08327823.2021.1993045

Abstract

Considering the importance of the embryonic stage, we investigated the brain and serum ADA of offspring chronically exposed to low and high frequency electromagnetic field (EMF-LF/HF) during their embryonic period. Male and female rats were randomly selected for mating. After mating, the females were divided into four groups. The first group was exposed to extremely EMF-LF (50 Hz) through a solenoid for 30 minutes per day, the second group was constantly exposed to EMF-HF (900 MHz) via a cell phone, the third group (sham) was placed inside solenoid without any exposure, and the last group (control) was placed in their cage. The brain and serum samples of offspring (6 females and 6 males in each group) were collected four weeks after birth. ADA was measured by a specific enzymatic kit and a spectrophotometer. Exposure to EMF-LF (1.5 mT) was significantly increased the brain ADA activity in both male and female offspring. In addition, long-term HF exposure significantly enhanced serum ADA activity in males in compared with control group but, the brain ADA level was increased significantly in both genders($p < 0.01$). The present study revealed alterations in the serum and brain ADA following embryonic exposure to HF and ELF. These alterations depended on gender, frequency and wave intensity.

https://www.tandfonline.com/doi/abs/10.1080/08327823.2021.1993045?journalCode=tpee20

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The Effect of Mobile Radiation on the Oxidative Stress Biomarkers in Pregnant Mice

Nargess Moghadasi, Iraj Alimohammadi, Ali Safari Variani, Azadeh Ashtarinezhad. The Effect of Mobile Radiation on the Oxidative Stress Biomarkers in Pregnant Mice. J Family Reprod Health. 2021 Sep;15(3):172-178. doi: 10.18502/jfrh.v15i3.7134.

Abstract

Objective: Due to the growing use of communication instruments such as cell phones and wireless devices, there is growing public concern about possible harmful effects, especially in sensitive groups such as pregnant women. This study aimed to investigate the oxidative stress induced by exposure to 900 MHz mobile phone radiation and

the effect of vitamin C intake on reducing possible changes in pregnant mice.

Materials and methods: Twenty-one pregnant mice were divided into three groups (control, mobile radiation-exposed, and mobile radiation plus with vitamin C intake co-exposed (200 mg /kg)). The mice in exposure groups were exposed to 900 MHz, 2 watts, and a power density of 0.045 µw /cm2 mobile radiation for eight hours/day for ten consecutive days. After five days of rest, MDA (Malondialdehyde), 8-OHdG (8-hydroxy-2' -deoxyguanosine), and TAC (Total Antioxidant Capacity) levels were measured in the blood of animals. The results were analyzed by SPSS.22.0 software.

Results: The results showed that exposure to mobile radiation increased MDA (P=0.002), and 8-OHdG (P=0.001) significantly and decreased Total Antioxidant Capacity in the exposed groups (P=0.001). Taking vitamin C inhibited the significant increase in MDA and 8-OHdG levels in exposed groups.

Conclusion: Although exposure to mobile radiation can cause oxidative stress in the blood of pregnant mice, vitamin C as an antioxidant can prevent it.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8536820/

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No Significant Effects of Cellphone Electromagnetic Radiation on Mice Memory or Anxiety: Some Mixed Effects on Traumatic Brain Injured Mice

Doaa Qubty, Shaul Schreiber, Vardit Rubovitch, Amir Boag, Chaim G Pick. No Significant Effects of Cellphone Electromagnetic Radiation on Mice Memory or Anxiety: Some Mixed Effects on Traumatic Brain Injured Mice. Neurotrauma Rep. 2021 Aug 17;2(1):381-390. doi: 10.1089/neur.2021.0009.

Abstract

Current literature details an array of contradictory results regarding the effect of radiofrequency electromagnetic radiation (RF-EMR) on health, both in humans and in animal models. The present study was designed to ascertain the conflicting data published regarding the possible impact of cellular exposure (radiation) on male and female mice as far as spatial memory, anxiety, and general well-being is concerned. To increase the likelihood of identifying possible "subtle" effects, we chose to test it in already cognitively impaired (following mild traumatic brain injury; mTBI) mice. Exposure to cellular radiation by itself had no significant impact on anxiety levels or spatial/visual memory in mice. When examining the dual impact of mTBI and cellular radiation on anxiety, no differences were found in the anxiety-like behavior as seen at the elevated plus maze (EPM). When exposed to both mTBI and cellular radiation, our results show improvement of visual memory impairment in both female and male mice, but worsening of the spatial memory of female mice. These results do not allow for a decisive conclusion regarding the possible hazards of cellular radiation on brain function in mice, and the mTBI did not facilitate identification of subtle effects by augmenting them.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8550818/

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Cellular stress response to extremely low-frequency electromagnetic fields (ELF-EMF): An explanation for controversial effects of ELF-EMF on apoptosis (Review)

Barati M, Darvishi B, Javidi MA, Mohammadian A, Shariatpanahi SP, Eisavand MR, Madjid Ansari A. Cellular stress response to extremely low-frequency electromagnetic fields (ELF-EMF): An explanation for controversial effects of ELF-EMF on apoptosis. Cell Prolif. 2021 Nov 6:e13154. doi: 10.1111/cpr.13154.

Abstract

Impaired apoptosis is one of the hallmarks of cancer, and almost all of the non-surgical approaches of eradicating tumour cells somehow promote induction of apoptosis. Indeed, numerous studies have stated that non-ionizing non-thermal extremely low-frequency magnetic fields (ELF-MF) can modulate the induction of apoptosis in exposed cells; however, much controversy exists in observations. When cells are exposed to ELF-EMF alone, very low or no statistically significant changes in apoptosis are observed. Contrarily, exposure to ELF-EMF in the presence of a co-stressor, including a chemotherapeutic agent or ionizing radiation, can either potentiate or inhibit apoptotic effects of the co-stressor. In our idea, the main point neglected in interpreting these discrepancies is "the cellular stress responses" of cells following ELF-EMF exposure and its interplay with apoptosis. The main purpose of the current review was to outline the triangle of ELF-EMF, the cellular stress response of cells and apoptosis and to interpret and unify discrepancies in results based on it. Therefore, initially, we will describe studies performed on identifying the effect of ELF-EMF on induction/inhibition of apoptosis and enumerate proposed pathways through which ELF-EMF exposure may affect apoptosis; then, we will explain cellular stress response and cues for its induction in response to ELF-EMF exposure; and finally, we will explain why such controversies have been observed by different investigators.

Open access paper: https://onlinelibrary.wiley.com/doi/10.1111/cpr.13154

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Melatonin: a Potential Shield against Electromagnetic Waves

Maya Jammoul, Nada Lawand. Melatonin: a Potential Shield against Electromagnetic Waves. Curr Neuropharmacol. 2021 Jun 9. doi: 10.2174/1570159X19666210609163946.

Abstract

Melatonin, a vital hormone synthesized by the pineal gland, has been implicated in various physiological functions and in circadian rhythm regulation. Its role in the protection against the non-ionizing electromagnetic field (EMF), known to disrupt the body's oxidative/anti-oxidative balance, has been called into question due to inconsistent results observed across studies. This review provides the current state of knowledge on the interwoven relationship between melatonin, EMF, and oxidative stress. Based on synthesized evidence, we present a model that best describes the mechanisms underlying the protective effects of melatonin against RF/ELF-EMF induced oxidative stress. We show that the free radical scavenger activity of melatonin is enabled through reduction of the radical pair singlet-triplet conversion rate and the concentration of the triplet products.

Moreover, this review aims to highlight the potential therapeutic benefits of melatonin against the detrimental effects of EMF, in general, and electromagnetic hypersensitivity (EHS), in particular.

https://pubmed.ncbi.nlm.nih.gov/34635042/

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Static magnetic field measurements of smart phones and watches and applicability to triggering magnet modes in implantable pacemakers and implantable cardioverter-defibrillators

Seth J Seidman, Joshua Guag, Brian Beard, Zane Arp. Static magnetic field measurements of smart phones and watches and applicability to triggering magnet modes in implantable pacemakers and implantable cardioverter-defibrillators. Heart Rhythm. 2021 Oct;18(10):1741-1744. doi: 10.1016/j.hrthm.2021.06.1203.

Abstract

Background: Implantable pacemakers and implantable cardioverter-defibrillators (ICDs) are designed to include a "magnet mode" feature that can be activated from magnets stronger than 10 G. This feature is designed to be used when a patient is undergoing a procedure where electromagnetic interference is possible, or anytime suspension of tachycardia detection and therapy is needed. A publication in Heart Rhythm demonstrates an iPhone 12 triggering the magnet mode of a Medtronic ICD.

Objective: The purpose of this study is to determine the separation distance between consumer electronic devices that may create magnetic interference, including cell phones and smart watches, and implantable pacemakers and ICDs where magnet mode can be triggered.

Methods: The static magnetic fields of the iPhone 12 models and Apple Watch were measured at several planes in 1 cm resolution using an FW Bell 5180 Gauss Meter with STD18-0404 Transverse probe (unidirectional probe).

Results: All iPhone 12 and Apple Watch 6 models tested have static magnetic fields significantly greater than 10 G in close proximity (1-11 mm), which attenuates to below 10 G between 11 and 20 mm.

Conclusion: The findings of this study support the US Food and Drug Administration recommendation that patients keep any consumer electronic devices that may create magnetic interference, including cell phones and smart watches, at least 6 inches away from implanted medical devices, in particular pacemakers and cardiac defibrillators.

Open access paper: https://www.frontiersin.org/articles/10.3389/fpubh.2021.721166/full

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Interpretation of Timetrends (1996-2017) of the Incidence of Selected Cancers in England in Relation to Mobile Phone Use as a Possible Risk Factor

Frank de Vocht. Interpretation of Timetrends (1996-2017) of the Incidence of Selected Cancers in England in Relation to Mobile Phone Use as a Possible Risk Factor. Bioelectromagnetics. 2021 Oct 11. doi: 10.1002/bem.22375.

Abstract

Radiofrequency (RF) radiation from mobile phones has been classified as possibly carcinogenic to humans (2b) by IARC. However, to date, the discussion on whether mobile phone use is a cancer risk factor has not been solved. In this context of continuing uncertainty, it is important to continue to monitor cancer incidence trends. Annual incidence rates and directly age-standardized rates of selected cancers by sex and 5-year age groups for 1996 to 2017 for England were obtained from the UK Office for National Statistics. Interpretation in light of mobile phone use as a contributing risk factor was conducted for cancers of the brain, parotid gland, thyroid, and colorectal cancer, which have all been hypothesized to be associated with RF exposure. Brain and parotid gland cancers were updated by an additional 10 years following a previous publication, and continue to provide little evidence of an association with mobile phone use. Although mobile phone use as a potential risk factor contributing to increased incidence of colorectal or thyroid cancer could not be excluded based on these ecological data, it is implausible that it is an important risk factor for either. In the absence of clarity from epidemiological studies, it remains important to continue to monitor trends. However, for the time being, and in agreement with data from other countries, there is little evidence of an association between mobile phone use and brain or parotid gland cancer, while the hypotheses of associations with thyroid or colorectal cancer are similarly weak.

https://pubmed.ncbi.nlm.nih.gov/34633685/

My comments:

This paper provides a biased interpretation of data from a weak observational study that employs ecological, time series data. Given the limitations of cancer registry data, interpretation of cancer incidence trends is fraught with problems. Although the results of this observational study are not clear-cut, the overall results suggest that standardized cancer incidence rates in England for all four cancers under investigation increased over time:

> “Although the DAS rates suggest an increase of 30% in the incidence rates of brain cancers in women and 34% in men from 1996 to 2017….”
>
> “A steady increase ($p<0.001$) from 0.4 to 0.6 incident cases per 100,000 women and 0.7 to 0.8 for men, respectively, over the 1999-2017 time period was observed for incidence of cancer of the parotid gland; mainly in DAS rates following the use of the revised ESP (Figure 2).”
>
> “Cancer of the thyroid gland has increased steadily over time ($p<0.001$), especially in women where the DAS rate has more than tripled from 1996 to 2017 from 2.7 incident cases to 8.5 per 100,000 women but also in men (from 1.2 to 3.6 incident cases per 100,000 men), with little differences between population rates and DAS rates (Figure 3).”

> "The incidence rates of colorectal cancer in England have been stable for women (+3% from 1999 to 2017; p<0.001) and slightly increasing for men (+15% from 1999 to 2017; p<0.0.01) (Figure 4)….In younger age groups clear increase in incidence can be observed, especially in the age groups 25-34 year olds describing annual increases of 7% in both sexes (p<0.001), with some indication of plateauing of this pattern in those of 29 years or younger."

The above results could have been interpreted as supportive of the association with increases in mobile phone use over time in England due to the considerable lag between exposure to a risk factor and diagnosis of solid tumors. Furthermore, the case-control research suggests the increased cancer risk is a function of heavy mobile phone use (e.g., 17 minutes per day over a ten-year period for risk of glioma [Choi et al., 2020]) and perhaps also genetic susceptibility (for thyroid cancer risk [Luo et al., 2018, 2020]) so not everyone would be affected.

Analyzing time trend data may be a fruitless endeavor when there are multiple risk factors for the tumors under investigation because some carcinogens may be increasing over time while others are decreasing. It is impossible to make causal attributions with time series designs when there is a considerable lag between an exposure (e.g., mobile phone use) and an outcome (e.g., cancer). Similarly, it is problematic to rule out a risk factor with such a weak research design. The results clearly do **not** warrant the following assertions made by this paper:

> "Although mobile phone use as a potential risk factor contributing to increased incidence of colorectal or thyroid cancer could not be excluded based on these ecological data, it is implausible that it is an important risk factor for either."

> "…there is little evidence of a causal relation of mobile phone use with brain or parotid gland cancer, while the hypotheses of associations with thyroid or colorectal cancer is similarly weak."

Although the strongest epidemiologic evidence for increased cancer risk associated with mobile phone use is for glioma, a subtype of brain cancer (IARC Working Group, 2013), the paper did not cite Philips et al. (2018). Yet the Philips study examined brain cancer incidence data for England from 1995-2015 to calculate incidence rates (ASR) per 100,000 person-years, age-standardized to the European Standard Population (ESP–2013). Philips et al. found "a sustained and highly statistically significant ASR rise in glioblastoma multiforme (GBM) [a subtype of glioma] across all ages. The ASR for GBM more than doubled from 2.4 to 5.0, with annual case numbers rising from 983 to 2531. Overall, this rise is mostly hidden in the overall data by a reduced incidence of lower grade tumours." Thus, it should come as no surprise that the current paper failed to find much of an increase in overall brain cancer incidence in England for almost the same time period.

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Psychological models of development of idiopathic environmental intolerances: Evidence from longitudinal population-based data

Luc Watrin, Steven Nordin, Renáta Szemerszky, Oliver Wilhelm, Michael Witthöft, Ferenc Köteles. Psychological

models of development of idiopathic environmental intolerances: Evidence from longitudinal population-based data. Environ Res. 2021 Sep 8;204(Pt A):111774. doi: 10.1016/j.envres.2021.111774.

Abstract

The origin of idiopathic environmental intolerances (IEIs) is an open question. According to the psychological approaches, various top-down factors play a dominant role in the development of IEIs. The general psychopathology model assumes a propensity towards mental ill-health (negative affectivity) increases the probability of developing IEIs. The attribution model emphasizes the importance of mistaken attribution of experienced somatic symptoms; thus, more symptoms should lead to more IEIs. Finally, the nocebo model highlights the role of expectations in the development of IEIs. In this case, worries about the harmful effects of environmental factors are assumed to evoke IEIs. We estimated cross-lagged panel models with latent variables based on longitudinal data obtained at two time points (six years apart) from a large near-representative community sample to test the hypothesized associations. Indicators of chemical intolerance, electromagnetic hypersensitivity, and sound sensitivity fit well under a common latent factor of IEIs. This factor, in turn, showed considerable temporal stability. However, whereas a positive association was found between IEIs and increased somatic symptoms and modern health worries six years later, the changes therein could not be predicted as hypothesized by the three psychological models. We discuss the implications of these results, as well as methodological aspects in the measurement and prediction of change in IEIs.

Highlights

• Compares and integrates theories of Idiopathic Environmental Intolerances (IEI).
• Tests competing theories in a large longitudinal study (N = 1837).
• Correlations, but no cross-lagged associations of IEIs with neighboring constructs.
• Latent variable models indicate a strong commonality of different IEIs.
• We advocate for more attention on the nomothetic span of IEIs.

Conclusion

In the current study, cross-lagged panel models were applied to investigate reciprocal association between IEIs and general psychopathology, somatic symptoms, and modern health worries in longitudinal data of a large near-representative community sample. Contrary to theoretical predictions, higher initial levels in either of the three constructs were not associated with increases in IEIs over a period of 6 years. The proneness to idiopathic environmental intolerances (IEIs), such as chemical intolerance, noise sensitivity, and electromagnetic hypersensitivity, appeared very stable. Somatic symptoms, indicators of negative affectivity, and modern health worries showed reliable associations with IEIs. However, they did not predict IEIs. Therefore, popular theories of the development of IEIs could not be confirmed empirically.

https://pubmed.ncbi.nlm.nih.gov/34506786/

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RF Measurements of EMFs for Human Exposure Assessment Due to Modern Cellular Base Stations (5G)

D. Capriglione. In-Situ RF Measurements of EMFs for Human Exposure Assessment Due to Modern Cellular Base Stations. *IEEE Instrumentation & Measurement Magazine*, vol. 24, no. 8, pp. 31-36, November 2021, doi: 10.1109/MIM.2021.9580794.

Abstract

TC-37-Measurements and Networking (current Chair Prof. Domenico Capriglione, University of Cassino and Southern Lazio, Italy) was built some years ago as an idea of Prof. Leopoldo Angrisani (University of Napoli Federico II, Italy) and Prof. Claudio Narduzzi (University of Padova, Italy), having in mind that given the complexity of modern networks and related systems, a multidisciplinary approach has to be followed for correctly addressing the technological challenges and issues that are arising and will arise in the future in the field of telecommunication systems and networking. So, the TC-37 is actively trying to promote the international cooperation and integration of researchers belonging to the Instrumentation and Measurement Society with ones coming from other areas of telecommunication and information technologies.

Conclusions and Open Issues

The measurement of human exposure to RF EMFs is a topic of great interest today because of the growing diffusion and fast evolution of communication technologies. Due to the importance of the topic and the technical difficulties arising from the ever-increasing level of complexity of the communication technologies and experimental scenarios, worldwide researchers are involved in designing and fine-tuning measurement methods, standard procedures, and instruments for achieving reliable results of human exposure.

The practical examples in this paper highlight how the research in this field needs continuous updates, and it should involve long-term experimental campaigns for assessing the reliability of measurement techniques and procedures in several experimental conditions and scenarios. These statements are strongly supported by current trends that push to employ DSS (Dynamic Spectrum Sharing) and 5G cellular technologies which will offer new challenges for the measurement of human exposure to EMFs generated by these kinds of sources. In particular, the antenna beamforming and the complexity of 5G technology will require the design of new and effective measurement techniques and protocols able to warrant an adequate tradeoff between accuracy and time needed to completely characterize human exposure in high-density urban scenarios, where several base stations simultaneously operate in the same area. These aspects shall be investigated for both narrowband and broadband approaches.

Furthermore, the estimation of the measurement uncertainty will be an important topic to be addressed, taking into account several quantities of influence among which the response of the antennas, probes, and instruments to the signals generated by modern communication systems, as well as the long-term variability of the power emitted by the related Base Stations in given points of analysis should be examined.

https://ieeexplore.ieee.org/document/9580794

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Spatial variability of outdoor exposure to radiofrequency radiation from mobile phone base stations, in Khartoum, Sudan

Mohammed O A Mohammed, Ahmed A Elzaki, Babiker A Babiker, Omer I Eid. Spatial variability of outdoor exposure to radiofrequency radiation from mobile phone base stations, in Khartoum, Sudan. Environ Sci Pollut Res Int. 2021 Oct 8. doi: 10.1007/s11356-021-16555-x.

Abstract

The wide-spread exposure to constantly evolving wireless technologies believed to pose a serious health threat. Human beings are persistently exposed to RF radiation from mobile phones and their base stations. The current study aimed at classifying and characterizing the exposure to RF radiation from the mobile phone base stations. Spatial distribution measurements were carried out in Khartoum city during two time periods, first in 2012 (pilot survey) and again during Sept. 2019-Jan. 2020, to cover a total of 282 antennas operating with GSM900, GSM1800, and UMTS2100. The tested antennas belong to three mobile communication companies namely Sudani, Zain, and MTN companies, that randomly coded into company A, company B, and company C for security purposes. Measurements were performed using frequency-selective RF analyzer at fixed distances from the antennas/towers. Data were subjected to advanced repeated measures ANOVA, linear discriminant analysis (LDA), and spatial interpolation with ArcGIS. The averages of GSM900, GSM1800, and UMTS measurements were 0.01933 W/m2, 0.0067 W/m2, and 0.0046 W/m2. The high levels of power densities for each single antenna were recorded at 90 m, 110 m, 130 m, and at 150 m distances, for the majority (70%) of the measured antennas and the peak/highest values reported mainly at 110 m distance. Conversely, the discriminant loadings as part of LDA, suggested that, much of variance among measurements is attributed to measurements at 150 m, 170 m, and 190 m distances, while visual illustration of group centroids implied that, the RF signals of the different companies were measured separately which support accuracy of frequency-selective measurements. The LDA has confirmed the ANOVA results that, the overall difference between the three companies was statistically significant for UMTS, and GSM900 measurements but not significant for GSM1800 measurements. Kriging interpolation using ArcGIS provided a strong evidence of great spatial distribution of exposure across the study area, with market places and typical urban residential quarters showing highest levels of RF. Few extreme values exceeding ICNIRP limits are reported but excluded from the calculations because of an issue of normality of data that is considered a prerequisite for parametric data analysis. Existence of extreme levels of RF indicates a need for further investigation and some antennas of Company B are mounted on towers belongs to Company C, implying multi exposure. Unexpected pattern of RF levels continued to increase up to 190 m distance and possibly beyond 190 m is reported for UMTS measurements of Company C.

https://pubmed.ncbi.nlm.nih.gov/34622411/

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Near Field Exposure Conditions by UHF-RFID Systems in Smart Healthcare Environments

S. de Miguel-Bilbao *et al*. Near Field Exposure Conditions by UHF-RFID Systems in Smart Healthcare Environments. 2021 IEEE International Joint EMC/SI/PI and EMC Europe Symposium. 2021, pp. 13-18, doi: 10.1109/EMC/SI/PI/EMCEurope52599.2021.9559189.

Abstract

Short range wireless RFID technology has many applications in socialcare and healthcare environments, having to coexist with other sources of electromagnetic (EM) radiation and even with patients' implanted devices. This work provides an overview of exposure conditions in near EM field conditions and evaluates this exposure. The near EM field conditions by RFID reader is discussed based on the results of measurements inside an anechoic chamber under strict experimental conditions, and numerical modelling with simulation software. The obtained results were considered with respect to the human EM exposure evaluation principles and exposure limitations provided by the relevant international guidelines and regulations. In areas close to the RFID reader, the local exposure to EM radiation has the near field nature, i.e. the impedance of EM field significantly differs from the far field (free space). Evaluating human exposure requires measurements of the electric and magnetic field strength, or even the numerical modelling of Specific Energy Absorption Rate (SAR). It was found that a near field nature of EM radiation near an RFID reader ranges several times longer when the operator is present nearby, compared to the same emitting device considered alone in the empty space. This is of significance when evaluating EM exposure of humans (patients or health care personnel, especially users of medical implants) if, for any reason, they are less than 50 cm away from an RFID reader, especially when emission from it exceed 2 W.

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9559189&isnumber=9559134

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Human-made electromagnetic fields: Ion forced-oscillation and voltage-gated ion channel dysfunction, oxidative stress and DNA damage (Review)

Dimitris J Panagopoulos, Andreas Karabarbounis, Igor Yakymenko, George P Chrousos. Human-made electromagnetic fields: Ion forced-oscillation and voltage-gated ion channel dysfunction, oxidative stress and DNA damage (Review). Int J Oncol. 2021 Nov;59(5):92. doi: 10.3892/ijo.2021.5272.

Abstract

Exposure of animals/biological samples to human-made electromagnetic fields (EMFs), especially in the extremely low frequency (ELF) band, and the microwave/radio frequency (RF) band which is always combined with ELF, may lead to DNA damage. DNA damage is connected with cell death, infertility and other pathologies, including cancer. ELF exposure from high-voltage power lines and complex RF exposure from wireless communication antennas/devices are linked to increased cancer risk. Almost all human-made RF EMFs include ELF components in the form of modulation, pulsing and random variability. Thus, in addition to polarization and coherence, the existence of ELFs is a common feature of almost all human-made EMFs. The present study reviews the DNA damage and related effects induced by human-made EMFs. The ion forced-oscillation mechanism for irregular gating of voltage-gated ion channels on cell membranes by polarized/coherent EMFs is extensively described. Dysfunction of ion channels disrupts intracellular ionic concentrations, which determine the cell's electrochemical balance and homeostasis. The present study shows how this can result in DNA damage through reactive oxygen species/free radical overproduction. Thus, a complete picture is provided of how human-made EMF exposure may indeed lead to DNA damage and related pathologies, including cancer.

Moreover, it is suggested that the non-thermal biological effects attributed to RF EMFs are actually due to their ELF components.

Open access paper: https://www.spandidos-publications.com/ijo/59/5/92

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Hippocampal Oxidative Stress Induced by Radiofrequency Electromagnetic Radiation and the Neuroprotective Effects of Aerobic Exercise in Rats: A Randomized Control Trial

Mina Rasouli Mojez, Abbas Ali Gaeini, Siroos Choobineh, Mohsen Sheykhlouvand. Hippocampal Oxidative Stress Induced by Radiofrequency Electromagnetic Radiation and the Neuroprotective Effects of Aerobic Exercise in Rats: A Randomized Control Trial. J Phys Act Health. 2021 Oct 25;1-7. doi: 10.1123/jpah.2021-0213.

Abstract

Background: The present study determined whether 4 weeks of moderate aerobic exercise improves antioxidant capacity on the brain of rats against oxidative stress caused by radiofrequency electromagnetic radiation emitted from cell phones.

Methods: Responses of malondialdehyde, catalase, glutathione peroxidase, and superoxide dismutase, as well as the number of hippocampal dead cells, were examined. Male Wistar rats (10-12 wk old) were randomly assigned to 1 of 4 groups (N = 8): (1) moderate aerobic exercise (EXE) (2 × 15-30 min at 1215 m/min speed with 5 min of active recovery between sets), (2) exposure to 900/1800 MHz radiofrequency electromagnetic waves 3 hours per day (RAD), (3) EXE + RAD, and (4) exposure to an experimental phone without battery.

Results: Following the exposure, the number of the hippocampal dead cells was significantly higher in group RAD compared with groups EXE, EXE + RAD, and control group. Malondialdehyde concentration in group RAD was significantly higher than that of groups EXE, EXE + RAD, and control group. Also, the activity of catalase, glutathione peroxidase, and superoxide dismutase in groups EXE, EXE + RAD, and control group was significantly higher compared with those of the exposure group.

Conclusion: This study demonstrated that moderate aerobic exercise enhances hippocampal antioxidant capacity against oxidative challenge in the form of radiofrequency electromagnetic waves.

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V_m-related extracellular potentials observed in red blood cells

Hughes MP, Kruchek EJ, Beale AD, Kitcatt SJ, Qureshi S, Trott ZP, Charbonnel O, Agbaje PA, Henslee EA, Dorey RA, Lewis R, Labeed FH. V_m-related extracellular potentials observed in red blood cells. Sci Rep. 2021 Sep 30;11(1):19446. doi: 10.1038/s41598-021-98102-9.

Abstract

Even in nonexcitable cells, the membrane potential V_m is fundamental to cell function, with roles from ion channel regulation, development, to cancer metastasis. V_m arises from transmembrane ion concentration gradients; standard models assume homogeneous extracellular and intracellular ion concentrations, and that V_m only exists across the cell membrane and has no significance beyond it. Using red blood cells, we show that this is incorrect, or at least incomplete; V_m is detectable beyond the cell surface, and modulating V_m produces quantifiable and consistent changes in extracellular potential. Evidence strongly suggests this is due to capacitive coupling between V_m and the electrical double layer, rather than molecular transporters. We show that modulating V_m changes the extracellular ion composition, mimicking the behaviour if voltage-gated ion channels in non-excitable channels. We also observed V_m-synchronised circadian rhythms in extracellular potential, with significant implications for cell-cell interactions and cardiovascular disease.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8484267/

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A survey on electromagnetic hypersensitivity: the example from Poland

Grzegorz Tatoń, Artur Kacprzyk, Tomasz Rok, Monika Pytlarz, Rafał Pawlak, Eugeniusz Rokita. A survey on electromagnetic hypersensitivity: the example from Poland. Electromagn Biol Med. 2021 Oct 22;1-8. doi: 10.1080/15368378.2021.1995873.

Abstract

Idiopathic environmental intolerance attributed to electromagnetic field (IEI-EMF) called electromagnetic hypersensitivity or electrosensitivity appeared in Polish society awareness due to a considerable change made at the end of 2019 in Polish telecommunication laws. The aims of the project were to access the prevalence of IEI-EMF in Poland and to define a reliable methodology to study this phenomenon. The first step was the internet survey performed at the end of 2018. The IEI-EMF prevalence estimated at the level of 39.7% suggested considerable bias affecting the results. The faults of the first approach were analysed and then a second study stage was performed as a telephone survey at the end of 2020. The latter survey allowed estimating the prevalence of IEI-EMF as less than 1.8%. These discrepancies in the results of both surveys were connected to the medium used in the first survey (Internet) indirectly causing that the group pooled was not representative. The second pitfall was the definition of the criteria used for an electrosensitive person classification. This is why the IEI-EMF prevalence was investigated in the second stage with the use of numerous criteria. The application of different criteria allowed for essential conclusions concerning the appropriate methodology for such kinds of studies. Corrections of the methodology before the second survey allowed reliable results consistent with the results obtained in similar studies performed in other countries. Our findings also show that the IEI-EMF frequency reports presented in the literature have to be treated carefully and with some dose of scepticism.

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The worldwide prevalence of IEI-EMF is estimated at 1–13%. The results vary according to the data source and

methodology of the studies used (Huang et al. 2018; Szemerszky et al. 2019).

Conclusions

The first study overestimated the incidence of IEI-EMF in Polish society at 39.7% due the limitations accompanying the study. The more realistic estimation based on the second research stage is 1.8%.

The proposed criterion of IEI-EMF qualification assumes that a hypersensitive person is one whose symptoms differ from the rest of society and are so severe that she or he seeks medical help.

Our results support the thesis that the criterion used in such studies for assigning subjects to the IEI-EMF group should be accurately defined and harmonized.

Even slight differences in the survey questions and methodologies can result in considerably different IEI-EMF prevalence estimations.

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The Havana Syndrome and Microwave Weapons [Health Matters]

James C. Lin. The Havana Syndrome and Microwave Weapons [Health Matters]. IEEE Microwave Magazine. 22(11):13-14. Nov. 2021. doi: 10.1109/MMM.2021.3102201.

Abstract

Every few months, if not weeks, another mysterious attack on U.S. diplomatic and intelligence personnel is reported. Some of the attacks occurred years ago, while others were recounted as recently as July 2021 [1] – [3] . Over the past four or five years, nearly 200 U.S. personnel have reported similar attacks while working in places like Havana, Guangzhou, London, Moscow, Vienna, and Washington, D.C. The acute symptoms include headache and nausea immediately following the sounds of loud buzzing or bursts. The illness and symptoms have been called the “Havana Syndrome” after the place where cases were first reported. It refers to the range of symptoms first experienced by U.S. State Department personnel overseas.

Excerpt

Assuming reported accounts are reliable, the microwave auditory effect provides a scientific explanation for the Havana Syndrome [4], [5]. Pulsed microwaves can create an acoustic wave inside the head [6], [7], [14]. It is plausible that the loud buzzing, burst of sound, or pressure waves could have been covertly delivered using a beam of high power pulsed microwave radiation rather than blasting the subjects with conventional sonic sources. Microwave hearing doesn’t go through the ear; it goes directly from the brain tissue to the cochlea. Absorption of short pulses of microwave energy by brain tissues creates a rapid expansion of brain matter and launches an acoustic wave of pressure (sound wave) that travels inside the head to the inner ear cochlea [7], [14]. The short high-power microwave pulses do not generate noticeable amounts of heat in the brain tissues.

https://ieeexplore.ieee.org/document/9557212

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Electromagnetic Exposure Dosimetry Study on Two Free Rats at 1.8 GHz via Numerical Simulation

Wang Xianghui, Xia Chengjie, Lu Lu, Qi Hongxin, Zhang Jie. Electromagnetic Exposure Dosimetry Study on Two Free Rats at 1.8 GHz via Numerical Simulation. Frontiers in Public Health. 9:1404. 2021. doi: 10.3389/fpubh.2021.721166

Abstract

Normally, the impact of electromagnetic exposure on human health is evaluated by animal study. The biological effect caused by electromagnetic exposure on such experimental animals as rats has been proven to be dose-dependent. However, though the dose of radio frequency (RF) electromagnetic exposure described by the specific absorbing rate (SAR) on fixed rats has been relatively well-studied utilizing the numerical simulations, the dosimetry study of exposure on free rat is insufficient, especially in the cases of two or more free rats. Therefore, the present work focuses on the variation of SAR caused by the existence of neighboring free rat in the same cage. Here, infrared thermography was used to record the activity of the two free rats who lived in the same cage that mounted at the far-field region in the microwave darkroom for a duration of 48 h. Then, using image processing techniques, the relative positions and orientations of the two rats are identified, which are defined by three parameters, such as the relative distance (d), relative direction angle (α), and relative orientation angle (β). Using the simulation software XFdtd 7.3, the influence of d, α, and β on the whole-body average SAR (WB-avgSAR) of the rats exposed to 1.8 GHz electromagnetic wave was calculated and analyzed. Then, the average variation of WB-avgSAR of the two rats compared with that of a single rat within 48 h was calculated. The numerical simulation results showed that the relative posture position described by (d, α, and β) of the two rats affects their WB-avgSAR and leads to fluctuations at different positions. However, the variation rate of the 48-h-average WB-avgSAR was only 10.3%, which implied that the over-time average SAR of two or more rats can be roughly described by the WB-avgSAR of a single free rat, except when a real-time precise control of exposure dose is necessary.

https://www.frontiersin.org/article/10.3389/fpubh.2021.721166

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Design and Dosimetric Characterization of a Broadband Exposure Facility for In Vitro Experiments in the Frequency Range 18-40.5 GHz

Gernot Schmid, Rene Hirtl, Isabel Gronau, Vivian Meyer, Karen Drees, Alexander Lerchl. Design and Dosimetric Characterization of a Broadband Exposure Facility for In Vitro Experiments in the Frequency Range 18-40.5 GHz. Bioelectromagnetics. 2021 Oct 7. doi: 10.1002/bem.22376.

Abstract

A novel exposure facility for exposing cell monolayers to centimeter and millimeter waves (18-40.5 GHz) used by future 5G mobile communication technology and similar applications has been developed. A detailed dosimetric characterization of the apparatus for frequencies of 27 and 40.5 GHz and 60 mm petri dishes, used in a presently ongoing study on human dermal fibroblasts and keratinocytes, was carried out. The exposure facility enables a well-defined, randomized, and blinded application of sham exposure and exposure with selectable values of incident power flux density, and additionally provides the possibility of continuous monitoring of the sample temperature during exposure while it does not require significant deviations from routine in vitro handling procedures, i.e. petri dishes are not required to be placed inside waveguides or TEM cells. Mean specific absorption rate (SAR) values inside the cell monolayer of 115 W/kg (27 GHz) and 160 W/kg (40.5 GHz) per watt antenna input power and corresponding transmitted power density (St) values at the bottom of the cell monolayer of 65 W/m2 (27 GHz) and 70 W/m2 (40.5 GHz) per watt antenna input power can be achieved, respectively. For reasonable amounts of harvested cells (80% of petri dish bottom area), the variation (max/min) of SAR and St over the cell monolayer remains below 3.7 dB (27 GHz) and 3.0 dB (40.5 GHz), respectively.

https://pubmed.ncbi.nlm.nih.gov/34622469/

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The ecology of electricity and electroreception

Sam J England, Daniel Robert. The ecology of electricity and electroreception. Biol Rev Camb Philos Soc. 2021 Oct 12. doi: 10.1111/brv.12804.

Abstract

Electricity, the interaction between electrically charged objects, is widely known to be fundamental to the functioning of living systems. However, this appreciation has largely been restricted to the scale of atoms, molecules, and cells. By contrast, the role of electricity at the ecological scale has historically been largely neglected, characterised by punctuated islands of research infrequently connected to one another. Recently, however, an understanding of the ubiquity of electrical forces within the natural environment has begun to grow, along with a realisation of the multitude of ecological interactions that these forces may influence. Herein, we provide the first comprehensive collation and synthesis of research in this emerging field of electric ecology. This includes assessments of the role electricity plays in the natural ecology of predator-prey interactions, pollination, and animal dispersal, among many others, as well as the impact of anthropogenic activity on these systems. A detailed introduction to the ecology and physiology of electroreception - the biological detection of ecologically relevant electric fields - is also provided. Further to this, we suggest avenues for future research that show particular promise, most notably those investigating the recently discovered sense of aerial electroreception

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Effects of an electric field on sleep quality and life span mediated by ultraviolet (UV)-A/blue light photoreceptor CRYPTOCHROME in Drosophila

Haruhisa Kawasaki, Hideyuki Okano, Takaki Nedachi, Yuzo Nakagawa-Yagi, Akikuni Hara, Norio Ishida. Effects of an electric field on sleep quality and life span mediated by ultraviolet (UV)-A/blue light photoreceptor CRYPTOCHROME in Drosophila. Sci Rep. 2021 Oct 15;11(1):20543. doi: 10.1038/s41598-021-99753-4.

Abstract

Although electric fields (EF) exert beneficial effects on animal wound healing, differentiation, cancers and rheumatoid arthritis, the molecular mechanisms of these effects have remained unclear about a half century. Therefore, we aimed to elucidate the molecular mechanisms underlying EF effects in Drosophila melanogaster as a genetic animal model. Here we show that the sleep quality of wild type (WT) flies was improved by exposure to a 50-Hz (35 kV/m) constant electric field during the day time, but not during the night time. The effect was undetectable in cryptochrome mutant (cryb) flies. Exposure to a 50-Hz electric field under low nutrient conditions elongated the lifespan of male and female WT flies by ~ 18%, but not of several cry mutants and cry RNAi strains. Metabolome analysis indicated that the adenosine triphosphate (ATP) content was higher in intact WT than cry gene mutant strains exposed to an electric field. A putative magnetoreceptor protein and UV-A/blue light photoreceptor, CRYPTOCHROME (CRY) is involved in electric field (EF) receptors in animals. The present findings constitute hitherto unknown genetic evidence of a CRY-based system that is electric field sensitive in animals.

Open access paper: https://www.nature.com/articles/s41598-021-99753-4

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Tracking Devices for Pets: Health Risk Assessment for Exposure to Radiofrequency Electromagnetic Fields

Judith Klune, Christine Arhant, Ines Windschnurer, Veronika Heizmann, Günther Schauberger. Tracking Devices for Pets: Health Risk Assessment for Exposure to Radiofrequency Electromagnetic Fields. Animals (Basel). 2021 Sep 17;11(9):2721. doi: 10.3390/ani11092721.

Abstract

Every year, approximately 3% of cats and dogs are lost. In addition to passive methods for identifying pets, radiofrequency tracking devices (TDs) are available. These TDs can track a pet's geographic position, which is transmitted by radio frequencies. The health risk to the animals from continuous exposure to radiofrequency electromagnetic fields (RF-EMFs) was reviewed. Fourteen out of twenty-one commercially available TDs use 2G, 3G, or 4G mobile networks, and the others work with public frequencies, WLAN, Bluetooth, etc. The exposure of pets to RF-EMFs was assessed, including ambient exposure (radios, TVs, and base stations of mobile networks), exposure from indoor devices (DECT, WLAN, Bluetooth, etc.), and the exposure from TDs. The exposure levels of

the three areas were found to be distinctly below the International Commission on Non-Ionising Radiation Protection (ICNIRP) reference levels, which assure far-reaching protection from adverse health effects. The highest uncertainty regarding the exposure of pets was related to that caused by indoor RF-emitting devices using WLAN and DECT. This exposure can be limited considerably through a reduction in the exposure time and an increase in the distance between the animal and the RF-emitting device. Even though the total RF-EMF exposure level experienced by pets was found to be below the reference limits, recommendations were derived to reduce potential risks from exposure to TDs and indoor devices.

Open access paper: https://www.mdpi.com/2076-2615/11/9/2721

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Effect of Radiation Emitted by Wireless Devices on Male Reproductive Hormones: A Systematic Review

Maluin Sofwatul Mokhtarah, Osman Khairul, Jaffar Farah Hanan Fathihah, Ibrahim Siti Fatimah. Effect of Radiation Emitted by Wireless Devices on Male Reproductive Hormones: A Systematic Review. Frontiers in Physiology. 12:1568. 2021. doi:10.3389/fphys.2021.732420.

Abstract

Exposure to radiofrequency electromagnetic radiation (RF-EMR) from various wireless devices has increased dramatically with the advancement of technology. One of the most vulnerable organs to the RF-EMR is the testes. This is due to the fact that testicular tissues are more susceptible to oxidative stress due to a high rate of cell division and mitochondrial oxygen consumption. As a result of extensive cell proliferation, replication errors occur, resulting in DNA fragmentation in the sperm. While high oxygen consumption increases the level of oxidative phosphorylation by-products (free radicals) in the mitochondria. Furthermore, due to its inability to effectively dissipate excess heat, testes are also susceptible to thermal effects from RF-EMR exposure. As a result, people are concerned about its impact on male reproductive function. The aim of this article was to conduct a review of literature on the effects of RF-EMR emitted by wireless devices on male reproductive hormones in experimental animals and humans. According to the findings of the studies, RF-EMR emitted by mobile phones and Wi-Fi devices can cause testosterone reduction. However, the effect on gonadotrophic hormones (follicle-stimulating hormone and luteinizing hormone) is inconclusive. These findings were influenced by several factors, which can influence energy absorption and the biological effect of RF-EMR. The effect of RF-EMR in the majority of animal and human studies appeared to be related to the duration of mobile phone use. Thus, limiting the use of wireless devices is recommended.

Conclusion

Existing animal and human data on the effect of RF-EMR emitted from wireless devices on male reproductive hormones are inconsistent and difficult to evaluate due to the heterogeneity of study design. However, most studies are consistent with the assertion that long-term exposure to RF-EMR from mobile phones and Wi-Fi devices can disrupt male reproductive hormones, particularly testosterone. Thus, avoiding long-term and excessive use of mobile phone is advisable to reduce the detrimental effect of RF-EMR.

Open access paper: https://www.frontiersin.org/article/10.3389/fphys.2021.732420

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Challenges on the effect of cell phone radiation on mammalian embryos and fetuses: a review of the literature

Maryam Mahaldashtian, Mohammad Ali Khalili, Fatemeh Anbari, Mohammad Seify, Manuel Belli. Challenges on the effect of cell phone radiation on mammalian embryos and fetuses: a review of the literature. Zygote. 2021 Sep 29;1-7. doi: 10.1017/S0967199421000691.

Abstract

Cell phones operate with a wide range of frequency bands and emit radiofrequency-electromagnetic radiation (RF-EMR). Concern on the possible health hazards of RF-EMR has been growing in many countries because these RF-EMR pulses may be absorbed into the body cells, directly affecting them. There are some in vitro and in vivo animal studies related to the consequences of RF-EMR exposure from cell phones on embryo development and offspring. In addition, some studies have revealed that RF-EMR from cellular phone may lead to decrease in the rates of fertilization and embryo development, as well as the risk of the developmental anomalies, other studies have reported that it does not interfere with in vitro fertilization or intracytoplasmic sperm injection success rates, or the chromosomal aberration rate. Of course, it is unethical to study the effect of waves generated from cell phones on the forming human embryos. Conversely, other mammals have many similarities to humans in terms of anatomy, physiology and genetics. Therefore, in this review we focused on the existing literature evaluating the potential effects of RF-EMR on mammalian embryonic and fetal development.

https://pubmed.ncbi.nlm.nih.gov/34583799/

Excerpts

Mobile phones are commonly placed on the lap or in pockets (Swerdlow et al., 2011), therefore exposing the genital area to RF-EMF. Germ cells are more susceptible to RF-EMF, as they are rapidly dividing through meiosis and mitosis. EMF induces modifications in cellular levels such as activation of voltage-gated calcium channels, formation of free radicals, protein misfolding and DNA damage (Altun et al., 2018). In the general population, pregnant women are at specific risk of exposure to environmental RF-EMF because of their higher oxygen consumption and amniotic fluid-induced ROS production (Çiğ and Nazıroğlu, 2015) (Fig. 1). Individuals should reduce their rate of exposure to RF-EMF-emitting devices including mobile phones (Okechukwu, 2020) as electromagnetic waves enhanced the amount of oxygen free radicals in the body that led to disturbance of spermatogenesis process and variations in spermatozoa membrane, which resulted in changes in capacitation, acrosome reaction and therefore disorder in the process of spermatozoa binding to the oocyte and failure of normal fertilization both in vivo and in vitro (Fatehi et al., 2018). In addition, exposure to RF may lead to a decline in ovarian follicle reservoirs at the start of the prepubertal time (Türedi et al., 2016).

To reduce the contact with RF-EMR radiated by cell phones, people should avoid keeping their phones inside

their pockets, also use of hand-free materials and gadgets and mobile covers limit direct expose of cell phones to the body (Okechukwu, 2020). Also, people do not appreciate that a cell phone is a small base station and usually underrate the importance of distance between the cell phone and the body (Cousin and Siegrist, 2010). In analyzing the relationship between the distance of cell phone antenna from the body and SAR, Hossain and colleagues reported that increasing the distance of cell phone from the body led to diminishing of both electric and magnetic field strength to the body, therefore reducing SAR values (Hossain et al., 2015). Furthermore, it is known that the EMF decreases with distance and magnetic induction...

Conclusion

At this time, it is difficult from the available animal studies to document confidently the role of RF-EMR exposure on human embryo development, both in vivo and in vitro. Further investigations with complementary techniques will be necessary to understand the mechanism of action of RF-EMR emitted by cell phones and the consequences on mammals, particularly human beings.

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An Exploration of the Effects of Radiofrequency Radiation Emitted by Mobile Phones and Extremely Low Frequency Radiation on Thyroid Hormones and Thyroid Gland Histopathology

Alkayyali T, Ochuba O, Srivastava K, Sandhu JK, Joseph C, Ruo SW, Jain A, Waqar A, Poudel S. An Exploration of the Effects of Radiofrequency Radiation Emitted by Mobile Phones and Extremely Low Frequency Radiation on Thyroid Hormones and Thyroid Gland Histopathology. Cureus. 2021 Aug 20;13(8):e17329. doi: 10.7759/cureus.17329.

Abstract

The use of mobile phones has widely increased over the last two decades. Mobile phones produce a radiofrequency electromagnetic field (RF-EMF), a form of non-ionizing radiation. In contrast to the ionizing radiation proven to cause DNA damage, the harmful effects of non-ionizing radiation on the human body have not been discovered yet. The thyroid gland is among the most susceptible organs to mobile phone radiation due to its location in the anterior neck. Our purpose in this literature review is to explore the effects of the electromagnetic field (EMF), especially radiofrequency emitted from mobile phones, on thyroid hormones and thyroid gland histopathology. We searched PubMed and Google Scholar databases for relevant studies published after the year 2000, using the following keywords: 'cell phones', 'mobile phones', 'telephones', 'electromagnetic fields', 'radiofrequency radiation', 'microwaves', 'thyroid gland', 'thyroid hormones', and 'thyroid cancer'. Our review revealed that mobile phone radiofrequency radiation (RFR) might be associated with thyroid gland insufficiency and alterations in serum thyroid hormone levels, with a possible disruption in the hypothalamic-pituitary-thyroid axis. The review also showed histopathological changes in the thyroid gland follicles after exposure of rats to non-ionizing radiation. The results were directly related to the amount and duration of exposure to EMF radiation. Further human studies exploring thyroid gland hormones, microscopic morphology, and thyroid cancer are highly recommended for future researches.

Conclusions

This article aimed to explore the effects of RF-EMF and ELF-EMF on the thyroid gland hormones and histopathology. Studies collected in this review showed that GSM mobile phone RFR could be associated with alterations in T3, T4, and TSH serum hormone levels. EMF emitted from mobile phones could disrupt the function of the HPT axis and lead to thyroid insufficiency. In addition, EMF could lead to hyperstimulation of thyroid gland follicles, causing oxidative stress and apoptosis of follicular cells. Most studies revealed a proportional correlation between thyroid gland dysfunction and the exposure duration, intensity, and SAR value of radiation. Moreover, non-ionizing radiation was seen to be significantly associated with histopathological changes in the thyroid gland follicles. The exposure duration and intensity also determined the degree of morphological damage occurring in the thyroid gland tissue. Non-ionizing EMF radiation might be responsible for the recent increase in the incidence of thyroid insufficiency and cancer in the general population. However, not enough data was found related to thyroid cancer risk with non-ionizing radiation exposure. Keeping in mind the ethical considerations, we recommend future observational studies be conducted on human beings to further explore the association of non-ionizing radiation emitted from mobile phones on the thyroid gland's hormones, histopathology, and cancers over the long term.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8451508/

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Mobile Phone Use and Time Trend of Brain Cancer Incidence Rate in Korea

Kyung-Hwa Choi, Johyun Ha, Sanghyuk Bae, Ae-Kyoung Lee, Hyung-Do Choi, Young Hwan Ahn, Mina Ha, Hyunjoo Joo, Ho-Jang Kwon, Kyu-Won Jung, Mobile Phone Use and Time Trend of Brain Cancer Incidence Rate in Korea. 20 September 2021. /doi: 10.1002/bem.22373.

Abstract

This study evaluated the time trends in mobile phone subscriber number by mobile network generation (G) and brain cancer incidence by type in Korea. We obtained data from the Information Technology Statistics of Korea (1984–2017) and Korea Central Cancer Registry (1999–2017). The average annual percent change was estimated using Joinpoint regression analysis. We evaluated 29,721 brain cancer cases with an age-standardized incidence rate (ASR) of 2.89/100,000 persons. The glioma and glioblastoma annual ASR significantly increased in 2.6% and 3.9% of males and 3.0% and 3.8% of females, respectively. The ASR for frontal lobe involvement was the highest. The ASR of gliomas of unspecified grade annually increased by 7.8%; those for unspecified topology and histology decreased. The incidence of glioma, glioblastoma, frontal, temporal, and high-grade glioma increased among those aged ≥60 years. No association was observed between the mobile phone subscriber number and brain cancer incidence in Korea. Furthermore, long-term research is warranted because of the latency period of brain cancer.

Grant sponsor: ICT R&D program of MSIT/IITP [2019-0-00102, A study on public health and safety in a complex EMF environment].

My summary of results:

- Glioma incidence increased over time (1999-2017) for adults aged 60 years and over.
- Glioblastoma incidence increased over time for adults aged 60 years and over.
- Unspecified brain tumor incidence **decreased** over time for adults aged 60 years and over.
- High-grade glioma incidence increased over time for male and female adults aged 60 years and over.
- The trend over time in standardized incidence of glioma exceeded the predicted relative risk of 1.5 based on mobile phone subscriber number.
- The trend over time in standardized incidence of glioblastoma exceeded the predicted relative risk of 1.5 based on mobile phone subscriber number.
- The trend over time in standardized incidence of brain cancer in the frontal lobe exceeded a predicted relative risk of 1.5 based on mobile phone subscriber number.

Excerpts

... According to the type of histology, the incidence of glioma was higher than that of other types, and it was significantly increased in both sexes (AAPC [95% CI], male: 2.6% [2.1, 3.2], female: 3.0% [2.1, 3.8]), whereas those of total brain cancers were not (AAPC [95% CI], male: 0.2% [−0.3, 0.6], female: 0.1% [−0.3, 0.5]). In particular, the incidence of glioblastoma increased more than that of other gliomas. The incidence of cancers with unspecified histology statistically decreased in both sexes (AAPC [95% CI], male: 7.9% [−9.6, −6.1], female: 7.8% [−8.9, −6.7]). According to the type of topology, the ASR of frontal lobe involvement (male: 0.53, female: 0.45) was higher than that of the temporal and parietal lobes. The ASR of cancers with unspecified topology decreased by 4.6% per year in males and 3.8% per year in females, whereas that of cancers of the other lobes increased. According to the type of grade, the incidence and AAPC of high-grade gliomas were higher than those of low-grade gliomas. The ASR of gliomas of unspecified grade increased by 7.8% per year, whereas those of unspecified topology (3.8% per year) and unspecified histology (7.8% per year) decreased.

... The incidence of glioma, glioblastoma, frontal, temporal, and high-grade glioma increased among those aged ≥60 years, and increased significantly among those aged ≥70 years (AAPC [95% CI]): glioma (male: 6.9 [5.6, 8.2], female: 8.5 [6.5, 10.6]); glioblastoma (male: 8.1 [6.1, 10.2], female: 9.9 [7.3, 12.5]); frontal (male: 6.2 [4.5, 8.0], female: 6.6 [4.0, 9.4]); temporal (male: 5.8 [2.9, 8.7], female: 7.1 [4.6, 9.7]); high-grade glioma (male: 7.5 [5.8, 9.3], female: 9.2 [7.0, 11.4]). There were no differences in the trend for unspecified brain cancer by histology, topology, or grade of glioma according to age group...

This study has several limitations. First, it is difficult to prove whether exposure to RF-EMF from mobile phones increases the incidence of brain cancers because this is a descriptive study. Further studies are required to evaluate the association between brain cancer incidence and mobile phone subscribers by age group, because this study shows different results for each age group, such as an increase in the incidence of brain cancer among older adults. Therefore, we could not determine whether the increase in brain cancer incidence, especially glioma and glioblastoma, was associated with an increase of mobile phone subscribers in older age groups. Second, it was not possible to calculate the predicted incidence according to the mobile phone subscription by sex and age. For this, it is better to acquire detailed information such as sex, age, and residential address of mobile phone subscribers in future studies and analyze them further. Studies have revealed a latency period of

more than 30 years for cancer [Sadetzki et al., 2005]. However, data on cancer incidence are only available for approximately 20 years in Korea. Hence, further analysis is required to verify our results.

This study found no evidence of an increase in brain cancer incidence associated with the increasing number of mobile phone subscribers in Korea. Further research is warranted using detailed information on mobile phone subscriptions, with research carried out for longer durations considering the latency period for brain cancer.

https://onlinelibrary.wiley.com/doi/10.1002/bem.22373

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5G New Radio Requires the Best Possible Risk Assessment Studies: Perspective and Recommended Guidelines

Mats-Olof Mattsson, Myrtill Simkó, Kenneth R. Foster. 5G New Radio Requires the Best Possible Risk Assessment Studies: Perspective and Recommended Guidelines. Frontiers in Communications and Networks. Vol 2:49. 2021. doi: 10.3389/frcmn.2021.724772.

Abstract

The development and establishment of mobile communication technologies has necessitated assessments of possible risks to human health from exposures to radio-frequency electromagnetic fields (RF EMF). A number of expert committees have concluded that there is no evidence for such risks as long as exposures are at or below levels that do not allow tissue heating. These assessments have been based primarily on studies investigating frequencies up to 6 GHz including frequencies similar to those used by two of three major bands of fifth generation (more accurately 5G New Radio or 5G NR) of mobile communication. Bioeffects studies in so-called high-band at 25–39 GHz are particularly sparse. Future assessments relevant for these frequencies will need to rely on still unperformed studies. Due to few available studies at 5G NR “high band” frequencies, and questions raised by some existing studies, a recent review recommended a wide range of RF biostudies be done at 5G NR “high band” frequencies. It is of importance that such studies be done using the best possible science. Here we suggest factors to consider when performing future studies in this area. The present focus is on laboratory studies to clarify biological effects of radiofrequency (RF) energy at 5G “high band” frequencies and, more generally at millimeter wave (mm-wave) frequencies (30-300 GHz) which will be increasingly used by communications technologies in the future. Similar comments would apply to epidemiology and exposure assessment studies, but those are not the focus of the present Perspective.

Open access paper: https://www.frontiersin.org/article/10.3389/frcmn.2021.724772

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Mapping of static magnetic fields near the surface of mobile phones

L. Zastko, L. Makinistian, A. Tvarožná, F. L. Ferreyra & I. Belyaev. Mapping of static magnetic fields near the surface of mobile phones. Scientific Reports. 11:19002. 2021. doi: 10.1038/s41598-021-98083-9.

Abstract

Whether the use of mobile phones (MP) represents a health hazard is still under debate. As part of the attempts to resolve this uncertainty, there has been an extensive characterization of the electromagnetic fields MP emit and receive. While the radiofrequencies (RF) have been studied exhaustively, the static magnetic fields (SMF) have received much less attention, regardless of the fact there is a wealth of evidence demonstrating their biological effects. We performed 2D maps of the SMF at several distances from the screen of 5 MP (models between 2013 and 2018) using a tri-axis magnetometer. We built a mathematical model to fit our measurements, extrapolated them down to the phones' screen, and calculated the SMF on the skin of a 3D head model, showing that exposure is in the µT to mT range. Our literature survey prompts the need of further research not only on the biological effects of SMF and their gradients, but also on their combination with extremely low frequency (ELF) and RF fields. The study of combined fields (SMF, ELF, and RF) as similar as possible to the ones that occur in reality should provide a more sensible assessment of potential risks.

Excerpts

The maximum SMF estimated in this work (6.6 mT) and others' (20 mT) 14 are far below the 400 mT exposure limit for the general public recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP)26. This might lead to the temptation of completely disregarding SMF as a variable of interest when assessing MP fields. In fact, a recent fact sheet from the Swiss Federal Office of Public Health 13 completely omitted any reference to SMF. Nevertheless, the sole capacity of these fields of inducing potentially harmful biological effects such as promotion of the production of reactive oxygen species (ROS) 21 should be enough to consider them seriously. As for the possible underlying mechanisms of interaction, the one based on magnetite nanoparticles 27 is of particular interest because these nanoparticles have been found in the human brain 28,29. Besides the brain, the ear is of an obvious interest for its proximity to the upper HS of MP. Interestingly, magnetic material was reported on the lagenal otoliths of fish and birds 30 (although this structure is not conserved in mammals). To the best of our knowledge, there have not been studies reporting the search of magnetic materials as constituents of the human inner ear. In this regard, it is to be mentioned that some epidemiological studies found an association between MP use and tinnitus (the perception of a sound in the absence of an external source), while a meta-analysis found no association 31...

Our measurements and calculations, along with the preceding discussion of the literature, prompt the need of further studies of the biological effects of the SMF and RF EMF generated by MP. We suggest special emphasis should be put into (1) inhomogeneous SMF (with a detailed characterization of both, intensities and gradients), and (2) combination of SMF (homogeneous and inhomogeneous) with RF EMF, with a fine sweeping of the parameters within the range of typical exposures (in opposition to testing single combinations). In even more complicated experiments, ELF EMF should also be considered 12 since their relationship with SMF have been long known 53. Lastly it is worth mentioning that substantial reduction of the SMF from MP could be accomplished by replacing the standard electrodynamic loudspeakers and microphones (which include a permanent magnet) by their capacitive counterparts (which do not).

Open access paper: https://www.nature.com/articles/s41598-021-98083-9

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Radio-Frequency Electromagnetic Fields: Simultaneous Exposure to Infinite Sources From Typical Base Stations

A. Linhares, A. P. de Azevedo and L. C. Fernandes. Radio-Frequency Electromagnetic Fields: Simultaneous Exposure to Infinite Sources From Typical Base Stations. IEEE Antennas and Propagation Magazine. doi: 10.1109/MAP.2021.3106829.

Introduction

This article shows that simultaneous exposure to infinite electromagnetic field (EMF) sources from typical base stations transmitting at multiple frequency bands is lower than international limits. Considering a real base station density and conservative path loss models, we show that the power density at a given location can be modeled by a convergent infinite series. To validate this model, we apply it to Brasília, Brazil, and compare the results with measurements. While the proposed model shows that the exposure ratio (ER) will not exceed 2.62%, the highest measured value reaches 85% of this estimation.

Conclusions

In this article, we proposed a method to estimate an upper limit for the TER due to infinite sources of typical base stations. When assessing human exposure to RF EMFs due to specific base stations, the exposure caused by all other base stations can be estimated using the model. The model was applied using base station density data from Brasília and shows that simultaneous exposure from infinite cellular macro base stations distributed as shown in Figure 2 will not be more than 2.62% of the ICNIRP limits. It was validated using simulations and more than 3,000 measurements, and our results agree with them regardless of the probe location. However, for a more conservative approach, when assessing individual base stations, the model can be used to estimate an upper limit for all other base stations (i.e., it provides an exposure addition to the results of the base station under test).

The model is not bounded to a specific frequency band and generic enough to be used by superimposing different categories of base stations, such as micro and macro cells. It may also be employed for 5G, but due to its antenna beamforming, the approach would be more conservative since RF EMF exposure may decrease due to its dynamic directional characteristics. This topic will be the subject of future studies. To ensure the reproducibility of the results in this article, the equations were implemented in numeric code and are available in [20]. The code and data to generate the results in Tables 1 and 2 and Figures 4, 5, 7, 8, and 9 are also available.

https://ieeexplore.ieee.org/document/9532004

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Alteration of intrapancreatic serotonin, homocysteine, TNF-α, and NGF levels as predisposing factors for diabetes following exposure to 900-MHz waves

Gholamali Jelodar, Mansour Azimzadeh, Fatemeh Radmard, Narges Darvishhoo. Alteration of intrapancreatic serotonin, homocysteine, TNF-α, and NGF levels as predisposing factors for diabetes following exposure to 900-MHz waves. Toxicol Ind Health. 2021 Aug;37(8):496-503. doi: 10.1177/07482337211022634.

Abstract

Exposure to mobile phone radiation causes deleterious health effects on biological systems. The objects of this study were to investigate the effect of 900-MHz radiofrequency waves (RFW) emitted from base transceiver station antenna on intrapancreatic homocysteine (Hcy), tumor necrosis factor-α (TNF-α), and nerve growth factor (NGF) as predisposing factors involved in pancreatic beta cell damage. Thirty male rats (Sprague-Dawley, 200 ± 10 g) were randomly divided into the control (without any exposure) and exposed groups: short time (2 h/day), long time (4 h/day), and exposed to 900-MHz RFW for 30 consecutive days. On the last days of the experiment, animals were killed and pancreas tissue was dissected out for evaluation of serotonin, Hcy, TNF-α, and NGF. There was a significant decrease in the serotonin and NGF levels in the pancreatic tissue of exposed groups compared to the control group ($p < 0.05$). Also, the levels of serotonin and NGF in the long-time exposure were significantly lower than the short-time exposure ($p < 0.05$). However, levels of Hcy and TNF-α were significantly increased in the pancreas of exposed groups compared to the control groups ($p < 0.05$). Exposure to 900-MHz RFW decreased pancreatic NGF and serotonin levels and increased the proinflammatory markers (Hcy and TNF-α), which can be a predisposing factor for type 2 diabetes.

https://pubmed.ncbi.nlm.nih.gov/34151670/

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The Research and Safety Discussion of Electromagnetic Radiation in Electric Vehicles

X. Wang *et al*. The Research and Safety Discussion of Electromagnetic Radiation in Electric Vehicles. *2021 International Applied Computational Electromagnetics Society Symposium (ACES)*, 2021, pp. 1-3, doi: 10.1109/ACES53325.2021.00038.

Abstract

To study the electromagnetic radiation in electric vehicles for human exposure, the electric field (6 Hz to 3 GHz) and magnetic field (6 Hz to 30 MHz) strengths in electric vehicles of driving mode, charging mode and stationary mode are measured, and the characteristics of the electric and magnetic field in electric vehicles are analysed and studied here. The studies show that the electromagnetic radiation of electric vehicles is mainly consisted of electromagnetic wave from 6 Hz to 500 Hz, and it might be higher in driving mode than that of charging mode and stationary mode. The abnormal values of electromagnetic radiation in electric vehicles often occur in driving mode, and usually appear in the front of the electric vehicles.

https://ieeexplore.ieee.org/document/9528788

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Oxidative Stress and NADPH Oxidase: Connecting Electromagnetic Fields, Cation Channels and Biological Effects

Christos D Georgiou, Lukas H Margaritis. Oxidative Stress and NADPH Oxidase: Connecting Electromagnetic Fields, Cation Channels and Biological Effects. Int J Mol Sci. 2021 Sep 17;22(18):10041. doi: 10.3390/ijms221810041.

Abstract

Electromagnetic fields (EMFs) disrupt the electrochemical balance of biological membranes, thereby causing abnormal cation movement and deterioration of the function of membrane voltage-gated ion channels. These can trigger an increase of oxidative stress (OS) and the impairment of all cellular functions, including DNA damage and subsequent carcinogenesis. In this review we focus on the main mechanisms of OS generation by EMF-sensitized NADPH oxidase (NOX), the involved OS biochemistry, and the associated key biological effects.

Conclusions

On the basis of the above findings, an EMF mechanism can involve ROS formation due to membrane and voltage-gated cation channel function deterioration [2,3,7,8] followed by stress activation and heat-shock protein overexpression [56], which may be associated with behavioural and physiological effects such as blood–brain barrier disruption, memory malfunction, changes in gene expression [53], autophagy, apoptosis [53,84] (especially due to modulation [85]), lifespan reduction, DNA damage, and cancer [18].

Theory and Research Perspectives for a Conclusive Linking of EMFs with ROS/RNS

EMF induction of OS via increased concentration of free radicals, has been challenged (by ICNIRP) mainly due to (i) the claimed non-ionizing nature of EMF (ELF/RF), where no covalent bonds are broken at non-thermal intensities, or so the argument goes, and because (ii) the measurement of OS is performed by non-specific methods. Indeed, OS is measured, either by methods that are not specific to the identification of generated free radicals, or indirectly by certain oxidative modifications they cause on key biological molecules (e.g., DNA damage, lipid/protein peroxidation, etc.).

Man-made EMFs do not possess high enough energy to generate free radicals, e.g., on freely moving single H2O molecules by a single photon. However, the individual EMF of such photons are fully synchronized (in terms of frequency, polarization, phase, and propagation direction), thereby producing cumulative macroscopic electric and magnetic fields and electromagnetic radiation (EMR). Nonetheless, these may be additively high enough to break covalent bonds and may directly generate free radicals. Secondly, concentrations of naturally occurring free radicals can increase by the prevention of either (i) reactions between them (e.g., appearing as the aforementioned reactants •NO + O2•− and products •OH + •NO2), or (ii) the reassociation of free radical pairs generated enzymically as transition states. Such prevention can be assisted by the EMF-induced free radical pair mechanism [86,87]. Here, EMFs can prevent the reassociation of free radical pairs by reversing the spin direction

of the single electron in one of these free radicals by flipping the direction of its magnetic field component. Thus, the magnetically affected free radical pair ends up consisting of two free radicals, the electron spins of which have become parallel, thereby preventing their re-binding and indirectly increasing their concentration. The free radical pair mechanism has been accounted for by the International Agency for Research on Cancer for the classification of the RF EMFs in the Group 2B category of "possibly carcinogenic to humans" [88]. These two mechanisms of free radical-concentration increase corroborate with the preliminary finding that ELF EMFs increase the concentration of O2•− by many fold in various organs of mice exposed to the ICNIRP limit of 100 μT at 50 Hz (pending publication by Dr. Georgiou's lab).

Therefore, methods for the in vivo specific detection of the key biological free radicals •OH and O2•− ([89,90]) are needed in order to unequivocally prove the generation of carcinogenic OS by EMFs.

Open access paper: https://www.mdpi.com/1422-0067/22/18/10041

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Residential extremely low frequency magnetic fields and skin cancer

Muhammad Waseem Khan, Jukka Juutilainen, Jonne Naarala, Päivi Roivainen. Residential extremely low frequency magnetic fields and skin cancer. Occup Environ Med. 2021 Sep 30;oemed-2021-107776. doi: 10.1136/oemed-2021-107776.

Abstract

Objective: Photoinduced radical reactions have a fundamental role in skin cancer induced by ultraviolet radiation, and changes in radical reactions have also been proposed as a mechanism for the putative carcinogenic effects of extremely low frequency (ELF) magnetic fields (MFs). We assessed the association of melanoma and squamous cell carcinoma with residential MF exposure.

Methods: All cohort members had lived in buildings with indoor transformer stations (TSs) during the period from 1971 to 2016. MF exposure was assessed based on apartment location. Out of the 225 492 individuals, 8617 (149 291 person-years of follow-up) living in apartments next to TSs were considered as exposed, while individuals living on higher floors of the same buildings were considered as referents. Associations between MF exposure and skin cancers were examined using Cox proportional hazard models.

Results: The HR for MF exposure ≥6 month was 1.05 (95% CI 0.72 to 1.53) for melanoma and 0.94 (95% CI 0.55 to 1.61) for squamous cell carcinoma. Analysis of the age at the start of residence showed an elevated HR (2.55, 95% CI 1.15 to 5.69) for melanoma among those who lived in the apartments when they were less than 15 years old. This finding was based on seven exposed cases.

Conclusions: The results of this study suggested an association between childhood ELF MF exposure and adult melanoma. This is in agreement with previous findings suggesting that the carcinogenic effects of ELF MFs may be associated particularly with childhood exposure

https://pubmed.ncbi.nlm.nih.gov/34593542/

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Electromagnetic Fields Modify Redox Balance in the Rat Gastrointestinal Tract

Sieroń Karolina, Knapik Katarzyna, Onik Grzegorz, Romuk Ewa, Birkner Ewa, Kwiatek Sebastian, Sieroń Aleksander. Electromagnetic Fields Modify Redox Balance in the Rat Gastrointestinal Tract. Frontiers in Public Health. 9:1283. 2021. DOI:10.3389/fpubh.2021.710484.

Abstract

Objective: The aim of the study was to assess the influence of electromagnetic fields with divergent physical properties on the prooxidative and antioxidative balances in homogenates of the tongue, salivary glands, esophagus, stomach, and small and large intestines of rats.

Material and Methods: Forty rats were randomly divided into four equal groups, namely, a control group, a group exposed to low-frequency electromagnetic fields (LF-EMFs; frequency: 50 Hz; intensity: 10 kV/m; magnetic induction: 4.3 pT), a group exposed to radiofrequency electromagnetic fields (RF-EMFs) emitted by mobile phones (frequency: 900 MHz), and a group exposed simultaneously to LF-EMFs and RF-EMFs emitted by mobile phones. After 28 consecutive days of the experiment, the following pro- and antioxidative markers were assessed in the gastrointestinal tract homogenates: superoxide dismutase (SOD) and its two isoenzymes (Mn-SOD, Cu,Zn-SOD) catalase (CAT), glutathione peroxidase (GPx), glutathione reductase (GR), glutathione S-transferase (GST), total antioxidative capacity (TAC), total oxidative status (TOS), and malondialdehyde (MDA).

Results: In rats exposed to LF-EMFs, higher concentrations of the markers of prooxidant processes, MDA or TOS, were observed in the salivary glands, esophagus, and small intestine homogenates in comparison with the control group. Additionally, in the group of rats opposite to the control, antioxidant activity was observed. The main differences included a higher activity of Cu,Zn-SOD in homogenates of the tongue, salivary glands, and esophagus as well as decreased activity of CAT in homogenates of the tongue, esophagus, and small intestine. In animals exposed to RF-EMFs, the concentration of TOS was higher in the large intestine than in control rats. The main difference of antioxidant activity was presented by decreased Cu,Zn-SOD in homogenates of the salivary glands, stomach, small and large intestine as well as CAT in homogenates of the tongue, esophagus, stomach, and small and large intestine. Moreover, in rats exposed simultaneously to LF-EMFs and RF-EMFs, a lower concentration of TOS was observed. Antioxidant activity was presented by a decreased activity of CAT in homogenates of the tongue, esophagus, stomach, and small and large intestine in comparison to the control group.

Conclusion: Among those applied in the study, electromagnetic fields of a low-frequency caused the most significant disturbances of oxidative stress in the rat gastrointestinal tract.

Open access paper: https://www.frontiersin.org/article/10.3389/fpubh.2021.710484

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Near Field Radio-Frequency Electromagnetic Field Exposure of a Western Honey Bee

D. Toribio, W. Joseph, A. Thielens. Near Field Radio-Frequency Electromagnetic Field Exposure of a Western Honey Bee. IEEE Transactions on Antennas and Propagation, doi: 10.1109/TAP.2021.3111286.

Abstract

It has been suggested that the wireless network evolution to smaller carrier wavelengths (from 2G to 5G) increases radio-frequency electromagnetic field (RF-EMF) absorption in Western Honey Bees (Apis mellifera). It is unknown whether the radiation performance of antennas is stable when an insect appears in their vicinity. In this research, the absorbed power in a worker honey bee and the influence of the bee's presence on antennas' radiation performance is investigated for the newly used frequencies in 5G networks, from 6-240 GHz. To these aims, numerical simulations using the finite-difference time-domain method were performed, in which a bee model, obtained by micro-CT scanning, was employed. These simulations showed that in the near field, the absorbed power can increase by a factor of 53, from 6-240 GHz. This is a factor of 7 higher than the increase reported in the far field, in previous studies. Furthermore, the simulations revealed that antennas' radiation efficiency can decrease by up to -40 % when a bee appears in the near field. Likewise, it was found that the gain pattern depends on the separation distance between the bee and the antenna, with a stronger dependency for higher frequencies.

CONCLUSION

Numerical simulations using finite-difference time-domain analysis were executed to calculate the radio-frequency electromagnetic fields (RF-EMFs) in and around a worker Western Honey Bee (Apis mellifera). This lead to the quantification of the whole-body averaged absorbed radio-frequency power Pabs, under near-field exposure, in the frequency range of 6-240 GHz. The simulations showed that, in the near field, Pabs decreases as the separation distance between the bee and the dipole increases, and increases as frequency increases. The frequency behavior of Pabs in the near field is thus different to its far-field behavior, since, for a given accepted power and distance, in the near field Pabs increases with frequency (an average of 30.5 dB from 6-240 GHz), while in the far field Pabs in the worker bee is maximized at 12 GHz. This near-field increase in Pabs as a function of frequency, can be a factor of 7 higher than the far-field increase.

Moreover, these simulations allowed the study of the influence of the bee's position (0.1 −10 λ from the dipoles) in the radiation performance of the dipoles. In particular, it was found that as the separation distance increases, the dipoles' isotropic gain decreases and approaches their free-space gain. Also, it was noted that as a result of the near-field frequency behavior of Pabs, the dipoles' radiation efficiency decreases with increasing frequency and increases with increasing separation distance. Additionally, it was acknowledged that the gain pattern in the direction where the bee approaches the antenna depends on the separation distance between the bee and the antenna, with a stronger dependency for higher frequencies. This is important for 5G telecomunication networks, because they rely on infrastructure (antennas) whose performance can be influenced by the presence of free-flying insects.

https://ieeexplore.ieee.org/document/9539081

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Sublethal neonicotinoid exposure attenuates the effects of electromagnetic fields on honey bee flight and learning

S. Shepherd, M.A.P. Lima, E.E. Oliveira, S.M. Sharkh, H. Aonuma, C.W. Jackson, P.L. Newland. Sublethal neonicotinoid exposure attenuates the effects of electromagnetic fields on honey bee flight and learning, Environmental Advances. Volume 4. 2021. 100051. doi:10.1016/j.envadv.2021.100051.

Abstract

Many environmental stressors are currently implicated in the decline of flying insects in general, and important pollinator species such as the honey bee. Recent studies have shown that extremely low frequency electromagnetic fields (ELF EMFs) affect many aspects of insect behaviour and cognition which raises the potential that ELF EMFs could interact with other environmental stressors such as neonicotinoid insecticides to have even greater impact on the decline of flying insects. Here we analysed the effects of individual and combined exposure of the honey bee to 50 Hz EMFs and sublethal exposure to clothianidin, in a tethered flight assay and an olfactory appetitive learning assay. Clothianidin was significantly toxic to bees and exposure to field-realistic levels (2.00 ng/bee) led to 25% mortality. Exposure to ELF EMFs alone led to a significant increase in wingbeat frequency at levels above 100 μT. Prior exposure to clothianidin attenuated the effects of EMFs on wingbeat frequency. Exposure to EMFs alone reduced learning of a proboscis extension reflex (PER). Prior exposure to low doses of clothianidin attenuated the effects of EMFs on PER. These results indicate no evidence of synergy between clothianidin and ELF EMFs as environmental stressors but suggest the potential for EMFs to affect the same susceptible fraction of the bee population that have been affected by clothianidin. Results lay the foundation to further explore the interactions of ELF EMFs with other environmental stressors and consider the key factors that may make bees susceptible to ELF EMFs.

Open access paper: https://www.sciencedirect.com/science/article/pii/S2666765721000223

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Microtubular structure impairment after GSM-modulated RF radiation exposure

Ana Marija Marjanović Čermak, Krunoslav Ilić, Ivan Pavičić. Microtubular structure impairment after GSM-modulated RF radiation exposure. Arh Hig Rada Toksikol. 2020 Oct 6;71(3):205-210. doi: 10.2478/aiht-2020-71-3267

Abstract

The objective of the study was to investigate whether low-level 915 MHz GSM-modulated radiofrequency (RF) radiation impairs microtubular structure and affects normal cell growth. V79 cells were exposed to a GSM-

modulated field in a Gigahertz Transversal Electromagnetic Mode cell (GTEM cell) for 1, 2, and 3 h. Signal generator combined with power and chip modulator generated the electromagnetic field (EMF). The electric field strength was adjusted to 10, 20, and 30 V/m, and the average specific absorption rate (SAR) was calculated to be 0.23, 0.8, and 1.6 W/kg. The structure of microtubule proteins was assessed by indirect immunocytochemistry, and cell growth was determined based on cell counts taken every day over six post-exposure days. Three-hour radiation exposure significantly altered microtubule structure regardless of the electric field strength. Moreover, on the third post-exposure day, three-hour radiation significantly reduced cell growth, regardless of field strength. The same was observed with two-hour exposure at 20 and 30 V/m. In conclusion, 915 MHz GSM-modulated RF radiation affects microtubular proteins in a time-dependent manner, which, in turn, affects cell proliferation. Our future research will focus on microtubule structure throughout the cell cycle and RF radiation effects on mitotic spindle.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7968504/

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Effects of Long-Term Exposure to L-Band (~2.0 GHz) High-Power (0.5, 1.0, and 1.5 W/m^2) Microwave on the Brain Function of Male Mice

Lin Y, Gao P, Guo Y, Chen Q, Lang H, Guo Q, Miao X, Li J, Zeng L, Guo G. Effects of Long-Term Exposure to L-Band High-Power Microwave on the Brain Function of Male Mice. Biomed Res Int. 2021 Sep 4;2021:2237370. doi: 10.1155/2021/2237370.

Abstract

Currently, the impact of electromagnetic field (EMF) exposure on the nervous system is an increasingly arousing public concern. The present study was designed to explore the effects of continuous long-term exposure to L-band (~ 2.0 GHz) high-power microwave (L-HPM) on brain function and related mechanisms. Forty-eight male Institute of Cancer Research (ICR) mice were exposed to L-HPM at various power densities (0.5, 1.0, and 1.5 W/m^2) and the brain function was examined at different time periods after exposure. The morphology of the brain was examined by hematoxylin-eosin (HE) and deoxynucleotidyl transferase-mediated dUTP nick-end labeling (TUNEL) staining. Furthermore, cholinergic markers, oxidative stress markers, and the expression of c-fos were evaluated to identify a "potential" mechanism. The results showed that exposure to L-HPM at 1.5 W/m^2 can cause generalized injuries in the hippocampus (CA1 and CA3) and cerebral cortex (the first somatosensory cortex) of mice, including cell apoptosis, cholinergic dysfunction, and oxidative damage. Moreover, the deleterious effects were closely related to the power density and exposure time, indicating that long-term and high-power density exposure may be detrimental to the nervous system.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8437633/

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Electromagnetic Pollution as a Possible Explanation for the Decline of House Sparrows in Interaction with Other Factors

Alfonso Balmori. Electromagnetic Pollution as a Possible Explanation for the Decline of House Sparrows in Interaction with Other Factors. Birds 2021, 2(3), 329-337; doi: 10.3390/birds2030024

Simple Summary

In recent decades, there has been a decline of the house sparrow (Passer domesticus), mainly in European cities, and several hypotheses have been proposed. The objective of this article is to delve into the reasons why an increase in electromagnetic radiation especially in cities, may be intervening in some way. Previous studies indicated that house sparrows were significantly negatively associated with increasing electromagnetic radiation and sparrows disappeared from areas most polluted. Electromagnetic radiation is the most plausible factor and is the only one that affects the other hypotheses proposed so far. Additionally, the recent sparrow decline matches the deployment of mobile telephony networks. For these reasons, electromagnetic radiation is not only a plausible but a probable hypothesis that must be seriously considered, probably in synergy with the other factors previously proposed.

Abstract

In recent decades, there has been a decline of the House Sparrow (Passer domesticus), mainly in European cities, and several hypotheses have been proposed that attempt to determine the causes of this rapid decline. Previous studies indicated that house sparrows were significantly negatively associated with increasing electromagnetic radiation and sparrows disappeared from areas most polluted. In addition, there are many studies on the impact of radiation on other bird and non-bird species, as well as numerous laboratory studies that demonstrated detrimental effects at electric field strength levels that can be found in cities today. Electromagnetic radiation is the most plausible factor for multiple reasons, including that this is the only one that affects the other hypotheses proposed so far. It is a type of pollution that affects productivity, fertility, decreases insects (chicken feed), causes loss of habitat, decreases immunity and can promote disease. Additionally, the recent sparrow decline matches the deployment of mobile telephony networks. Further, there are known mechanisms of action for non-thermal effects of electromagnetic radiation that may affect sparrows causing their decline. Thus, electromagnetic radiation must be seriously considered as a factor for house sparrows' decline, probably in synergy with the other factors previously proposed.

Open access paper: https://www.mdpi.com/2673-6004/2/3/24/htm

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One-time Electromagnetic Irradiation Modifies Stress-sensitive Gene Expressions in Rice Plant

Ardhendu Kundu, Sathish Vangaru, Sucharita Bhowmick, Somnath Bhattacharyya, Amirul I Mallick, Bhaskar Gupta. One-time Electromagnetic Irradiation Modifies Stress-sensitive Gene Expressions in Rice Plant. Bioelectromagnetics. 2021 Sep 24. doi: 10.1002/bem.22374.

Abstract

Electromagnetic energy is utilized over multiple frequency bands to provide seamless wireless communication services. Plants can well perceive electromagnetic energy present in open environment due to reasonably high permittivity and electrical conductivity of constituent tissues. Moreover, higher surface-to-volume ratio of plant structure facilitates increased interaction with the incident electromagnetic waves. To date, a few well-designed studies have been conducted inside controlled electromagnetic reverberation chambers to investigate either short duration-low amplitude or long duration-periodic electromagnetic irradiation-induced molecular responses in plants. However, as far as is known, studies investigating molecular responses particularly at the mid-vegetative stage in plants following one-time (hours-long) electromagnetic irradiation have not been reported earlier. Hence, the present study aimed at investigating molecular responses in 40-day-old Swarnaprabha rice plants following one-time 1837.50 MHz, 2.75 mW/m2 electromagnetic irradiation of 2 h 30 min duration. Controlled electromagnetic irradiation inside a simple reverberation chamber was ensured to achieve pure electromagnetic environment at 1837.50 MHz with deterministic electromagnetic power density at selected position. Swarnaprabha rice plant was chosen for this investigation since the rice variety is widely cultivated and consumed in the Indian subcontinent. Subsequent alterations in some selected stress-sensitive gene expressions were assayed using real-time quantitative polymerase chain reaction technique-significant upregulation in calmodulin and phytochrome B gene expressions were noted. This investigation was purposefully focused on subsequent molecular responses immediately following electromagnetic irradiation so that the possible effects of secondary stimulations could be avoided. Observed molecular responses strongly suggested that plants perceive 1837.50 MHz, 2.75 mW/m2 electromagnetic irradiation similar to other injurious stimuli.

https://pubmed.ncbi.nlm.nih.gov/34559898/

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Short-Term Extremely Low-Frequency Electromagnetic Field Inhibits Synaptic Plasticity of Schaffer Collateral-CA1 Synapses in Rat Hippocampus via the Ca 2+/Calcineurin Pathway

Pei Xia, Yu Zheng, Lei Dong, Chunxiao Tian. Short-Term Extremely Low-Frequency Electromagnetic Field Inhibits Synaptic Plasticity of Schaffer Collateral-CA1 Synapses in Rat Hippocampus via the Ca 2+/Calcineurin Pathway. ACS Chem Neurosci. 2021 Sep 9. doi: 10.1021/acschemneuro.1c00500.

Abstract

In this study, we investigate the intrinsic mechanism by which an extremely low-frequency electromagnetic field (ELF-EMF) influences neurons in the Schaffer collateral-CA1 (SC-CA1) region of rat hippocampus using electrophysiological techniques. ELF-EMF has an interesting effect on synaptic plasticity: it weakens long-term potentiation and enhances long-term depression. Here, the magnetic field effect disappeared after a blockade of voltage-gated calcium channels and calcineurin, which are key components in the Ca2+/calcineurin pathway, with two blockers, cadmium chloride and cyclosporin A. This fully establishes that the effect of ELF-EMF on

synaptic plasticity is mediated by the Ca2+/calcineurin pathway and represents a novel technique for studying the specific mechanisms of action of ELF-EMF on learning and memory.

https://pubmed.ncbi.nlm.nih.gov/34498467/

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DNMT1 and miRNAs: possible epigenetics footprints in electromagnetic fields utilization in oncology

Mohadeseh Shayeghan, Flora Forouzesh, Alireza Madjid Ansari, Mohammad Amin Javidi. DNMT1 and miRNAs: possible epigenetics footprints in electromagnetic fields utilization in oncology. Med Oncol. 2021 Sep 8;38(10):125. doi: 10.1007/s12032-021-01574-y.

Abstract

Many studies were performed to unravel the effects of different types of Electromagnetic fields (EMFs) on biological systems. Some studies were conducted to exploit EMFs for medical purposes mainly in cancer therapy. Although many studies suggest that the EMFs exposures can be effective in pre-clinical cancer issues, the treatment outcomes of these exposures on the cancer cells, especially at the molecular level, are challenging and overwhelmingly complicated yet. This article aims to review the epigenetic mechanisms that can be altered by EMFs exposures with the main emphasis on Extremely low frequency electromagnetic field (ELF-EMF). The epigenetic mechanisms are reversible and affected by environmental factors, thus, EMFs exposures can modulate these mechanisms. According to the reports, ELF-EMF exposures affect epigenetic machinery directly or through the molecular signaling pathways. ELF-EMF in association with DNA methylation, histone modification, miRNAs, and nucleosome remodeling could affect the homeostasis of cancer cells and play a role in DNA damage repairing, apoptosis induction, prevention of metastasis, differentiation, and cell cycle regulation. In general, the result of this study shows that ELF-EMF exposure probably can be effective in cancer epigenetic therapy, but more molecular and clinical investigations are needed to clarify the safe and specific dosimetric characteristics of ELF-EMF in practice.

https://pubmed.ncbi.nlm.nih.gov/34495398/

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Safety of Wireless Power Transfer

James C. Lin. Safety of Wireless Power Transfer. IEEE Access. 10 September 2021. doi: 10.1109/ACCESS.2021.3108966.

Abstract

Wireless power transfer (WPT) systems are developed to provide electric power either directly or via battery-charging. The optimism on WPT technology is driven by the ubiquity of cellphones, laptops, and mobile communication devices. Aside from not having to plug in a cellphone or laptop, WPT battery charging offers the potential for mobile devices to get electrical power the same way they get data through harvesting ambient electromagnetic radiation. The dream is a truly wireless mobility scenario with tether-free electric power for cellphones, laptops, appliances, and transportation systems. Beyond wireless communication, the electromagnetic power required for large-scale commercial WPT implementation is substantial. A key facet of the system design and research should include consideration of health effects and safety of radiofrequency electromagnetic radiation.

https://ieeexplore.ieee.org/document/9535368

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Cellular effects of terahertz waves

Cherkasova OP, Serdyukov DS, Nemova EF, Ratushnyak AS, Kucheryavenko AS, Dolganova IN, Xu G, Skorobogatiy M, Reshetov IV, Timashev PS, Spektor IE, Zaytsev KI, Tuchin VV. Cellular effects of terahertz waves. J Biomed Opt. 2021 Sep;26(9). doi: 10.1117/1.JBO.26.9.090902.

Abstract

Significance: An increasing interest in the area of biological effects at exposure of tissues and cells to the terahertz (THz) radiation is driven by a rapid progress in THz biophotonics, observed during the past decades. Despite the attractiveness of THz technology for medical diagnosis and therapy, there is still quite limited knowledge about safe limits of THz exposure. Different modes of THz exposure of tissues and cells, including continuous-wave versus pulsed radiation, various powers, and number and duration of exposure cycles, ought to be systematically studied.

Aim: We provide an overview of recent research results in the area of biological effects at exposure of tissues and cells to THz waves.

Approach: We start with a brief overview of general features of the THz-wave-tissue interactions, as well as modern THz emitters, with an emphasis on those that are reliable for studying the biological effects of THz waves. Then, we consider three levels of biological system organization, at which the exposure effects are considered: (i) solutions of biological molecules; (ii) cultures of cells, individual cells, and cell structures; and (iii) entire organs or organisms; special attention is devoted to the cellular level. We distinguish thermal and nonthermal mechanisms of THz-wave-cell interactions and discuss a problem of adequate estimation of the THz biological effects' specificity. The problem of experimental data reproducibility, caused by rareness of the THz experimental setups and an absence of unitary protocols, is also considered.

Results: The summarized data demonstrate the current stage of the research activity and knowledge about the

THz exposure on living objects.

Conclusions: This review helps the biomedical optics community to summarize up-to-date knowledge in the area of cell exposure to THz radiation, and paves the ways for the development of THz safety standards and THz therapeutic applications.

Conclusion

Recent research results in the area of THz-wave effects on biological systems of the different organization levels, such as biomolecules, cells, and organism, were discussed. Despite the considerable data accumulated in this demanding research direction, we still possess quite limited knowledge about biological effects of THz waves. Further research and engineering efforts are required to develop adequate safe limits of THz-wave exposure and to objectively uncover strengths and weaknesses of THz technology in different branches of medial therapy. Thus, this review summarizes up-to-date knowledge in the area of cell exposure to THz radiation and paves the ways to the THz dosimetry and therapeutic avenues.

Open access paper: https://www.spiedigitallibrary.org/journals/journal-of-biomedical-optics/volume-26/issue-09/090902/Cellular-effects-of-terahertz-waves/10.1117/1.JBO.26.9.090902.full

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Numerical modelling and experimental verification of thermal effects in living cells exposed to high-power pulses of THz radiation

D S Sitnikov, A A Pronkin, I V Ilina, V A Revkova, M A Konoplyannikov, V A Kalsin, V P Baklaushev. Numerical modelling and experimental verification of thermal effects in living cells exposed to high-power pulses of THz radiation. Sci Rep. 2021 Sep 9;11(1):17916. doi: 10.1038/s41598-021-96898-0.

Abstract

Exposure of cells or biological tissues to high-power pulses of terahertz (THz) radiation leads to changes in a variety of intracellular processes. However, the role of heating effects due to strong absorption of THz radiation by water molecules still stays unclear. In this study, we performed numerical modelling in order to estimate the thermal impact on water of a single THz pulse as well as a series of THz pulses. A finite-element (FE) model that provides numerical solutions for the heat conduction equation is employed to compute the temperature increase. A simple expression for temperature estimation in the center of the spot of THz radiation is presented for given frequency and fluence of the THz pulse. It has been demonstrated that thermal effect is determined by either the average power of radiation or by the fluence of a single THz pulse depending on pulse repetition rate. Human dermal fibroblasts have been exposed to THz pulses (with an energy of [Formula: see text] and repetition rate of 100 Hz) to estimate the thermal effect. Analysis of heat shock proteins expression has demonstrated no statistically significant difference ([Formula: see text]) between control and experimental groups after 3 h of irradiation.

Open access paper: https://www.nature.com/articles/s41598-021-96898-0

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Electric field detection as floral cue in hoverfly pollination

Khan SA, Khan KA, Kubik S, Ahmad S, Ghramh HA, Ahmad A, Skalicky M, Naveed Z, Malik S, Khalofah A, Aljedani DM. Electric field detection as floral cue in hoverfly pollination. Sci Rep. 2021 Sep 21;11(1):18781. doi: 10.1038/s41598-021-98371-4.

Abstract

Pollinators can detect the color, shape, scent, and even temperature of the flowers they want to visit. Here, we present the previously unappreciated capacity of hoverflies (Eristalis tenax and Cheilosia albipila) to detect the electric field surrounding flowers. Using hoverflies as key dipteran pollinators, we explored the electrical interactions between flies and flowers-how a hoverfly acquired a charge and how their electrical sensing ability for target flowers contributed to nectar identification and pollination. This study revealed that rapid variations in a floral electric field were related to a nectar reward and increased the likelihood of the fly's return visits. We found that thoracic hairs played a role in the polarity of hoverfly charge, revealing their electro-mechanosensory capability, as in bumblebees (Bombus terrestris). Electrophysiological analysis of the hoverfly's antennae did not reveal neural sensitivity to the electric field, which favors the mechanosensory hairs as putative electroreceptive organs in both species of hoverflies.

Open access paper: https://www.nature.com/articles/s41598-021-98371-4

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Effects of mobile phone radiofrequency radiation on sperm quality (Review)

Romualdo Sciorio, Luca Tramontano, Sandro C Esteves. Effects of mobile phone radiofrequency radiation on sperm quality. Zygote. 2021 Aug 13;1-10. doi: 10.1017/S096719942100037X

Abstract

In the last decades, the universal use of mobile phones has contributed to radiofrequency electromagnetic radiation environmental pollution. The steady growth in mobile phone usage has raised concerns about the effects of phone radiation on male reproductive health. Epidemiological studies report a sharp decline in sperm counts in developing countries, and worldwide with c. 14% of couples having difficulties to conceive, many of which are attributed to a male infertility factor. Environment and lifestyle factors are known to contribute to male infertility. Exposure to heat, radiation, or radioactivity might induce damage to biological tissue organs, including the testis. Given the ubiquitous use of mobile phones, the potential adverse effects of the resulting environmental radiation needs to be elucidated further. It seems to be an apparent relationship between the increased exposure to mobile phone radiofrequency and sperm quality decline, but the evidence is not conclusive. Our review summarizes the evidence concerning the possible adverse effects of cell phone radiation on the male reproductive system, with a focus on sperm quality. Also, we critically analyze the effects of

elevated testicular temperature and oxidative stress on male fertility and how these factors could interfere with the physiological activities of the testis.

https://pubmed.ncbi.nlm.nih.gov/34384508/

Future perspectives and conclusions

The rapid technological advances in personal computers and communication devices might pose a risk for human health. Cell phone devices emit radiofrequency electromagnetic waves that seem to affect male reproductive health and other body functions (McClelland 3rd and Jaboin, 2018; Sage and Burgio, 2018; Wall et al., 2019). Although the current data are not unequivocal, it seems sound to speculate that mobile phone exposure might be contributing to subfertility. However, the existing evidence primarily relates to adverse effects on sperm motility and morphology, which are limited endpoints for evaluating the male fertility potential.

The exact mechanisms of how RF-EMR might affect the testis, epididymis, and sperm have not yet been fully understood. Additional studies are warranted, particularly prospective studies assessing sperm functional markers, such as sperm DNA integrity and OS, in fertile and subfertile men. Equally important will be to analyze whether the decreased sperm quality associated with mobile phone exposure translates into impaired pregnancy chances. The effects of short-term and long-term exposure and energy intensity should be also investigated in more detail, taking into account relevant confounders. Only then will scientific societies and regulatory bodies be able to provide users with transparent information concerning the risks and guidance for proper use.

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Threshold of radiofrequency electromagnetic field effect on human brain (review)

Hiie Hinrikus, Jaanus Lass, Maie Bachmann. Threshold of radiofrequency electromagnetic field effect on human brain. Int J Radiat Biol. 2021 Aug 17;1-38. doi: 10.1080/09553002.2021.1969055.

Abstract

Purpose: This review aims to estimate the threshold of radiofrequency electromagnetic field (RF EMF) effects on human brain based on analyses of published research results. To clarify the threshold of the RF EMF effects, two approaches have been applied: 1) the analyses of restrictions in sensitivity for different steps of the physical model of low-level RF EMF mechanism and 2) the analyses of experimental data to clarify the dependence of the RF EMF effect on exposure level based on the results of published original neurophysiological and behavioral human studies for 15 years 2007-2021.

Conclusions: The analyses of the physical model of non-thermal mechanisms of RF EMF effect leads to conclusion that no principal threshold of the effect can be determined. According to the review of experimental data, the rate of detected RF EMF effects is 76.7% in resting EEG studies, 41.7% in sleep EEG and 38.5% in

behavioral studies. The changes in EEG probably appear earlier than alterations in behavior become evident. The lowest level of RF EMF at which the effect in EEG was detected is 2.45 V/m (SAR =0.003 W/kg). There is a preliminary indication that the dependence of the effect on the level of exposure follows rather field strength than SAR alterations. However, no sufficient data are available for clarifying linearity-nonlinearity of the dependence of effect on the level of RF EMF. The finding that only part of people are sensitive to RF EMF exposure can be related to immunity to radiation or hypersensitivity. The changes in EEG caused by RF EMF appeared similar in the majority of analyzed studies and similar to these in depression. The possible causal relationship between RF EMF effect and depression among young people is highly important problem.

https://pubmed.ncbi.nlm.nih.gov/34402382/

Excerpt

Does the RF EMF has a threshold, lower of which the RF EMF does not have biological effect? This is an important question and crucial to avoid possible consequences on health.

Theoretical estimations for the sensitivity of living cells to electric field provided the threshold values about 10^{-6} - 10^{-7} V/m $Hz^{1/2}$ (Weaver and Astumian, 1990; Hinrikus et al., 1998). In the case of wide-band telecommunication technology, the threshold rises: at 1 MHz bandwidth, the sensitivity is 10^{-3} - 10^{-4} V/m. However, these estimations used a simple single cell model. Realistic model involving combinations of different cells, molecules and partly nonlinear physiological processes is highly complex. To the best of our knowledge, the calculations using complex model have been not performed.

Conclusions

The analyses of the model of the non-thermal mechanism of RF EMF effect shows that the steps of the model contain no principal threshold for the effect. Therefore, the only way to estimate the possible threshold is analyses of experimental data. The review of experimental data of human RF EMF neurophysiological effects results in following main conclusions that indicated the directions of future research:

1) The lowest field strength that has caused the effect in EEG, according to the reviewed studies, is 2.45 V/m (SAR=0.003 W/kg), close to the radio and TV broadcasting RF EMF field strength about 0.1 V/m. The future large-scale human, animal and in vitro studies are required to clarify the level and to increase the reliability of the experimentally determined threshold of RF EMF effect.

2) There is a preliminary indication that the intensity of the effect follows rather the field strength than SAR alteration. However, no sufficient data are available for clarifying regularity and linearity-nonlinearity of the relationship. The studies with systematic variations in exposure level (electric and magnetic field strengths, power density) would help to advance the field. The research from cellular to humans is needed in this direction.

3) Very limited data are available about the repair and adaptive phenomena important in the interpretation of the RF EMF effects on health. Special studies are required to clarify the mechanisms and possibilities of the repair processes.

4) The finding that only part of people are sensitive to RF EMF exposure can be related to immunity to radiation or hypersensitivity. The variability of sensitivity between people and longterm stability of the status required large-scale long-term experimental studies.

5) The indication that the changes in EEG caused by RF EMF appeared similar to these in depression need a special attention. The fast increase of depression with the highest prevalence among young individuals and more intense use of mobile telecommunication technology with prevalence in young people during the same period needs attention. The possible causal relationship between RF EMF effect and depression among young people is the problem of high importance. The methodology and large-scale investigations in this direction are required.

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Effects of Radiofrequency Electromagnetic Radiation on Neurotransmitters in the Brain

Cuicui Hu, Hongyan Zuo, Yang Li. Effects of Radiofrequency Electromagnetic Radiation on Neurotransmitters in the Brain. Frontiers in Public Health. 9:1139. 2021. doi: 10.3389/fpubh.2021.691880.

Abstract

With the rapid development of electronic information in the past 30 years, technical achievements based on electromagnetism have been widely used in various fields pertaining to human production and life. Consequently, electromagnetic radiation (EMR) has become a substantial new pollution source in modern civilization. The biological effects of EMR have attracted considerable attention worldwide. The possible interaction of EMR with human organs, especially the brain, is currently where the most attention is focused. Many studies have shown that the nervous system is an important target organ system sensitive to EMR. In recent years, an increasing number of studies have focused on the neurobiological effects of EMR, including the metabolism and transport of neurotransmitters. As messengers of synaptic transmission, neurotransmitters play critical roles in cognitive and emotional behavior. Here, the effects of EMR on the metabolism and receptors of neurotransmitters in the brain are summarized.

Open access paper: https://www.frontiersin.org/article/10.3389/fpubh.2021.691880

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The effect of exposure to radiofrequency fields on cancer risk in the general and working population: A protocol for a systematic review of human observational studies

Susanna Lagorio, Maria Blettner, Dan Baaken, Maria Feychting, Ken Karipidis, Tom Loney, Nicola Orsini, Martin Röösli, Marilia Silva Paulo, Mark Elwood. The effect of exposure to radiofrequency fields on cancer risk in the general and working population: A protocol for a systematic review of human observational studies. Environ Int. 2021 Aug 22;157:106828. doi: 10.1016/j.envint.2021.106828.

Highlights

- RF-EMF was classified by IARC as possibly carcinogenic to humans (2B) in May 2011
- A systematic review of all subject-relevant epidemiological studies is now needed.
- A detailed protocol ensures the review's transparency, utility and credibility.
- Original study validity will be evaluated with a customized OHAT risk of bias tool.
- Internal coherence and external plausibility will inform conclusions.

Abstract

Background: The World Health Organization (WHO) has an ongoing project to assess potential health effects of exposure to radiofrequency electromagnetic fields (RF-EMF) in the general and working population. Here we present the protocol for a systematic review of the scientific literature on cancer hazards from exposure to RF-EMF in humans, commissioned by the WHO as part of that project.

Objective: To assess the quality and strength of the evidence provided by human observational studies for a causal association between exposure to RF-EMF and risk of neoplastic diseases.

Eligibility criteria: We will include cohort and case-control studies investigating neoplasia risks in relation to three types of exposure to RF-EMF: near-field, head-localized, exposure from wireless phone use (SR-A); far-field, whole body, environmental exposure from fixed-site transmitters (SR-B); near/far-field occupational exposures from use of handheld transceivers or RF-emitting equipment in the workplace (SR-C). While no restriction on tumour type will be applied, we will focus on selected neoplasms of the central nervous system (brain, meninges, pituitary gland, acoustic nerve) and salivary gland tumours (SR-A); brain tumours and leukaemias (SR-B, SR-C).

Information sources: Eligible studies will be identified through Medline, Embase, and EMF-Portal.

Risk-of-bias assessment: We will use a tailored version of the OHAT's tool to evaluate the study's internal validity.

Data synthesis: We will consider separately studies on different tumours, neoplasm-specific risks from different exposure sources, and a given exposure-outcome pair in adults and children. When a quantitative synthesis of findings can be envisaged, the main aims of the meta-analysis will be to assess the strength of association and the shape of the exposure-response relationship; to quantify the degree of heterogeneity across studies; and explore the sources of inconsistency (if any). When a meta-analysis is judged inappropriate, we will perform a narrative synthesis, complemented by a structured tabulation of results and appropriate visual displays.

Evidence assessment: Confidence in evidence will be assessed in line with the GRADE approach.

Funding: This project is supported by the World Health Organization. Co-financing was provided by the New Zealand Ministry of Health; the Istituto Superiore di Sanità in its capacity as a WHO Collaborating Centre for

Radiation and Health; ARPANSA as a WHO Collaborating Centre for Radiation Protection.

Registration: PROSPERO CRD42021236798.

https://pubmed.ncbi.nlm.nih.gov/34433115/

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Effects of Radiofrequency Field exposure on male fertility & pregnancy & birth outcomes: Protocols for a systematic review of experimental studies in non-human mammals & in human sperm exposed in vitro

Francesca Pacchierotti, Lucia Ardoino, Barbara Benassi, Claudia Consales, Eugenia Cordelli,Patrizia Eleuteri, Carmela Marino, Maurizio Sciortino, Martin H.Brinkworth, Guangdi Chen, James P. McNamee, Andrew William Wood, Carlijn R. Hooijmans. Rob B.M. de Vries. Effects of Radiofrequency Electromagnetic Field (RF-EMF) exposure on male fertility and pregnancy and birth outcomes:

Protocols for a systematic review of experimental studies in non-human mammals and in human sperm exposed in vitro. Environment Intl. Volume 157, December 2021, 106806.

Highlights

- Male infertility and adverse pregnancy outcomes are relevant human health problems.
- Radiofrequency electromagnetic fields are widespread in the human environment.
- A link between radiofrequency and adverse reproductive outcomes is controversial.
- This is the protocol of WHO-funded systematic review and meta-analysis on this issue.

Abstract

Background Radiofrequency Electromagnetic Fields (RF-EMF) at environmental level have been reported to induce adverse effects on the male reproductive system and developing embryos. However, despite the number of experiments conducted since the 1970s, the diversity of testing approaches and exposure conditions, inconsistencies among results, and dosimetric flaws have not yet permitted a solid assessment of the relationship between RF-EMF exposure and such effects, warranting a more systematic and methodologically rigorous approach to the evaluation of available data.

Objectives This study aims at evaluating the effects of RF-EMF exposure on male fertility and pregnancy outcomes by a systematic review (SR) of experimental studies, conducted in compliance with international guidelines. The evidence will be organized into three streams: 1) Studies evaluating the impact of RF-EMF on the male reproductive system of experimental mammals; 2) studies evaluating the impact of RF-EMF on human sperm exposed in vitro; 3) studies evaluating the impact of RF-EMF on adverse pregnancy, birth outcomes and delayed effects in experimental mammals exposed in utero.

Study eligibility and criteria Eligible studies will include peer-reviewed articles reporting of original results about

effects of controlled exposures to RF-EMF in the frequency range 100 kHz–300 GHz on the selected outcomes without any language or year-of-publication restrictions. Eligible studies will be retrieved by calibrated search strings applied to three electronic databases, PubMed, Scopus and EMF Portal and by manual search of the list of references of included papers and published reviews.

Study appraisal and synthesis method The internal validity of the studies will be evaluated using the Risk of Bias (RoB) Rating Tool developed by National Toxicology Program/Office of Health Assessment and Translation (NTP/OHAT) integrated with input from the SYRCLE RoB tool. Given sufficient commensurate data, meta-analyses will be performed, otherwise narrative syntheses will be produced. Finally, the certainty of the effects of RF-EMF exposure on male fertility and pregnancy and birth outcomes will be established following GRADE.

Funding The study is financially supported by the World Health Organization.

Registration OSF Registration DOI https://doi.org/10.17605/OSF.IO/7MUS3; PROSPERO CRD42021227729, CRD42021227746.

https://www.sciencedirect.com/science/article/pii/S0160412021004311

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The effects of radiofrequency electromagnetic fields exposure on tinnitus, migraine and non-specific symptoms in the general and working population: A protocol for a systematic review on human observational studies

Martin Röösli, Stefan Dongus, Hamed Jalilian, Maria Feychting, John Eyers, Ekpereonne Esu, Chioma Moses Oringanje, Martin Meremikwu, Xavier Bosch-Capblanch. The effects of radiofrequency electromagnetic fields exposure on tinnitus, migraine and non-specific symptoms in the general and working population: A protocol for a systematic review on human observational studies. Environment International, Volume 157, 2021. doi: 10.1016/j.envint.2021.106852.

Highlights

- There is public concern to develop non-specific symptoms from EMF.
- No up to date comprehensive systematic review is available.
- Priority outcomes for head exposure are tinnitus, migraine, and headaches.
- Further priority outcomes are sleep disturbances and composite symptom scores.

Abstract

Background Applications emitting radiofrequency electromagnetic fields (RF-EMF; 100 kHz to 300 GHz) are widely used for communication (e.g. mobile phones), in medicine (diathermy) and in industry (RF heaters). Concern has been raised that RF-EMF exposure affects health related quality of life, because a part of the

population reports to experience a variety of symptoms related to low exposure levels below regulatory limits.

Objectives To systematically review the effects of longer-term or repeated local and whole human body RF-EMF exposure on the occurrence of symptoms evaluating migraine, tinnitus, headaches, sleep disturbances and composite symptom scores as primary outcomes.

Methods We will follow the WHO handbook for guideline development. For the development of the systematic review protocol we considered handbook for conducting systematic reviews for health effects evaluations from the National Toxicology Program-Office of Health Assessment and Translation (NTP-OHAT) and COSTER (Recommendations for the conduct of systematic reviews in toxicology and environmental health research).

Eligibility criteria Peer-reviewed epidemiological studies in the general population or workers aiming to investigate the association between local or whole-body RF-EMF exposure for at least one week and symptoms are eligible for inclusion. Only cohort, case-control and panel studies will be included.

Information sources We will search the scientific literature databases Medline, Web of Science, PsycInfo, Cochrane Library, Epistemonikos and Embase, using a predefined search strategy. This search will be supplemented by a search in the EMF-Portal and checks of reference lists of relevant papers and reviews.

Study appraisal and synthesis method Data from included papers will be extracted according to predefined forms. Findings will be summarized in tables, graphical displays and in a narrative synthesis of the available evidence, complemented with meta-analyses. We will separately review effects of local, far field and occupational exposure.

Risk of bias The internal validity of included studies will be assessed using the NTP-OHAT Risk of Bias Rating Tool for Human and Animal Studies, elaborated to observational RF-EMF studies.

Evidence appraisal To rate certainty of the evidence, we will use the OHAT GRADE-based approach for epidemiological studies.

Framework and funding This protocol concerns one of the ten different systematic reviews considered in a larger systematic review of the World Health Organization to assess potential health effects of exposure to RF-EMF in the general and working population.

Registration PROSPERO CRD42021239432.

Open access paper: https://www.sciencedirect.com/science/article/pii/S0160412021004773?via%3Dihub

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More Reliable Bioeffects Studies at “High Band” 5G Frequencies

Kenneth R Foster, Vijayalaxmi. More Reliable Bioeffects Studies at “High Band” 5G Frequencies. Frontiers in Communications and Networks. 2:39. 2021. doi:10.3389/frcmn.2021.721925.

Abstract

One major source of controversy related to possible health effects of radiofrequency radiation (RFR) is the large number of reported statistically significant effects of exposure, over the entire RF part of the spectrum and over a wide range of exposure levels, even as health agencies do not find clear evidence for health hazards of exposure at levels within current IEEE and ICNIRP exposure limits. This Perspective considers 31 studies related to genetic damage produced by exposure to RFR at frequencies above 6 GHz, including at millimeter-wave (mm-wave) frequencies. Collectively, the papers report many statistically significant effects related to genetic damage, many at exposure levels below current exposure limits. However, application of five risk of bias (RoB) criteria and other considerations suggest that the studies in many cases are vulnerable to false discovery (nonreplicable results). The authors call for improvements in study design, analysis and reporting in future bioeffects research to provide more reliable information for health agencies and regulatory decision makers. This Perspective is a companion to another Perspective by Mattsson et al. elsewhere in this volume (Mattsson et al., 2021).

Conflict of interest

KF has received minor support for research on an unrelated topic (thermal dosimetry) by Microwave and Wireless Forum, an industry group.

The remaining author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Open access paper: https://www.frontiersin.org/article/10.3389/frcmn.2021.721925

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Dosimetry of Various Human Bodies Exposed to Microwave Broadband Electromagnetic Pulses

Jerdvisanop Chakarothai, Wake Kanako, Fujii Katsumi. Dosimetry of Various Human Bodies Exposed to Microwave Broadband Electromagnetic Pulses. Frontiers in Public Health. 9:1182. 2021. doi:10.3389/fpubh.2021.725310.

Abstract

In this paper, human exposures to ultra-wideband (UWB) electromagnetic (EM) pulses in the microwave region are assessed using a frequency-dependent FDTD scheme previously proposed by the authors. Complex permittivity functions of all biological tissues used in the numerical analyses are accurately expressed by the four-term Cole–Cole model. In our method, we apply the fast inverse Laplace transform to determine the time-domain impulse response, utilize the Prony method to find the Z-domain representation, and extract residues

and poles for use in the FDTD formulation. Update equations for the electric field are then derived via the Z-transformation. Firstly, we perform reflection and transmission analyses of a multilayer composed of six different biological tissues and then confirm the validity of the proposed method by comparison with analytical results. Finally, numerical dosimetry of various human bodies exposed to EM pulses from the front in the microwave frequency range is performed, and the specific energy absorption is evaluated and compared with that prescribed in international guidelines.

Conclusion

We have performed numerical dosimetry on human bodies illuminated by an EM pulse from the front by using the $(FD)^2TD$ method, previously proposed by the authors. The method fully considers broadband characteristics of the complex relative permittivity of the biological media used in the analysis model via the application of the FILT and the Prony method. Firstly, we demonstrated the validity of the update coefficients, i.e., the residues and poles of the expression for the IIR in the z-domain, by comparing the numerical reflection coefficients with those derived from the EM theory. It was clarified that the numerical results within 2% of those obtained theoretically over a broad frequency range from 50 MHz to 10 GHz, demonstrating the validity of the proposed approach. It was also found that the transmission characteristics of the EM pulse into the CSF layer of a multilayer mimicking a human head are almost flat over a frequency range between 300 and 800 MHz and that the transmission decreases with increasing EM traveling distance from the skin boundary due to higher energy absorption at superficial biological tissues such as “Skin” and “Fat” when the frequency is higher than 1 GHz. Therefore, most of the pulse energy that penetrates into the biological body has a frequency below 1 GHz. Then, numerical dosimetry of various human models exposed to an EM pulse having a frequency component of up to ~1.3 GHz was performed. The whole-body average SAR at 24 frequencies was determined by a single run of broadband FDTD simulations. The results matched those published in the literature, demonstrating the validity and availability of the proposed FDTD method. Then the SA distribution of each numerical model was determined, and it was found that the maximum SA occurs at the hands and neck for the ungrounded model, while they appear at the hands and ankle when the model is grounded. The maximum SA value was 0.290 pJ/kg for an incident electric field strength of 1 V/m or 0.437 nJ/kg for an incident power density of 2 W/m^2. It has been shown for the first time that, by using our proposed FDTD approach with the FILT and the Prony method, we can obtain quantitatively detailed information on SA that can be compared with the limits prescribed in international guidelines or standards.

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Simultaneous exposure to electromagnetic field from mobile phone and unimpeded fructose drinking during pre-, peri-, and post-pubertal stages perturbs the hypothalamic and hepatic regulation of energy homeostasis by early adulthood: experimental evidence

Ruchi Tripathi, Sanjay Kumar Banerjee, Jay Prakash Nirala, Rajani Mathur. Simultaneous exposure to electromagnetic field from mobile phone and unimpeded fructose drinking during pre-, peri-, and post-pubertal stages perturbs the hypothalamic and hepatic regulation of energy homeostasis by early adulthood: experimental evidence. Environ Sci Pollut Res Int. 2021 Sep 2. doi: 10.1007/s11356-021-15841-y.

Abstract

The present-day children-adolescents ubiquitously use the mobile phones and unrestrictedly consume fructose-laden diet. Unfortunately, a rise in the incidence of insulin resistance and fatty liver syndrome in young adults has also been recorded. To delineate a possible correlate, the effect of exposure to electromagnetic field (EMF) from the mobile phone and unrestricted fructose intake during pre-, peri-, and post-pubertal stages of development on orexigenic and anorexigenic signals arising from the hypothalamus and liver of rats is investigated here. The study design included four arms, i.e., "Normal", "Exposure Only (ExpO)", "Fructose Only (FruO)", and "Exposure with Fructose (EF)", wherein weaned rats received either "normal chow and drinking water" or "normal chow and fructose (15%) drinking solution" in presence and absence of EMF exposure (2 h/day) for 8 weeks. The results indicate that the total calories consumed by the EF were higher by early adulthood than normal, possibly under the influence of the raised levels of the orexigenic hormone, i.e., ghrelin, and it reflected as raised rate of weight gain. At early adulthood, the EF recorded mitigated response and sensitivity of insulin. Despite EF being a "fed-state", both centrally and peripherally, the glycolysis was restrained, but the gluconeogenesis was raised. Additionally, the altered lipid profile and the glycogen levels indicate that the EF developed fatty liver. The energy homeostasis of the EF was compromised as evidenced by (a) reduced expression of the glucosensors-GLUT2 and glucokinase in the hypothalamus and liver and (b) reduced expression of the cellular energy regulator-AMPK, orexigenic peptide-NPY, and anorexigenic peptide-POMC in the hypothalamus. Taken together, the present study evidences that the exposure to EMFfrom the mobile phone and unrestricted fructose intake during childhood-adolescence impairs the central and peripheral pathways that mediate the glucosensing, glucoregulation, feeding, and satiety behavior by early adulthood.

https://pubmed.ncbi.nlm.nih.gov/34476698/

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Oxidative damage in the liver and brain of the rats exposed to frequency-dependent radiofrequency electromagnetic exposure: Biochemical and histopathological evidence

Anjali Sharma, Sadhana Shrivastava, Sangeeta Shukla. Oxidative damage in the liver and brain of the rats exposed to frequency-dependent radiofrequency electromagnetic exposure: Biochemical and histopathological evidence. Free Radic Res. 2021 Aug 17;1-30. doi: 10.1080/10715762.2021.1966001.

Highlights

• EMR exposure showed frequency-dependent toxicity.
• Alterations in blood profile and modifications in the serological markers.
• Increasing lipid peroxidation indicating membrane damage.
• Inhibition of acetylcholinesterase activity affecting cholinergic neurotransmission.
• EMR exposure resulted in the loss of cellular energy and production of excess amounts of ROS thereby altering several antioxidant enzymes.
• Histopathological evidence of severe degenerative changes in the liver and brain.

Abstract

The study aimed to discover a link between the liver and brain's functional status due to frequency dependent-radiofrequency electromagnetic radiation (RF-EMR).

40 Wistar rats were randomly classified as control (sham-exposed) and EMR exposed groups. Animals were exposed to 900, 1800, and 2100 MHz with the specific absorption rate (SAR) 0.434 (W/Kg), 0.433 (W/Kg), and 0.453 (W/Kg) respectively. Animal exposure was limited at 1 hour/day, 5 days/week for 1 month with a restricted power density (900 MHz- 11.638μW/m2, 1800- 11.438 μW/m2 and 2100 MHz frequency- 8.237 μW/m2).

Exposure at various frequencies showed a frequency-dependent change in the body weight and hematologic parameters (RBCs, WBCs, platelets, hemoglobin, and hematocrit) as compared with the control group ($P \leq 0.01$)($P \leq 0.001$). A significant elevation in serum transaminases and bilirubin, urea, uric acid, and creatinine was noted, whereas albumin significantly decreased after EMR exposure ($P \leq 0.01$)($P \leq 0.001$). The blood glucose, lipid peroxidation, triglycerides, and cholesterol were elevated while adenosine triphosphatases, acetylcholinesterase, and tissue antioxidants such as glutathione, superoxide dismutase, catalase, glutathione reductase, glutathione Peroxidase, glutathione-S-transferase, and glucose-6-phosphate dehydrogenases were decreased significantly ($P \leq 0.001$). Histopathological observations of the liver showed centrilobular mononuclear cell infiltration and swelling in sinusoidal spaces, while in the brain degenerated pyramidal and Purkinje neurons were seen. Furthermore, Substantial evidence was found that the brain is more susceptible to oxidative mutilation compared to the liver of exposed animals.

In conclusion, RF-EMR exposure showed oxidative damage to the liver, increasing the incidence of brain damage in a frequency-dependent manner.

Highlights EMR exposure showed frequency-dependent toxicity.Alterations in blood profile and modifications in the serological markers.Increasing lipid peroxidation indicating membrane damage.Inhibition of acetylcholinesterase activity affecting cholinergic neurotransmission.EMR exposure resulted in the loss of cellular energy and production of excess amounts of ROS thereby altering several antioxidant enzymes.Histopathological evidence of severe degenerative changes in the liver and brain.

https://pubmed.ncbi.nlm.nih.gov/34404322/

Conclusion

Our findings documented that the frequency of EMR exposure is a significant factor associated with its toxicity, the extent of toxicity is increased with a simultaneous increase in the frequency of exposure. In addition, this study confirms that EMR exposure initiates hepatic and neural injury, but the potency of damage was more prominent in the brain.Our results will provide support for future studies in the analysis of electromagnetic radiation and its associated systemic injury.

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900 MHz Radiofrequency Field Induces Mitochondrial Unfolded Protein Response in Mouse Bone Marrow Stem Cells

Xie Wen, Xu Rui, Fan Caiyun, Yang Chunyu, Chen Haiyan, Cao Yi. 900 MHz Radiofrequency Field Induces Mitochondrial Unfolded Protein Response in Mouse Bone Marrow Stem Cells. Frontiers in Public Health. 9:1265. 2021. doi: 10.3389/fpubh.2021.724239

Abstract

Objective: To examine whether exposure of mouse bone marrow stromal cells (BMSC) to 900 MHz radiofrequency fields used in mobile communication devices can induce mitochondrial unfolded protein response (UPR^{mt}).Methods: BMSCs were exposed to continuous wave 900 MHz radiofrequency fields (RF) at 120 μW/cm² power intensity for 4 h/d for 5 consecutive days. Cells in sham group (SH) were cultured in RF exposure system, but without RF radiation. The positive control cells were irradiated with 6 Gy X-ray at a dose rate of 1.103 Gy/min (XR). To inhibit the upstream molecular JNK2 of UPR^{mt}, cells in siRNA + RF, and siRNA + XR group were also pretreated with 100 nM siRNA-JNK2 for 48 h before RF/XR exposure. Thirty minutes, 4 h, and 24 h post-RF/XR exposure, cells were collected, the level of ROS was measured with flow cytometry, the expression levels of UPR^{mt}-related proteins were detected using western blot analysis.Results: Compared with Sham group, the level of ROS in RF and XR group was significantly increased 30 min and 4 h post-RF/XR exposure ($P < 0.05$), however, the RF/XR-induced increase of ROS level reversed 24 h post-RF/XR exposure. Compared with Sham group, the expression levels of HSP10/HSP60/ClpP proteins in cells of RF and XR group increased significantly 30 min and 4 h post-RF/XR exposure ($P < 0.05$), however, the RF/XR-induced increase of HSP10/HSP60/ClpP protein levels reversed 24 h post-RF exposure. After interfering with siRNA-JNK2, the RF/XR exposures could not induce the increase of HSP10/HSP60/ClpP protein levels any more.Conclusions: The exposure of 900 MHz RF at 120 μW/cm² power flux density could increase ROS level and activate a transient UPR^{mt} in BMSC cells. Mitochondrial homeostasis in term of protein folding ability is restored 24 h post-RF exposure. Exposure to RF in our experimental condition did not cause permanent and severe mitochondrial dysfunctions. However, the detailed underlying molecular mechanism of RF-induced UPR^{mt} remains to be further studied.

Open access paper: https://www.frontiersin.org/article/10.3389/fpubh.2021.724239

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Effects of Microwave 10 GHz Radiation Exposure in the Skin of Rats: An Insight on Molecular Responses

Saurabh Verma, Gaurav K Keshri, Santanu Karmakar, Kumar Vyonkesh Mani, Satish Chauhan, Anju Yadav, Manish Sharma, Asheesh Gupta. Effects of Microwave 10 GHz Radiation Exposure in the Skin of Rats: An Insight on Molecular Responses. Radiat Res. 2021 Aug 18. doi: 10.1667/RADE-20-00155.1.

Abstract

Microwave (MW) radiation poses the risk of potential hazards on human health. The present study investigated the effects of MW 10 GHz exposure for 3 h/day for 30 days at power densities of 5.23 ± 0.25 and 10.01 ± 0.15 mW/cm2 in the skin of rats. The animals exposed to 10 mW/cm2 (corresponded to twice the ICNIRP-2020

occupational reference level of MW exposure for humans) exhibited significant biophysical, biochemical, molecular and histological alterations compared to sham-irradiated animals. Infrared thermography revealed an increase in average skin surface temperature by 1.8°C and standard deviation of 0.3°C after 30 days of 10 mW/cm2 MW exposure compared to the sham-irradiated animals. MW exposure also led to oxidative stress (ROS, 4-HNE, LPO, AOPP), inflammatory responses (NFkB, iNOS/NOS2, COX-2) and metabolic alterations [hexokinase (HK), lactate dehydrogenase (LDH), citrate synthase (CS) and glucose-6-phospahte dehydrogenase (G6PD)] in 10 mW/cm2 irradiated rat skin. A significant alteration in expression of markers associated with cell survival (Akt/PKB) and HSP27/p38MAPK-related stress-response signaling cascade was observed in 10 mW/cm2 irradiated rat skin compared to sham-irradiated rat skin. However, MW-irradiated groups did not show apoptosis, evident by unchanged caspase-3 levels. Histopathological analysis revealed a mild cytoarchitectural alteration in epidermal layer and slight aggregation of leukocytes in 10 mW/cm2 irradiated rat skin. Altogether, the present findings demonstrated that 10 GHz exposure in continuous-wave mode at 10 mW/cm2 (3 h/day, 30 days) led to significant alterations in molecular markers associated with adaptive stress-response in rat skin. Furthermore, systematic scientific studies on more prevalent pulsed-mode of MW-radiation exposure for prolonged duration are warranted.

https://pubmed.ncbi.nlm.nih.gov/34407201/

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High Power Electromagnetic Waves Exposure of Healthy and Tumor Bearing Mice: Assessment of Effects on Mice Growth, Behavior, Tumor Growth, and Vessel Permeabilization

Kolosnjaj-Tabi J, Golzio M, Bellard E, Catrain A, Chretiennot T, Saurin Q, Tarayre J, Vezinet R, Rols MP. High Power Electromagnetic Waves Exposure of Healthy and Tumor Bearing Mice: Assessment of Effects on Mice Growth, Behavior, Tumor Growth, and Vessel Permeabilization. Int J Mol Sci. 2021 Aug 7;22(16):8516. doi: 10.3390/ijms22168516.

Abstract

High power radiofrequencies may transiently or permanently disrupt the functioning of electronic devices, but their effect on living systems remains unknown. With the aim to evaluate the safety and biological effects of narrow-band and wide-band high-power electromagnetic (HPEM) waves, we studied their effects upon exposure of healthy and tumor-bearing mice. In field experiments, the exposure to 1.5 GHz narrow-band electromagnetic fields with the incident amplitude peak value level in the range of 40 kV/m and 150 MHz wide-band electric fields with the amplitude peak value in the range of 200 kV/m, did not alter healthy and tumor-bearing animals' growth, nor it had any impact on cutaneous murine tumors' growth. While we did not observe any noticeable behavioral changes in mice during the exposure to narrow-band signals when wide-band HPEM signals were applied, mice could behave in a similar way as they respond to loud noise signals: namely, if a mouse was exploring the cage prior to signal application, it returned to companion mates when wide-band HPEM signals were applied. Moreover, the effect of wide-band signals was assessed on normal blood vessels permeability in real-time in dorsal-chamber-bearing mice exposed in a pilot study using wide-band signal applicators. Our pilot study conducted within the applicator and performed at the laboratory scale suggests that the exposure to wide-band signals with the amplitude of 47.5 kV/m does not result in increased vessel permeability.

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Health effects of WiFi radiation: a review based on systematic quality evaluation

Stefan Dongus, Hamed Jalilian, David Schürmann & Martin Röösli (2021) Health effects of WiFi radiation: a review based on systematic quality evaluation, Critical Reviews in Environmental Science and Technology, DOI: 10.1080/10643389.2021.1951549

Abstract

Although WiFi contributes little to total radiofrequency electromagnetic field (RF-EMF) exposure in our everyday environment, concern has raised whether this specific type of modulated RF-EMF causes health problems. The aim of this review is to evaluate all types of studies that investigated biological and health effects of WiFi exposure and fulfilled basic quality criteria. Eligible for inclusion were epidemiological, human experimental, in vivo and in vitro studies using realistic WiFi exposure settings. We conducted a systematic literature search for all papers published between January 1997 and August 2020 followed by a quality review addressing blinding and dosimetry in experimental studies and various types of biases in epidemiological studies. All studies fulfilling the quality criteria were descriptively summarized in terms of observation or absence of associations. From 1385 articles identified by the literature search, 23 fulfilled basic quality criteria: 6 epidemiological papers, 6 human experimental articles, 9 in vivo articles, and 2 in vitro articles. Whereas in vivo and in vitro studies applied exposure levels up to 4 W/kg, human studies dealt with exposure levels several orders of magnitude below the ICNIRP guidelines, which are typical for WiFi exposure situations in the everyday environment. Numerous outcomes ranging from biological markers to symptoms were mostly found not to be associated with WiFi exposure. Sporadic findings were not consistent in terms of outcomes or exposure-response associations. This review based on a systematic literature search and quality evaluation does not suggest detrimental health effects from WiFi exposure below regulatory limits.

https://doi.org/10.1080/10643389.2021.1951549

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'Proof of EHS beyond all reasonable doubt'

Michael Bevington. 'Proof of EHS beyond all reasonable doubt'. Comment on: Leszczynski D. Review of the scientific evidence on the individual sensitivity to electromagnetic fields (EHS). Rev Environ Health 2021; doi: 10.1515/reveh-2021-0038. *Reviews on Environmental Health*, vol. , no. , 2021, pp. 000010151520210101. https://doi.org/10.1515/reveh-2021-0101

No abstract

Open access letter: https://www.degruyter.com/document/doi/10.1515/reveh-2021-0101/html

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Pooled analysis of recent studies of magnetic fields and childhood leukemia

Aryana T. Amoon, John Swanson, Corrado Magnani, Christoffer Johansen, Leeka Kheifets. Pooled analysis of recent studies of magnetic fields and childhood leukemia. Environmental Research, 2021, 111993, doi: 10.1016/j.envres.2021.111993.

Highlights

• No association in recent studies between magnetic fields and childhood leukemia.
• Current results are not in line with previous pooled analyses.
• A small elevated risk for the aggregate evidence remains.

Abstract

Background Over forty epidemiologic studies have addressed an association between measured or calculated extremely-low-frequency magnetic fields (MF) and childhood leukemia. These studies have been aggregated in a series of pooled analyses, but it has been 10 years since the last such.

Methods We present a pooled analysis combining individual-level data (24,994 cases, 30,769 controls) from four recent studies on MF and childhood leukemia.

Results Unlike previous pooled analyses, we found no increased risk of leukemia among children exposed to greater MF: odds ratio (OR) = 1.01, for exposure ≥0.4 μT (μT) compared with exposures <0.1 μT. Similarly, no association was observed in the subset of acute lymphoblastic leukemia, birth homes, studies using calculated fields, or when geocoding accuracy was ignored. In these studies, there is a decline in risk over time, also evident when we compare three pooled analyses. A meta-analysis of the three pooled analyses overall presents an OR of 1.45 (95% CI: 0.95–2.20) for exposures ≥0.4 μT.

Conclusions Our results are not in line with previous pooled analysis and show a decrease in effect to no association between MF and childhood leukemia. This could be due to methodological issues, random chance, or a true finding of disappearing effect.

https://pubmed.ncbi.nlm.nih.gov/34481821/

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Human detection thresholds of DC, AC, and hybrid electric fields: a double-blind study

Michael Kursawe, Dominik Stunder, Thomas Krampert, Andrea Kaifie, Sarah Drießen, Thomas Kraus, Kathrin Jankowiak. Human detection thresholds of DC, AC, and hybrid electric fields: a double-blind study. Environ Health. 2021 Aug 21;20(1):92. doi: 10.1186/s12940-021-00781-4.

Abstract

Background: In the course of the ongoing transition of electric energy systems, transmission corridors are often upgraded to higher voltages and other technologies leading to another quality of human exposure. The study aims to determine human detection thresholds for direct current (DC), alternating current (AC), and hybrid electric fields (various DC; constant AC).

Methods: A total of 203 participants were exposed to DC, AC, and hybrid electric fields (EFs) in a highly specialized whole-body exposure laboratory using a double-blind experimental setting. Additionally, the participants were exposed to ion currents in part of the DC and hybrid sessions. To investigate environmental influences, relative humidity was changed in two subgroups during EF perception. Methods derived from the signal detection theory and the adaptive staircase procedure based on the single interval adjustment matrix were used to assess individual sensitivity and detection thresholds, respectively.

Results: The results indicated that detection thresholds of hybrid EF were lower compared to single EF presentation of DC or AC. Ion current exposure enhanced EF perception. High relative humidity facilitated DC EF perception, whereas low relative humidity reinforced the perception of AC EFs.

Conclusions: With this systematic investigation of human perception of DC, AC, and hybrid EFs, detection thresholds were provided, which can help improve the construction processes of energy transmission systems and the prevention of unwanted sensory perception by contributing to the determination of limit values.

Conclusion

This study is the first systematic investigation of hybrid EF perception in humans using a double-blind experimental setup. While detection thresholds of DC and AC EF were lower compared to previous studies, the synergistic effect of both field types on human perception was shown. Especially, in the minimal hybrid EF combination (2 kV/m DC and 4 kV/m AC), 40% of the participants were able to successfully detect the EF. In terms of unwanted sensory perception, this should be considered in the discussion on reference levels and recommendations for hybrid EFs, which current remain non-existent. Furthermore, we suggest a further investigation on low hybrid EFs in detail to obtain a fine-grained picture of the lower bound of human EF perception. Although the average detection thresholds do not undercut the existing reference levels for DC and AC EFs, the study found evidence for successful EF perception around these reference levels in a small subset of participants. As the reference levels were mainly designed to prevent adverse health effects during EF exposure [14, 16], the current results do not question these values. Furthermore, the findings can be utilized in the discussion on whether sensory perception, as a byproduct of EF exposure, is acceptable.

We enhanced the external validity of the results by investigating subgroups across different levels of relative humidity. Hints for an enhanced perception of DC EF in a high-humidity environment and a facilitated AC perception under low-humidity conditions were confirmed. These results may further contribute to the understanding of the underlying mechanisms and should be considered as well in the discussion on recommendations for EF exposure. Thus, this study provided reliable EF detection thresholds that add

quantitative information on sensory perception to the discourse on the impact of EF exposure. In this manner, it can help to improve the construction processes of planned HVDC and hybrid overhead power lines.

Open access paper: https://ehjournal.biomedcentral.com/articles/10.1186/s12940-021-00781-4

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Effects of Wi-Fi Radiofrequency Radiation on Carbapenem-Resistant Klebsiella pneumoniae

Ilham Said-Salman, Wissam Yassine, Ali Rammal, Mohammad Hneino, Hoda Yusef, Mohamed Moustafa. Effects of Wi-Fi Radiofrequency Radiation on Carbapenem-Resistant Klebsiella pneumoniae. Bioelectromagnetics. 2021 Aug 1. doi: 10.1002/bem.22364.

Abstract

The hazardous consequences of electromagnetic field (EMF) exposure represent a public health concern. Common sources of EMF include smartphones and wireless fidelity (Wi-Fi). The aim of our study is to assess whether exposure to Wi-Fi radiofrequency radiation influences the pathogenic traits of carbapenem-resistant Klebsiella pneumoniae. The susceptibility to antibiotics was evaluated by the determination of minimum inhibitory concentrations (MIC). In this study, K. pneumoniae showed a non-linear response to treatments with Colistin and Gentamycin following different Wi-Fi exposure periods. Transmission electron microscopy revealed morphological changes in the bacterial cell membrane within 24 h of Wi-Fi exposure. Crystal violet quantification and quantitative real-time polymerase chain reaction showed that the ability to form biofilms was greater in Wi-Fi exposed K. pnemoniae when compared to control. Moreover, higher levels of bcsA, mrkA, and luxS messenger RNAs were observed. Our data suggest that Wi-Fi exposure can influence bacteria in a stressful way, leading to an alteration in their antibiotic susceptibility, morphological changes, and cumulative biofilm formation.

https://pubmed.ncbi.nlm.nih.gov/34337771/

Excerpts

"Several opportunistic bacterial pathogens with multidrug resistance were identified in the area of telecommunication stations [Adebayo et al., 2015]. Research in this area seems to be of big interest and mandatory in order to improve the measures of protection assessment against the occurrence of antibiotic-resistant organisms in the environment."

"We measured a constant field of 6 V/m at the position of the exposed sample corresponding to a power flux density of 0.05 W/m2. The influence of the exposure to Wi-Fi waves was investigated, and the protocol consisted of continuous radiation expositions for different periods (1, 5, 10, 20, 24, and 48 h). A control measurement was done for each experimental condition in a Faraday bag at an identical temperature to avoid any external radiation."

"K. pneumonia is a rod-shaped Gram-negative opportunistic pathogenic bacterium causing nosocomial infections. K. pneumonia has emerged in recent years with enhanced virulence. K. pneumoniae carbapenemase

(KPC) is the main enzymatic resistance mechanism used by K. pneumoniae against antibiotics [Wang et al., 2011]. Carbapenem-resistant K. pneumoniae carries the blaKPC gene which confers resistance to carbapenem antibiotics. Bacterial virulence factors such as antimicrobial resistance (AMR) and biofilm formation play key roles in infection settlement. The World Health Organization (WHO) stated that AMR is a “global health crisis” [WHO, 2018]."

"In summary, exposure of K. pneumoniae to 2.4 GHz Wi-Fi radiofrequency radiation affected the pathogenic traits of multidrug-resistant bacteria. There was a nonlinear response of K. pneumoniae to Colistin and Gentamycin antibiotics after Wi-Fi pre-exposure. The 24 h exposure period to Wi-Fi radiation disrupted the cell membrane and disintegrated its protoplasm. In addition, the transcription of representative genes implicated in biofilm formation and quorum sensing in K. pneumoniae was upregulated due to Wi-Fi exposure.

The different bacterial responses to EMF observed among reported studies may result from the differences found in cell wall composition between Gram-positive and Gram-negative bacteria as well as the duration and type of the radiation. Low and continuous far-field exposure such as Wi-Fi may cause unexpected antibiotic resistance in the future. Under stress, bacteria tend to regulate their membrane properties through homeostasis by altering the lipid composition, thus resulting in higher permeability [Zhang and Rock, 2008]. While there might be a modification in membrane permeability by such low fields, allowing increased susceptibility to antibiotics, it is not, however, sufficient to induce cell death. Thus, bacteria are more easily affected by lower doses of antibiotics in the environment. Further molecular experiments at gene and protein levels are required for understanding more details on the mechanisms by which these biological changes are taking place in bacteria following exposure to Wi-Fi radiation. Considering the impact of EMF on bacteria is an essential approach for controlling public health threats and may be beneficial for medical applications."

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Medicinal plants in mitigating electromagnetic radiation-induced neuronal damage: a concise review

Raghu SV, Kudva AK, Rajanikant GK, Baliga MS. Medicinal plants in mitigating electromagnetic radiation-induced neuronal damage: a concise review. Electromagn Biol Med. 2021 Aug 12:1-14. doi: 10.1080/15368378.2021.1963762.

Abstract

Although the evidence is inconclusive, epidemiological studies strongly suggest that increased exposure to electromagnetic radiation (EMR) increases the risk of brain tumors, parotid gland tumors, and seminoma. The International Agency for Research on Cancer (IARC) has classified mobile phone radiofrequency radiation as possibly carcinogenic to humans (Group 2B). Humans being are inadvertently being exposed to EMR as its prevalence increases, mainly through mobile phones. Radiation exposure is unavoidable in the current context, with mobile phones being an inevitable necessity. Prudent usage of medicinal plants with a long history of mention in traditional and folklore medicine and, more importantly, are safe, inexpensive, and easily acceptable for long-term human use would be an appealing and viable option for mitigating the deleterious effects of EMR. Plants with free radical scavenging, anti-oxidant and immunomodulatory properties are beneficial in maintaining salubrious health. Green tea polyphenols, *Ginkgo biloba*, lotus seedpod procyanidins, garlic extract, *Loranthus longiflorus, Curcuma amada*, and *Rosmarinus officinalis* have all been shown to confer neuroprotective effects in

validated experimental models of study. The purpose of this review is to compile for the first time the protective effects of these plants against mobile phone-induced neuronal damage, as well as to highlight the various mechanisms of action that are elicited to invoke the beneficial effects.

https://pubmed.ncbi.nlm.nih.gov/34382485/

Conclusions

Recent research suggests green tea polyphenols, *Ginkgo biloba*, lotus seedpod procyanidins, garlic extract, *Loranthus longiflorus, Curcuma amada*, and *Rosmarinus officinalis* may be beneficial in preventing EMR-induced brain damage.The brain-protective effects of these plants are thought to be mediated by a variety of mechanisms, including scavenging of radiation-induced free radicals, increased cellular anti-oxidant status, inhibition of neuronal apoptosis, and improved neurobehavioral outcomes. Given the increasing prevalence of intentional and unintentional EMR exposure in daily life, more comprehensive cell culture, animal, and clinical studies using pharmacologically validated models that incorporate multiple biochemical, physiological, pathological, and neurobehavioral end points are required.Such studies will be highly beneficial because these agents have been validated for various health benefits and are known to improve/maintain general health; if they are also protective against EMR-induced damage in multiple studies, they will be extremely useful to both the scientific fraternity and society at large.The most important factors to consider when starting clinical studies are that these medicinal plants have been used since antiquity, are non-toxic, have a wide range of medicinal properties, and are easily acceptable for human use. Green tea polyphenols could be particularly useful because it is one of the most widely consumed beverages, has a wide range of medicinal applications, and is a relatively non-toxic agent with widespread acceptance. According to data from various clinical trial registries, green tea is being studied at various stages (phases 1 to 4) in humans for various ailments.A well-designed study aimed at collecting secondary endpoints with a checklist for daily mobile phone use in volunteers enrolled in clinical trials will be a cost- and time-effective way to validate the neuroprotective effects of medicinal plants against EMR-induced damage.

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Microarray profiling of LncRNA expression in the testis of pubertal mice following morning and evening exposure to 1800 MHz radiofrequency fields

Qin F, Cao H, Feng C, Zhu T, Zhu B, Zhang J, Tong J, Pei H. Microarray profiling of LncRNA expression in the testis of pubertal mice following morning and evening exposure to 1800 MHz radiofrequency fields. Chronobiol Int. 2021 Aug 8:1-16. doi: 10.1080/07420528.2021.1962902.

Abstract

In this paper, the chronotoxicity of radiofrequency fields (RF) in the pubertal testis development and the involved molecular pathways were investigated by exposing four-week-old mice to RF (1800 MHz, SAR, 0.50 W/kg) in the morning and evening of each day for three weeks. Then, pathological changes and functional indices within the testis were determined. We also used a long non-coding RNA (lncRNA) microarray and GO/KEGG pathway analyses to determine lncRNA expression profiles and predict their potential functions. The cis and trans regulation of lncRNAs were investigated, and an interaction network was constructed using Cytoscape software. RF exposure led to a range of pathological changes in the testes of adolescent mice, as testicular weights and daily sperm productions decreased, and the testosterone secretion reduced.

Furthermore, RF induced dysregulation in the expression of testicular lncRNAs. We identified 615 and 183 differentially expressed lncRNAs that were associated with morning and evening exposure to RF, respectively. From 15 differential expression lncRNAs both in morning RF group and evening RF group, we selected 6 lncRNAs to be validated by quantitative reverse transcription PCR (qRT-PCR). The differentially expressed lncRNAs induced by morning RF exposure were highly correlated with many different pathways, including Fanconi syndrome, metabolic processes, cell cycle, DNA damage, and DNA replication. Trans-regulation analyses further showed that differentially expressed lncRNAs were involved in multiple transcription factor-regulated pathways, such as TCFAP4, NFkB, HINFP, TFDP2, FoxN1, and PAX5. These transcription factors have all been shown to be involved in the modulation of testis development, cell cycle progression, and spermatogenesis. These findings suggest that the extent to which 1800 MHz RF induced toxicity in the testes and changed the expression of lncRNAs showed differences between morning exposure and evening exposure. These data indicate that differentially expressed lncRNAs play crucial roles in the RF exposure damage to the developing pubertal testis. Collectively, our findings provide a better understanding of the mechanisms underlying the toxic effects of RF exposure on testicular development.

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Proteomic and Biological Analyses Reveal the Effect on Growth under Flooding Stress of Chickpea Irradiated with Millimeter Waves

Setsuko Komatsu, Junya Maruyama, Takashi Furuya, Xiaojian Yin, Hisateru Yamaguchi, Keisuke Hitachi, Natsuki Miyashita, Kunihiro Tsuchida, Masahiko Tani. Proteomic and Biological Analyses Reveal the Effect on Growth under Flooding Stress of Chickpea Irradiated with Millimeter Waves. J Proteome Res. 2021 Aug 30. doi: 10.1021/acs.jproteome.1c00368.

Abstract

Chickpea cultivated on marginal lands in arid and semiarid tropics is one of the food legumes, and its growth is reduced by flooding stress. Millimeter-wave irradiation has influences on organisms, and it improves the growth of plants such as soybean. To reveal the dynamic effects of millimeter-wave irradiation on chickpea under flooding, gel- and label-free proteomic analysis was conducted. Millimeter-wave irradiation improved chickpea growth and its tolerance to flooding stress. According to functional categorization, oppositely changed proteins were correlated with photosynthesis, fermentation, and protein degradation. Immunoblot analysis confirmed that RuBisCO activase and large subunits decreased in leaves under flooding; however, they are recovered in irradiated chickpea even if it was in this condition. The activity and accumulation of alcohol dehydrogenase increased in roots under flooding; however, this followed the same pattern. Cell death was significantly increased and decreased by flooding on unirradiated and irradiated chickpeas, respectively. These findings suggest that irradiation with millimeter waves on chickpea seeds improves the recovery of plant growth through regulation of photosynthesis in leaves and fermentation in roots. Furthermore, millimeter-wave irradiation might promote chickpea tolerance under flooding via the regulation of cell death.

https://pubmed.ncbi.nlm.nih.gov/34455783/

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Transcriptomic Profile Reveals Deregulation of Hearing-Loss Related Genes in Vestibular Schwannoma Cells Following Electromagnetic Field Exposure (50 Hz)

Colciago A, Audano M, Bonalume V, Melfi V, Mohamed T, Reid AJ, Faroni A, Greer PA, Mitro N, Magnaghi V. Transcriptomic Profile Reveals Deregulation of Hearing-Loss Related Genes in Vestibular Schwannoma Cells Following Electromagnetic Field Exposure. Cells. 2021 Jul 20;10(7):1840. doi: 10.3390/cells10071840.

Abstract

Hearing loss (HL) is the most common sensory disorder in the world population. One common cause of HL is the presence of vestibular schwannoma (VS), a benign tumor of the VIII cranial nerve, arising from Schwann cell (SC) transformation. In the last decade, the increasing incidence of VS has been correlated to electromagnetic field (EMF) exposure, which might be considered a pathogenic cause of VS development and HL. Here, we explore the molecular mechanisms underlying the biologic changes of human SCs and/or their oncogenic transformation following EMF exposure. Through NGS technology and RNA-Seq transcriptomic analysis, we investigated the genomic profile and the differential display of HL-related genes after chronic EMF. We found that chronic EMF exposure modified the cell proliferation, in parallel with intracellular signaling and metabolic pathways changes, mostly related to translation and mitochondrial activities. Importantly, the expression of HL-related genes such as NEFL, TPRN, OTOGL, GJB2, and REST appeared to be deregulated in chronic EMF exposure. In conclusion, we suggest that, at a preclinical stage, EMF exposure might promote the transformation of VS cells and contribute to HL.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8307028/

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Exposure to 60 Hz magnetic field can affect membrane proteins and membrane potential in human cancer cells

Seiya Hayashi, Makiko Kakikawa. Exposure to 60 Hz magnetic field can affect membrane proteins and membrane potential in human cancer cells. Electromagn Biol Med. 2021 Aug 15;1-8. doi: 10.1080/15368378.2021.1958340.

Abstract

The experimental data support the hypothesis that extremely low frequency magnetic field (ELF-MF) can affect cell membranes. Since our previous studies suggested that MF changes the permeability of cell membrane, in this study we focused on the cell membrane and investigated the effect of 60 Hz, 50 mT MF on the membrane potential and membrane proteins. The membrane potentials of three cultured human cancer cell lines, A549, MES-SA, and MES-SA/Dx5, were increased by exposure to ELF-MF. When exposed to MF and an anticancer drug, changes in the membrane potentials were detected in A549 and MES-SA cells, but not in the multi drug-resistant cells, MES-SA/Dx5. We examined whether MF has an influence on the membrane proteins extracted from cultured A549 cells, using DiBAC4(3) dye enhanced fluorescence binding to a hydrophobic site. The increase in

fluorescence observed following MF exposure for 10 min indicated that the structure of the hydrophobic site on the membrane proteins changed and became more likely to bind the probe dye. A decrease in fluorescence was detected following exposure to MF for 240 min. These results indicated that 60 Hz, 50 mT MF causes changes in the membrane potential of cultured cancer cells and the conformation of membrane proteins extracted from cultured cancer cells, and has different effects depending on the exposure time.

https://pubmed.ncbi.nlm.nih.gov/34396886/

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Selective induction of rapid cytotoxic effect in glioblastoma cells by oscillating magnetic fields

Helekar SA, Hambarde S, Ijare OB, Pichumani K, Baskin DS, Sharpe MA. Selective induction of rapid cytotoxic effect in glioblastoma cells by oscillating magnetic fields. J Cancer Res Clin Oncol. 2021 Sep 3. doi: 10.1007/s00432-021-03787-0.

Abstract

Purpose: The mechanisms underlying anticancer effects of electromagnetic fields are poorly understood. An alternating electric field-generating therapeutic device called Optune™ device has been approved for the treatment of glioblastoma (GBM). We have developed a new device that generates oscillating magnetic fields (OMF) by rapid rotation of strong permanent magnets in specially designed patterns of frequency and timing and have used it to treat an end-stage recurrent GBM patient under an expanded access/compassionate use treatment protocol. Here, we ask whether OMF causes selective cytotoxic effects in GBM and whether it is through generation of reactive oxygen species (ROS).

Methods: We stimulated patient derived GBM cells, lung cancer cells, normal human cortical neurons, astrocytes, and bronchial epithelial cells using OMF generators (oncoscillators) of our Oncomagnetic Device and compared the results to those obtained under unstimulated or sham-stimulated control conditions. Quantitative fluorescence microscopy was used to assess cell morphology, viability, and ROS production mechanisms.

Results: We find that OMF induces highly selective cell death of patient derived GBM cells associated with activation of caspase 3, while leaving normal tissue cells undamaged. The cytotoxic effect of OMF is also seen in pulmonary cancer cells. The underlying mechanism is a marked increase in ROS in the mitochondria, possibly in part through perturbation of the electron flow in the respiratory chain.

Conclusion: Rotating magnetic fields produced by a new noninvasive device selectively kill cultured human glioblastoma and non-small cell lung cancer cells by raising intracellular reactive oxygen species, but not normal human tissue cells.

https://pubmed.ncbi.nlm.nih.gov/34477946/

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Combined effect of co-exposure to di (2-ethylhexyl) phthalates and 50-Hz magnetic-fields on promoting human amniotic cells proliferation

Liangjing Chen, Anfang Ye, Xiaochen Liu, Jingchun Lu, Qixin Xie, Yixin Guo, Wenjun Sun. Combined effect of co-exposure to di (2-ethylhexyl) phthalates and 50-Hz magnetic-fields on promoting human amniotic cells proliferation. Ecotoxicol Environ Saf. 2021 Aug 26;224:112704. doi: 10.1016/j.ecoenv.2021.112704.

Abstract

Di (2-ethylhexyl) phthalate (DEHP) and extremely low-frequency electromagnetic fields (ELF-EMFs) exist far and wide in our surroundings. Studies have reported that both of DEHP and ELF-EMFs could promote cell proliferation which is related with adverse bioeffects. In this study, we investigated whether there is the combined effect between DEHP and 50-Hz magnetic fields (MFs) on cell proliferation in human amniotic (FL) cells. Results revealed that the low-concentration DEHP (1 μM) could promote FL cell proliferation, whereas the high-dose DEHP (100 μM) inhibited cell proliferation. When FL cells were treated jointly by a 50-Hz, 0.2-mT MF and 0.1 μM DEHP, the proliferation rate of cells was significantly higher than that of single factor exposure. Additionally, co-exposure to under-threshold MF and DEHP could cooperatively activate protein kinase B (Akt), sphingosine kinase 1 (SphK1) and extracellular signal regulated kinase (ERK) in a cascade manner, and finally mediate cell proliferation. Taken together, the findings of this study indicated that the co-exposure to under-threshold MF and DEHP could jointly promote cell proliferation through activating proliferation-related signal pathway, which warned us that it should be cautious about assessing the underlying health hazards of co-exposure to MFs and DEHP at under-threshold levels.

Open access paper: https://pubmed.ncbi.nlm.nih.gov/34455183/

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Evaluation of Pulsed Electromagnetic Field Effects: A Systematic Review and Meta-Analysis on Highlights of Two Decades of Research In Vitro Studies

Mahsa Mansourian, Ahmad Shanei. Evaluation of Pulsed Electromagnetic Field Effects: A Systematic Review and Meta-Analysis on Highlights of Two Decades of Research In Vitro Studies. Biomed Res Int. 2021 Jul 29;2021:6647497. doi: 10.1155/2021/6647497.

Abstract

Pulsed electromagnetic field (PEMF) therapy is a type of physical stimulation that affects biological systems by producing interfering or coherent fields. Given that cell types are significantly distinct, which represents an important factor in stimulation, and that PEMFs can have different effects in terms of frequency and intensity, time of exposure, and waveform. This study is aimed at investigating if distinct positive and negative responses would correspond to specific characteristics of cells, frequency and flux density, time of exposure, and waveform. Necessary data were abstracted from the experimental observations of cell-based in vitro models. The observations were obtained from 92 publications between the years 1999 and 2019, which are available on

PubMed and Web of Science databases. From each of the included studies, type of cells, pulse frequency of exposure, exposure flux density, and assayed cell responses were extracted. According to the obtained data, most of the experiments were carried out on human cells, and out of 2421 human cell experiments, cell changes were observed only in 51.05% of the data. In addition, the results pointed out the potential effects of PEMFs on some human cell types such as MG-63 human osteosarcoma cells (p value < 0.001) and bone marrow mesenchymal stem cells. However, human osteogenic sarcoma SaOS-2 (p < 0.001) and human adipose-derived mesenchymal stem cells (AD-MSCs) showed less sensitivity to PEMFs. Nevertheless, the evidence suggests that frequencies higher than 100 Hz, flux densities between 1 and 10 mT, and chronic exposure more than 10 days would be more effective in establishing a cellular response. This study successfully reported useful information about the role of cell type and signal characteristic parameters, which were of high importance for targeted therapies using PEMFs. Our findings would provide a deeper understanding about the effect of PEMFs in vitro, which could be useful as a reference for many in vivo experiments or preclinical trials.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8342182/

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Growth alteration of Allium cepa L. roots exposed to 1.5 mT, 25 Hz pulsed magnetic field

Alejandro González-Vidal, Silvia Mercado-Sáenz, Antonio M Burgos-Molina, Francisco Sendra-Portero, Miguel J Ruiz-Gómez. Growth alteration of Allium cepa L. roots exposed to 1.5 mT, 25 Hz pulsed magnetic field. Int J Environ Health Res. 2021 Sep 2;1-13. doi: 10.1080/09603123.2021.1972090.

Abstract

The response of plants to magnetic fields (MF) is not fully understood. This work studies the effects of pulsed MF on the germination and growth of Allium cepa roots. Onions were exposed to 25Hz, 1.5mT, 33h. Pulsed MF was generated by a Helmholtz-type equipment that generated rectangular voltage pulses. The results showed that fewer roots grew in the specimens exposed to pulsed MF (14±6 roots on day 1 to 21±8 on day 4) than in the control groups (32±17 to 48±23) ($p<0.05$ Friedman). Control specimens showed a root mean length of 7±4 mm (day 1) and 24±10 mm (day 4). The specimens treated with pulsed MF showed a length of 4±2 mm (day 1), reaching 18±9 mm on day 4 ($p<0.001$ ANOVA). In conclusion, the exposure of Allium cepa specimens to 25Hz, 1.5mT pulsed MF during 33h produces a decrease in the germination and growth of roots.

https://pubmed.ncbi.nlm.nih.gov/34474627/

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Electrical Control of Escherichia coli Growth Measured with Simultaneous Modulation and Imaging

Xu Han, Bradley R Foster, Christine K Payne. Electrical Control of Escherichia coli Growth Measured with Simultaneous Modulation and Imaging. Bioelectricity. 2020 Sep 1;2(3):221-228. doi: 10.1089/bioe.2020.0002.

Abstract

Background: The use of electricity to mediate bacterial growth is unique in providing spatial control, but requires a more detailed understanding. Methods: We use two gold wires on a glass coverslip with an overlayer of agar to image Escherichia coli cells with brightfield and fluorescence microscopy while simultaneously applying a voltage. Cells outside of the wires provide a control population to measure cell growth as a function of voltage, rather than any difference in culture conditions or growth phase. Results: An applied voltage suppresses the fraction of E. coli undergoing elongation and division with recovery to control values when the voltage is removed. Depolarization is observed over the same voltage range suggesting a membrane potential-mediated response. Conclusions: Our experiments identify and use subcytotoxic voltages to measure differences in the fraction of E. coli cells elongating and dividing as a function of applied voltage. It is hoped that this research will inform the developing field of bacterial electrophysiology.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8370336/

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Can static electric fields increase the activity of nitric oxide synthase and induce oxidative stress and damage of spleen?

Li Dong, Junli Xiang, Jingyi Guo, Guangdi Chen, Guoqing Di. Can static electric fields increase the activity of nitric oxide synthase and induce oxidative stress and damage of spleen? Environ Sci Pollut Res Int. 2021 Aug 16. doi: 10.1007/s11356-021-15853-8.

Abstract

With the rapid development of ultra-high-voltage (UHV) direct-current (DC) transmissions, the impact of static electric fields (SEF) in the vicinity of overhead UHV DC transmission lines on health has aroused much public concern. This study explored the effects of 56.3kV/m SEF on the spleen of mice. Results showed that SEF exposure of 21days significantly increased malonic dialdehyde content, superoxide dismutase activity, calcineurin activity, nitric oxide synthase (NOS) activity, and the mRNA expression levels of tumor necrosis factor-α (TNF-α) and nuclear factor-κB (NF-κB) in the spleen and caused the separation of nucleus and nuclear membrane, the disappearance of mitochondrial membrane, and the deficiency of mitochondrial cristae in splenic lymphocytes. By analysis and discussion, it was deduced that SEF could induce oxidative stress of the spleen by increasing the activity of NOS. Oxidative stress could further cause ultrastructural changes of splenic lymphocytes. Moreover, oxidative stress could cause the increase of the mRNA expression levels of TNF-α and NF-κB, which contributed to the occurrence of spleen inflammation.

https://pubmed.ncbi.nlm.nih.gov/34398376/

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Combined Effects of Pesticides and Electromagnetic-Fields on Honeybees: Multi-Stress Exposure

Daniela Lupi, Marco Palamara Mesiano, Agnese Adani, Roberto Benocci, Roberto Giacchini, Paolo Parenti, Giovanni Zambon, Antonio Lavazza, Maria B. Boniotti, Stefano Bassi, Mario Colombo, Paolo Tremolada. 2021. Combined Effects of Pesticides and Electromagnetic-Fields on Honeybees: Multi-Stress Exposure. *Insects*. 12(8):716. doi: 10.3390/insects12080716.

Simple Summary

Multi-stress conditions are considered the most putative cause of honeybee decline. The ongoing reduction of domestic and natural pollinators is considered a very severe signal of the current loss of biodiversity, and it requires a broad research effort to clarify the causes. In this research, the combined effects of two possible stress sources for bees, pesticides and electromagnetic fields (multi-stress conditions) were analyzed by a field trial. After one year of monitoring, a complex picture of several induced effects was present, especially in the multi-stress site, such as disease appearance (American foulbrood), higher mortality in the underbaskets (common to pesticide-stress site), behavioral alterations (queen changes, excess of both drone-brood deposition and honey storage) and biochemical anomalies (higher ALP activity at the end of the season). The multi-stress site showed the worst health condition of the bee colonies, with only one alive at the end of the experimentation out of the four ones present at the beginning.

Abstract

Honeybee and general pollinator decline is extensively reported in many countries, adding new concern to the general biodiversity loss. Many studies were addressed to assess the causes of pollinator decline, concluding that in most cases multi-stress effects were the most probable ones. In this research, the combined effects of two possible stress sources for bees, pesticides and electromagnetic fields (multi-stress conditions), were analyzed in the field. Three experimental sites were chosen: a control one far from direct anthropogenic stress sources, a pesticide-stress site and multi-stress one, adding to the same exposure to pesticides the presence of an electromagnetic field, coming from a high-voltage electric line. Experimental apiaries were monitored weekly for one year (from April 2017 to April 2018) by means of colony survival, queen activity, storage and brood amount, parasites and pathogens, and several biomarkers in young workers and pupae. Both exposure and effect biomarkers were analysed: among the first, acetylcholinesterase (AChE), catalase (CAT), glutathione S-transferase (GST) and alkaline phosphatase (ALP) and Reactive Oxygen Species (ROS); and among the last, DNA fragmentation (DNAFRAGM) and lipid peroxidation (LPO). Results showed that bee health conditions were the worst in the multi-stress site with only one colony alive out of the four ones present at the beginning. In this site, a complex picture of adverse effects was observed, such as disease appearance (American foulbrood), higher mortality in the underbaskets (common to pesticide-stress site), behavioral alterations (queen changes, excess of honey storage) and biochemical anomalies (higher ALP activity at the end of the season). The overall results clearly indicate that the multi-stress conditions were able to induce biochemical, physiological and behavioral alterations which severely threatened bee colony survival.

Open access paper: https://www.mdpi.com/2075-4450/12/8/716

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Effects of Extremely Low Frequency Electromagnetic Field on different developmental stages of Drosophila

melanogaster

Neha Agrawal, Kalyani Verma, Doli Baghel, Amitabh Chauhan, Dipti N Prasad, Sanjeev K Sharma, Ekta Kohli. Effects of Extremely Low Frequency Electro Magnetic Field on different developmental stages of Drosophila melanogaster. Int J Radiat Biol. 2021 Aug 17;1-35. doi: 10.1080/09553002.2021.1969465.

Abstract

Purpose: The model biological organism Drosophila melanogaster has been utilized to assess effect of extremely low-frequency electromagnetic field (ELF-EMF) on locomotion, longevity, developmental dynamics, cell viability and oxidative stress.

Materials and method: Developmental stages of Drosophila melanogaster (Oregon R strain) individually exposed to ELF-EMF (75 Hz, 550 μT) for 6 h once for acute exposure. For chronic exposure, complete life cycle of fly, that is, egg to adult fly was exposed to ELF-EMF for 6 h daily. The effect of exposure on their crawling and climbing ability, longevity, development dynamics, cellular damage and oxidative stress (generation of Reactive Oxygen Species (ROS)) was evaluated.

Results: The crawling ability of larvae was significantly ($p < 0.05$) reduced on acute (third stage instar larvae) as well as chronic exposure (F0 and F1 larvae). When locomotion of flies were tested using climbing assay, no alteration was observed in their climbing ability under both acute and chronic exposure, however, when their speed of climbing was compared, a significant decrease in speed of F1 flies was observed (p value 0.0027) on chronic exposure. The survivability of flies was significantly affected under chronic and acute exposure (at third stage instar larvae). In case of acute exposure of the third stage instar larvae, though all the flies were eclosed by the 17th day, but there was a significant decline in the number of flies (p value 0.007) in comparison to control. While, in case of chronic exposure apart from low number of flies eclosed in comparison to control, there was delay in eclosion by one day (p value 0.0004). Using trypan blue assay the internal gut damage of third stage instar larvae was observed. Under acute exposure condition at third stage instar larvae, 30% larvae has taken up trypan blue, while only 10% larvae from acute exposure at adult stage. On chronic exposure, 50% larvae of the F1 generation have taken up trypan blue. On evaluation of oxidative stress, there is significant rise in ROS in case of acute exposure at third stage instar larvae (p value 0.0004), adult fly stage (p value 0.0004) and chronic exposure (p value 0.0001).

Conclusion: ELF-EMF has maximum effects on acute exposure of third stage instar larvae and chronic exposure (egg to adult fly stage). These results suggest that electromagnetic radiations, though have become indispensible part of our lives but they plausibly effect our health.

https://pubmed.ncbi.nlm.nih.gov/34402374/

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Electromagnetic Fields and Calcium Signaling by the Voltage Dependent Anion Channel

Volker Ullrich, Hans-Jürgen Apell. Electromagnetic Fields and Calcium Signaling by the Voltage Dependent Anion Channel. Open Journal of Veterinary Medicine. 11(1):57-86, January 2021. DOI: 10.4236/ojvm.2021.111004.

Abstract

Electromagnetic fields (EMFs) can interact with biological tissues exerting positive as well as negative effects on cell viability, but the underlying sensing and signaling mechanisms are largely unknown. So far in excitable cells EMF exposure was postulated to cause Ca2+ influx through voltage-dependent Ca channels (VDCC) leading to cell activation and an antioxidant response. Upon further activation oxidative stress causing DNA damage or cell death may follow. Here we report collected evidence from literature that voltage dependent anion channels (VDAC) located not only in the outer microsomal membrane but also in the cytoplasmic membrane convert to Ca2+ conducting channels of varying capacities upon subtle changes of the applied EMF even in non-excitable cells like erythrocytes. Thus, VDAC can be targeted by external EMF in both types of membranes to release Ca2+ into the cytosol. The role of frequency, pulse modulation or polarization remains to be investigated in suitable cellular models. VDACs are associated with several other proteins, among which the 18 kDa translocator (TSPO) is of specific interest since it was characterized as the central benzodiazepine receptor in neurons. Exhibiting structural similarities with magnetoreceptors we propose that TSPO could sense the magnetic component of the EMF and thus together with VDAC could trigger physiological as well as pathological cellular responses. Pulsed EMFs in the frequency range of the brain-wave communication network may explain psychic disturbances of electromagnetic hypersensitive persons. An important support is provided from human psychology that states deficits like insomnia, anxiety or depression can be treated with diazepines that indicates apparent connections between the TSPO/VDAC complex and organismic responses to EMF.

Open access paper: https://www.scirp.org/journal/paperinformation.aspx?paperid=106911

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Induced radiofrequency fields in patients undergoing MRI (Magnetic Resonance Imaging) exams: insights for risk assessment

Aiping Yao, Manuel Murbach, Tolga Goren, Earl Zastrow, Wolfgang Kainz, Niels Kuster. Induced radiofrequency fields in patients undergoing MR examinations: insights for risk assessment. Phys Med Biol. 2021 Aug 25. doi: 10.1088/1361-6560/ac212d.

Abstract

Purpose: To characterize and quantify the induced radiofrequency (RF) E-fields and B1+rms fields in patients undergoing magnetic resonance (MR) examinations; to provide guidance on aspects of RF heating risks for patients with and without implants; and to discuss some strengths and limitations of safety assessments in current ISO, IEC, and ASTM standards to determine the RF heating risks for patients with and without implants.

Methods: Induced E-fields and B1+rms fields during 1.5T and 3T MR examinations were numerically estimated for high-resolution patient models of the Virtual Population exposed to ten two-port birdcage RF coils from head

to feet imaging landmarks over the full polarization space, as well as in surrogate ASTM phantoms.

Results: Worst-case B1+rms exposure greater than 3.5µT (1.5T) and 2µT (3T) must be considered for all MR examinations at the Normal Operating Mode limit. Representative induced electric (E)-field and specific absorption rate (SAR) distributions under different clinical scenarios allow quick estimation of clinical factors of high and reduced exposure. B1 shimming can cause +6dB enhancements to E-fields along implant trajectories. The distribution and magnitude of induced E-fields in the ASTM phantom differ from clinical exposures and are not always conservative for typical implant locations.

Conclusions: Field distributions in patient models are condensed, visualized for quick estimation of risks, and compared to those induced in the ASTM phantom. Induced E-fields in patient models can significantly exceed those in the surrogate ASTM phantom in some cases. In the recent 19e2 revision of the ASTMF2182 standard, the major shortcomings of previous versions have been addressed by requiring that the relationship between ASTM test conditions and in vivo tangential E-fields be established, e.g. numerically. With this requirement, the principal methods defined in the ASTM standard for passive implants are reconciled with those of the ISO10974 standard for active implantable medical devices.

Open access paper: https://iopscience.iop.org/article/10.1088/1361-6560/ac212d

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How the Geomagnetic Field Influences Life on Earth - An Integrated Approach to Geomagnetobiology

Weronika Erdmann, Hanna Kmita, Jakub Z Kosicki, Łukasz Kaczmarek. How the Geomagnetic Field Influences Life on Earth - An Integrated Approach to Geomagnetobiology. Orig Life Evol Biosph. 2021 Aug 7. doi: 10.1007/s11084-021-09612-5.

Abstract

Earth is one of the inner planets of the Solar System, but - unlike the others - it has an oxidising atmosphere, relatively stable temperature, and a constant geomagnetic field (GMF). The GMF does not only protect life on Earth against the solar wind and cosmic rays, but it also shields the atmosphere itself, thus creating relatively stable environmental conditions. What is more, the GMF could have influenced the origins of life: organisms from archaea to plants and animals may have been using the GMF as a source of spatial information since the very beginning. Although the GMF is constant, it does undergo various changes, some of which, e.g. a reversal of the poles, weaken the field significantly or even lead to its short-term disappearance. This may result in considerable climatic changes and an increased frequency of mutations caused by the solar wind and cosmic radiation. This review analyses data on the influence of the GMF on different aspects of life and it also presents current knowledge in the area. In conclusion, the GMF has a positive impact on living organisms, whereas a diminishing or disappearing GMF negatively affects living organisms. The influence of the GMF may also be an important factor determining both survival of terrestrial organisms outside Earth and the emergence of life on other planets.

https://pubmed.ncbi.nlm.nih.gov/34363564/

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Health impact of 5G: Current state of knowledge of 5G-related carcinogenic and reproductive/developmental hazards as they emerge from epidemiological studies and in vivo experimental studies

Fiorella Belpoggi. Health impact of 5G: Current state of knowledge of 5G-related carcinogenic and reproductive/developmental hazards as they emerge from epidemiological studies and in vivo experimental studies. Panel for the Future of Science and Technology. European Parliamentary Research Service. Scientific Foresight Unit (STOA). PE 690.012. June 2021.

Abstract

The upcoming deployment of 5G mobile networks will allow for significantly faster mobile broadband speeds and increasingly extensive mobile data usage. Technical innovations include a different transmission system (MIMO: use of multiple-input and multiple-output antennas), directional signal transmission or reception (beamforming), and the use of other frequency ranges. At the same time, a change is expected in the exposure to electromagnetic fields (EMF) of humans and the environment. In addition to those used to date, the 5G pioneer bands identified at EU level have frequencies of 700 MHz, 3.6 GHz (3.4 to 3.8 GHz) and 26 GHz (24.25 to 27.5 GHz). The first two frequencies (FR1) are similar to those used for 2G to 4G technologies and have been investigated in both epidemiological and experimental studies for different end points (including carcinogenicity and reproductive/developmental effects), while 26 GHz (FR2) and higher frequencies have not been adequately studied for the same end points.

The International Agency for Research on Cancer (IARC) classified radiofrequency (RF) EMF as 'possibly carcinogenic to humans' (Group 2B) and recently recommended RF exposure for re-evaluation 'with high priority' (IARC, 2019). Since 2011 a great number of studies have been performed, both epidemiological and experimental. The present review addresses the current knowledge regarding both carcinogenic and reproductive/ developmental hazards of RF as exploited by 5G. There are various in vivo experimental and epidemiological studies on RF at a lower frequency range (450 to 6000 MHz), which also includes the frequencies used in previous generations' broadband cellular networks, but very few (and inadequate) on the higher frequency range (24 to 100 GHz, centimetre/MMW).

The review shows: 1) 5G lower frequencies (700 and 3 600 MHz): a) sufficient evidence of carcinogenicity in epidemiological studies; b) sufficient evidence of carcinogenicity in experimental bioassays; c) sufficient evidence of reproductive/developmental adverse effects in humans; d) sufficient evidence of reproductive/ developmental adverse effects in experimental animals; 2) 5G higher frequencies (24.25-27.5 GHz): the systematic review found no adequate studies either in humans or in experimental animals.

Conclusions: 1) cancer: FR1 (450 to 6 000 MHz): EMF are probably carcinogenic for humans, in particular related to gliomas and acoustic neuromas; FR2 (24 to 100 GHz): no adequate studies were performed on the higher frequencies; 2) reproductive developmental effects: FR1 (450 to 6 000 MHz): these frequencies clearly affect male fertility and possibly female fertility too. They may have possible adverse effects on the development of

embryos, foetuses and newborns; FR2 (24 to 100 GHz): no adequate studies were performed on non-thermal effects of the higher frequencies.

Open access report:
https://www.europarl.europa.eu/RegData/etudes/STUD/2021/690012/EPRS_STU(2021)690012_EN.pdf

See also: European Parliament: 5G Health Effects and Environmental Impact

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Environmental impacts of 5G: A literature review of effects of radio-frequency electromagnetic field exposure of non-human vertebrates, invertebrates and plants

Arno Thielens. Environmental impacts of 5G: A literature review of effects of radio-frequency electromagnetic field exposure of non-human vertebrates, invertebrates and plants. Panel for the Future of Science and Technology (STOA). European Parliament. 2021, 137 pp. PE 690.021, ISBN 9789284680337. doi: 10.2861/318352.

Abstract

Telecommunication networks use radio-frequency electromagnetic fields to enable wireless communication. These networks have evolved over time, and have been launched in successive generations. The fifth generation of telecommunication networks will operate at frequencies that were not commonly used in previous generations, changing the exposure of wildlife to these waves. This report reviews the literature on the exposure of vertebrates, invertebrates and plants to radio-frequency electromagnetic fields in anticipation of this change.

The review shows that dielectric heating can occur at all considered frequencies (0.4-300 GHz) and for all studied organisms. Summarising and discussing the results of a series of studies of radio-frequency electromagnetic field exposure of wildlife, the review shows that several studies into the effects of radio-frequency electromagnetic field exposure on invertebrates and plants in the frequency bands considered demonstrate experimental shortcomings. Furthermore, the literature on invertebrate and plant exposure to radio-frequency electromagnetic fields above 6 GHz is very limited. More research is needed in this field.

Open access report:
https://www.europarl.europa.eu/RegData/etudes/STUD/2021/690021/EPRS_STU(2021)690021_EN.pdf

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Development of health-based exposure limits for radiofrequency radiation from wireless devices using a benchmark dose approach

Uloma Igara Uche, Olga V Naidenko. Development of health-based exposure limits for radiofrequency radiation from wireless devices using a benchmark dose approach. Environ Health 20, 84 (2021). doi: 10.1186/s12940-021-00768-1.

Abstract

Background Epidemiological studies and research on laboratory animals link radiofrequency radiation (RFR) with impacts on the heart, brain, and other organs. Data from the large-scale animal studies conducted by the U.S. National Toxicology Program (NTP) and the Ramazzini Institute support the need for updated health-based guidelines for general population RFR exposure.

Objectives The development of RFR exposure limits expressed in whole-body Specific Absorption Rate (SAR), a metric of RFR energy absorbed by biological tissues.

Methods Using frequentist and Bayesian averaging modeling of non-neoplastic lesion incidence data from the NTP study, we calculated the benchmark doses (BMD) that elicited a 10% response above background (BMD10) and the lower confidence limits on the BMD at 10% extra risk (BMDL10). Incidence data for individual neoplasms and combined tumor incidence were modeled for 5% and 10% response above background.

Results Cardiomyopathy and increased risk of neoplasms in male rats were the most sensitive health outcomes following RFR exposures at 900 MHz frequency with Code Division Multiple Access (CDMA) and Global System for Mobile Communications (GSM) modulations. BMDL10 for all sites cardiomyopathy in male rats following 19 weeks of exposure, calculated with Bayesian model averaging, corresponded to 0.27–0.42 W/kg whole-body SAR for CDMA and 0.20–0.29 W/kg for GSM modulation. BMDL10 for right ventricle cardiomyopathy in female rats following 2 years of exposure corresponded to 2.7–5.16 W/kg whole-body SAR for CDMA and 1.91–2.18 W/kg for GSM modulation. For multi-site tumor modeling using the multistage cancer model with a 5% extra risk, BMDL5 in male rats corresponded to 0.31 W/kg for CDMA and 0.21 W/kg for GSM modulation.

Conclusion BMDL10 range of 0.2—0.4 W/kg for all sites cardiomyopathy in male rats was selected as a point of departure. Applying two ten-fold safety factors for interspecies and intraspecies variability, we derived a whole-body SAR limit of 2 to 4 mW/kg, an exposure level that is 20–40-fold lower than the legally permissible level of 0.08 W/kg for whole-body SAR under the current U.S. regulations. Use of an additional ten-fold children's health safety factor points to a whole-body SAR limit of 0.2–0.4 mW/kg for young children.

Open access paper: https://ehjournal.biomedcentral.com/articles/10.1186/s12940-021-00768-1

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Effects of mobile phone usage on sperm quality - No time-dependent relationship on usage: A systematic review and updated meta-analysis

Sungjoon Kim, Donghyun Han, Jiwoo Ryu, Kihun Kim, Yun Hak Kim. Effects of mobile phone usage on sperm quality - No time-dependent relationship on usage: A systematic review and updated meta-analysis. Environ Res. 2021 Jul 29;111784. doi: 10.1016/j.envres.2021.111784.

Abstract

Background: Mobile phones emit radiofrequency (RF) electromagnetic waves (EMWs), a low-level RF that can be absorbed by the human body and exert potential adverse effects on the brain, heart, endocrine system, and reproductive function. Owing to the novel findings of numerous studies published since 2012 regarding the

effect of mobile phone use on sperm quality, we conducted a systematic review and updated meta-analysis to determine whether the exposure to RF-EMWs affects human sperm quality.

Methods: This study was conducted in accordance with the PRISMA guidelines. The outcome measures depicting sperm quality were motility, viability, and concentration, which are the most frequently used parameters in clinical settings to assess fertility.

Results: We evaluated 18 studies that included 4280 samples. Exposure to mobile phones is associated with reduced sperm motility, viability, and concentration. The decrease in sperm quality after RF-EMW exposure was not significant, even when the mobile phone usage increased. This finding was consistent across experimental in vitro and observational in vivo studies.

Discussion: Accumulated data from in vivo studies show that mobile phone usage is harmful to sperm quality. Additional studies are needed to determine the effect of the exposure to EMWs from new mobile phone models used in the present digital environment.

https://pubmed.ncbi.nlm.nih.gov/34333014/

Excerpts

... 18 studies fulfilled all inclusion criteria and were included in the meta-analysis (Table 1 and Fig. 1) (Agarwal et al., 2008, 2009; Ahmad and Baig, 2011; Al-Bayyari, 2017b; De Iuliis et al., 2009; Ding et al., 2018a; Dkhil et al., 2011; Erogul et al., 2006; Falzone et al., 2008; Fejes et al., 2005; Kaya et al., 2020; Malini, 2017b; Rago et al., 2013; Sajeda and Al-Watter, 2011; Veerachari and Vasan, 2012; Wdowiak et al., 2018; Yildirim et al., 2015; Zalata et al., 2015). Nine studies from a previous meta-analysis and nine new studies that included 4280 samples were used for analysis. One conference paper included in the previous study was excluded. The sperm quality parameters established in each paper varied and were subjected to a meta-analysis; 16 papers provided data on sperm motility, 6 provided data on sperm viability, and 12 provided data on sperm concentration. All in vitro studies were experimental, whereas all in vivo studies were observational. We identified the MD values of the entire 4280 samples and analyzed the MD values of each group after classifying them according to four criteria: control group setting (non-exposure vs. less exposure), study design (in vivo and in vitro), participant group (fertility clinic and population), and storage location (trousers or not).

Conclusion

Mobile phone use decreased the overall sperm quality by affecting the motility, viability, and concentration. It was further reduced in the group with high mobile phone usage. In particular, the decrease was remarkable in in vivo studies with stronger clinical significance in subgroup analysis. Therefore, long-term cell phone use is a factor that must be considered as a cause of sperm quality reduction. Additional studies are needed to determine the effect of the exposure to EMWs emitted from new mobile phone models in the present digital environment.

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Association between mobile phone use and hearing impairment: a systematic review and meta-analysis

Mohammad Hosein Taziki Balajelini, Masoud Mohammadi, Abdolhalim Rajabi. Association between mobile phone use and hearing impairment: a systematic review and meta-analysis. Rev Environ Health. 2021 Jul 22. doi: 10.1515/reveh-2021-0062.

Abstract

Objectives: To investigate whether a possible association of mobile phone use with hearing impairment was conducted a systematic review and meta-analysis.

Content: This is a systematic review and meta-analysis. A comprehensive literature search was carried out based on the Meta-analysis of Observational Studies in Epidemiology (MOOSE) methodology using PubMed, Scopus, Web of Science, OVID, and Cochrane. The Robins-I tool was used for quality assessment and risk of bias. Two investigators independently reviewed all articles. Pooled effect size was calculated and meta-analysis was performed to compute an overall effect size.

Summary: Overall, five relevant studies (two cross-sectional and three cohort studies) with 92,978 participants were included in the analysis. The studies were stratified by design, there was no significant association between mobile phone use and hearing impairment in cross-sectional studies (OR=0.94, 95% CI=0.57-1.31) and cohort studies (OR=1.09, 95% CI=0.93-1.25). In addition, the effect estimates did not differ significantly between cross-sectional and cohort studies (Q=0.50, p=0.48). Overall, the pooled odds ratio (OR) of hearing impairment was 1.07 (95% CI: 0.94-1.20), which indicates no significant association between mobile phone use and hearing impairment.

Outlook: Our findings indicate no association between mobile phone use and hearing impairment. However, these findings must be interpreted with caution.

https://pubmed.ncbi.nlm.nih.gov/34293837/

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Effects of non-ionizing electromagnetic fields on flora and fauna, Part 2 impacts: how species interact with natural and man-made EMF

B. Blake Levitt, Henry C. Lai, Albert M Manville. Effects of non-ionizing electromagnetic fields on flora and fauna, Part 2 impacts: how species interact with natural and man-made EMF. Rev Environ Health. 2021 Jul 8.doi: 10.1515/reveh-2021-0050.

Abstract

Ambient levels of nonionizing electromagnetic fields (EMF) have risen sharply in the last five decades to become a ubiquitous, continuous, biologically active environmental pollutant, even in rural and remote areas. Many species of flora and fauna, because of unique physiologies and habitats, are sensitive to exogenous EMF in ways

that surpass human reactivity. This can lead to complex endogenous reactions that are highly variable, largely unseen, and a possible contributing factor in species extinctions, sometimes localized. Non-human magnetoreception mechanisms are explored. Numerous studies across all frequencies and taxa indicate that current low-level anthropogenic EMF can have myriad adverse and synergistic effects, including on orientation and migration, food finding, reproduction, mating, nest and den building, territorial maintenance and defense, and on vitality, longevity and survivorship itself. Effects have been observed in mammals such as bats, cervids, cetaceans, and pinnipeds among others, and on birds, insects, amphibians, reptiles, microbes and many species of flora. Cyto- and geno-toxic effects have long been observed in laboratory research on animal models that can be extrapolated to wildlife. Unusual multi-system mechanisms can come into play with non-human species — including in aquatic environments — that rely on the Earth's natural geomagnetic fields for critical life-sustaining information. Part 2 of this 3-part series includes four online supplement tables of effects seen in animals from both ELF and RFR at vanishingly low intensities. Taken as a whole, this indicates enough information to raise concerns about ambient exposures to nonionizing radiation at ecosystem levels. Wildlife loss is often unseen and undocumented until tipping points are reached. It is time to recognize ambient EMF as a novel form of pollution and develop rules at regulatory agencies that designate air as 'habitat' so EMF can be regulated like other pollutants. Long-term chronic low-level EMF exposure standards, which do not now exist, should be set accordingly for wildlife, and environmental laws should be strictly enforced — a subject explored in Part 3.

https://pubmed.ncbi.nlm.nih.gov/34243228/

Conclusion

Effects from both natural and man-made EMF over a wide range of frequencies, intensities, wave forms, and signaling characteristics have been observed in all species of animals and plants investigated. The database is now voluminous with in vitro, in vivo, and field studies from which to extrapolate. The majority of studies have found biological effects at both high and low-intensity man-made exposures, many with implications for wildlife health and viability. It is clear that ambient environmental levels are biologically active in all non-human species which can have unique physiological mechanisms that require natural geomagnetic information for their life's most important activities. Sensitive magnetoreception allows living organisms, including plants, to detect small variations in environmental EMF and react immediately as well as over the long term, but it can also make some organisms exquisitely vulnerable to man-made fields. Anthropogenic EMF may be contributing more than we currently realize to species' diminishment and extinction. Exposures continue to escalate without understanding EMF as a potential causative and/or co-factorial agent. It is time to recognize ambient EMF as a potential novel stressor to other species, design technology to reduce exposures to as low as reasonably achievable, keep systems wired as much as possible to reduce ambient RFR, and create laws accordingly — a subject explored more thoroughly in Part 3.

https://www.degruyter.com/document/doi/10.1515/reveh-2021-0050/html

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The effect of exposure to radiofrequency electromagnetic fields on cognitive performance in human experimental studies: A protocol for a systematic review

Blanka Pophof, Jacob Burns, Heidi Danker-Hopfe, Hans Dorn, Cornelia Egblomassé-Roidl, Torsten Eggert, Kateryna Fuks, Bernd Henschenmacher, Jens Kuhne, Cornelia Sauter, Gernot Schmid. The effect of exposure to radiofrequency electromagnetic fields on cognitive performance in human experimental studies: A protocol for a

systematic review. Environ Int. 2021 Jul 29;157:106783. doi: 10.1016/j.envint.2021.106783.

Abstract

Background: The World Health Organization (WHO) is currently assessing the potential health effects of exposure to radiofrequency electromagnetic fields (RF-EMFs) in the general and working population. Related to one such health effect, there is a concern that RF-EMFs may affect cognitive performance in humans. The systematic review (SR) aims to identify, summarize and synthesize the evidence base related to this question. Here, we present the protocol for the planned SR.

Objectives: The main objective is to present a protocol for a SR which will evaluate the associations between short-term exposure to RF-EMFs and cognitive performance in human experimental studies.

Data sources: We will search the following databases: PubMed, Embase, Web of Science, Scopus, and the EMF-Portal. The reference lists of included studies and retrieved review articles will be manually searched.

Study eligibility and criteria: We will include randomized human experimental studies that assess the effects of RF-EMFs on cognitive performance compared to no exposure or lower exposure. We will include peer-reviewed articles of any publication date in any language that report primary data.

Data extraction and analysis: Data will be extracted according to a pre-defined set of forms developed and piloted by the review author team. To assess the risk of bias, we will apply the Rating Tool for Human and Animal Studies developed by NTP/OHAT, supplemented with additional questions relevant for cross-over studies. Where sufficiently similar studies are identified (e.g. the heterogeneity concerning population, exposure and outcome is low and the studies can be combined), we will conduct random-effects meta-analysis; otherwise, we will conduct a narrative synthesis.

Assessment of certainty of evidence: The certainty of evidence for each identified outcome will be assessed according to Grading of Recommendations Assessment, Development, and Evaluation (GRADE). Performing the review according to this protocol will allow the identification of possible effects of RF-EMFs on cognitive performance in humans. The protocol has been registered in PROSPERO, an open-source protocol registration system, to foster transparency.

Open access paper: https://www.sciencedirect.com/science/article/pii/S0160412021004086?via%3Dihub

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Improving the Quality of Radiofrequency Bioeffects Research: The Need for a Carrot and a Stick

Vijayalaxmi, Kenneth R Foster. Improving the Quality of Radiofrequency Bioeffects Research: The Need for a Carrot and a Stick. Radiat Res. 2021 Jul 16. doi: 10.1667/RADE-21-00079.1.

Abstract

This commentary considers research needs for radiofrequency (RF) energy above 6 GHz, including in the "high band" of 5G New Radio (NR) communications systems that exists just beneath the mm-wave band (30-300 GHz). As of late 2020, approximately 100 RF bioeffects studies have been published involving exposures above 6 GHz, encompassing a wide range of exposure levels and frequencies. A majority of these studies report statistically significant effects of exposure, many at exposures within international safety limits. This commentary examines 31 genetic damage studies involving RF exposures above 6 GHz in the context of two sets of quality-assessment criteria: 1. "Risk of bias" (RoB) criteria used for systematic reviews of health-related studies; and 2. a broader set of criteria for research quality from a different scholarly approach (metascience). The 31 studies report several statistically significant effects of exposure on different markers for genetic damage. These effects, if real, would have great potential significance for carcinogen risk assessment. However, the studies as a group have significant technical weaknesses, including small size, failure to meet multiple RoB criteria, naïve use of statistics, and lack of prespecified hypotheses and methods of analysis, all of which increase the chances of false discovery. Here we propose a "carrot" (adequate funding to support high-quality research) and a "stick" (more stringent review of bioeffects manuscripts, including explicit instructions to reviewers to assess study quality) approach to increase the reliability of RF bioeffects studies to facilitate health agency reviews of this socially controversial topic.

https://pubmed.ncbi.nlm.nih.gov/34270779/

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American National Standard for Methods of Measurements of Radio-Frequency Emissions from Wireless Power Transfer Equipment

"American National Standard for Methods of Measurements of Radio-Frequency Emissions from Wireless Power Transfer Equipment," in *ANSI C63.30-2021* , vol., no., pp.1-253, 15 July 2021, doi: 10.1109/IEEESTD.2021.9491984.

Abstract

U.S. consensus standard methods, instrumentation, and facilities for measurement of radio-frequency (RF) emissions and signals emitted from wireless power transfer equipment in the frequency range from 9 kHz to 40 GHz are specified. This standard does not include generic nor product-specific emission limits. Where possible, the specifications herein are harmonized with other national and international standards used for similar purposes.

Scope This standard includes procedures for evaluating the compliance of wireless power transfer (WPT) equipment with applicable electromagnetic compatibility (EMC) requirements. Test procedures for radiated field strength and conducted disturbance measurements are included, with reference to established standards, where applicable. WPT RF exposure compliance procedures are not included. This document covers measurement methodologies but is not intended to specify regulatory limits. This standard does not consider

test methods for the transmitter or receiver portion of any radio apparatus subcomponents that might be included in the equipment under test (EUT), other than those operating at the WPT frequency (or frequencies). These non-WPT radio subcomponents, which can be related or not to the WPT function of the EUT, are covered by other standards (e.g., ANSI C63.10 [B1] and ANSI C63.26 [B2]).

Purpose This standard specifies the methods of measurement to be used for evaluating compliance with the applicable radiated and ac mains power-line conducted emissions requirements for WPT devices that are either already in wide use or soon to be introduced on the market, at the time of publishing this first edition of ANSI C63.30 (such as Qi, PMA, A4WP2, and SAE3 J2954 [B26]compliant models -- see Annex A). This document includes procedures developed from an exhaustive investigation of such devices, inclusive of field propagation properties, simulation-based analysis, and test site dynamics (see Annex B).

https://ieeexplore.ieee.org/servlet/opac?punumber=9491982

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Use of Machine Learning for the Estimation of Down- and Up-Link Field Exposure in Multi-Source Indoor WiFi Scenarios

Gabriella Tognola, David Plets, Emma Chiaramello, Silvia Gallucci, Marta Bonato, Serena Fiocchi, Marta Parazzini, Luc Martens, Wout Joseph, Paolo Ravazzani. Use of Machine Learning for the Estimation of Down- and Up-Link Field Exposure in Multi-Source Indoor WiFi Scenarios. Bioelectromagnetics. 2021 Jul 23. doi: 10.1002/bem.22361.

Abstract

A novel Machine Learning (ML) method based on Neural Networks (NN) is proposed to assess radio-frequency (RF) exposure generated by WiFi sources in indoor scenarios. The aim was to build an NN capable of addressing the complexity and variability of real-life exposure setups, including the effects of not only down-link transmission access points (APs) but also up-link transmission by different sources (e.g. laptop, printers, tablets, and smartphones). The NN was fed with easy to be found data, such as the position and type of WiFi sources (APs, clients, and other users) and the position and material characteristics (e.g. penetration loss) of walls. The NN model was assessed using an additional new layout, distinct from that one used to build and optimize the NN coefficients. The NN model achieved a remarkable field prediction accuracy across exposure conditions in both layouts, with a median prediction error of -0.4 to 0.6 dB and a root mean square error of 2.5-5.1 dB, compared with the target electric field estimated by a deterministic indoor network planner. The proposed approach performs well for the different layouts and is thus generally used to assess RF exposure in indoor scenarios.

Open access paper: https://onlinelibrary.wiley.com/doi/10.1002/bem.22361

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Time-temperature Thresholds and Safety Factors for Thermal Hazards from Radiofrequency Energy above 6 GHz

Kenneth R Foster, Marvin C Ziskin, Quirino Balzano. Time-temperature Thresholds and Safety Factors for Thermal Hazards from Radiofrequency Energy above 6 GHz. Health Phys. 2021 Jul 9. doi: 10.1097/HP.0000000000001447.

Abstract

Two major sets of exposure limits for radiofrequency (RF) radiation, those of the International Commission on Nonionizing Radiation Protection (ICNIRP 2020) and the Institute of Electrical and Electronics Engineers (IEEE C95.1-2019), have recently been revised and updated with significant changes in limits above 6 GHz through the millimeter wave (mm-wave) band (30-300 GHz). This review compares available data on thermal damage and pain from exposure to RF energy above 6 GHz with corresponding data from infrared energy and other heat sources and estimates safety factors that are incorporated in the IEEE and ICNIRP RF exposure limits. The benchmarks for damage are the same as used in ICNIRP IR limits: minimal epithelial damage to cornea and first-degree burn (erythema in skin observable within 48 h after exposure). The data suggest that limiting thermal hazard to skin is cutaneous pain for exposure durations less than ≈20 min and thermal damage for longer exposures. Limitations on available data and thermal models are noted. However, data on RF and IR thermal damage and pain thresholds show that exposures far above current ICNIRP and IEEE limits would be required to produce thermally hazardous effects. This review focuses exclusively on thermal hazards from RF exposures above 6 GHz to skin and the cornea, which are the most exposed tissues in the considered frequency range.

https://pubmed.ncbi.nlm.nih.gov/34261892/

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Effects of 5.8 GHz microwave on hippocampal synaptic plasticity of rats

Gang Rui, Li-Yuan Liu, Ling Guo, Yi-Zhe Xue, Pan-Pan Lai, Peng Gao, Jun-Ling Xing, Jing Li, Gui-Rong Ding. Effects of 5.8 GHz microwave on hippocampal synaptic plasticity of rats. Int J Environ Health Res. 2021 Jul 22;1-13. doi: 10.1080/09603123.2021.1952165.

Abstract

Objective 5.8 GHz spectrum is gaining more attention in wireless technology. To explore the potential hazards, we investigated the effect of exposure to 5.8 GHz microwave on learning and memory ability of rats.

Methods Morris Water maze (MWM), Novel object recognition (NOR) and Fear conditioning test (FCT) were used to evaluate the ability of spatial and non-spatial memory of rats. The hippocampal morphology, the level of brain injury factors in serum and the mitochondrial membrane potential of hippocampal neurons was examined to evaluate the damage of hippocampal neurons. The density of dendritic spines, the ultrastructure of synapses

and the level of PSD95, Synaptophysin, p-CREB and CREB were detected to evaluate the hippocampal synaptic plasticity.

Results Compared with Sham group, there was no significant difference in the performance of ethology (in MWM, NOR, FCT) in Microwave 2 h group or Microwave 4 h group. The hippocampal morphology, the serum level of brain injury factors and the content of mitochondrial JC-1 monomer in Microwave 2 h group or Microwave 4 h group did not change obviously, compared with Sham group. The density of dendritic spines, the ultrastructure of synapse and the level of PSD95, Synaptophysin, p-CREB and CREB in hippocampus in Microwave 2 h group or Microwave 4 h group did not significantly change, compared with Sham group.

Conclusion Under this experimental condition, exposure to 5.8 GHz microwave could not affect the hippocampal synaptic plasticity of rats.

https://pubmed.ncbi.nlm.nih.gov/34293966/

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Specific electromagnetic radiation in the wireless signal range increases wakefulness in mice

Lingyu Liu, Hu Deng, Xiaping Tang, Yingxian Lu, Jiayao Zhou, Xiaofei Wang, Yanyu Zhao, Bing Huang, Yigong Shi. Specific electromagnetic radiation in the wireless signal range increases wakefulness in mice.Proc Natl Acad Sci U S A. 2021 Aug 3;118(31):e2105838118. doi: 10.1073/pnas.2105838118.

Abstract

Electromagnetic radiation (EMR) in the environment has increased sharply in recent decades. The effect of environmental EMR on living organisms remains poorly characterized. Here, we report the impact of wireless-range EMR on the sleep architecture of mouse. Prolonged exposure to 2.4-GHz EMR modulated by 100-Hz square pulses at a nonthermal output level results in markedly increased time of wakefulness in mice. These mice display corresponding decreased time of nonrapid eye movement (NREM) and rapid eye movement (REM). In contrast, prolonged exposure to unmodulated 2.4-GHz EMR at the same time-averaged output level has little impact on mouse sleep. These observations identify alteration of sleep architecture in mice as a specific physiological response to prolonged wireless-range EMR exposure.

Open access paper: https://www.pnas.org/content/118/31/e2105838118

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Glioblastoma Cell Migration is Directed by Electrical Signals

Hannah Clancy, Michal Pruski, Bing Lang, Jared Ching, Colin D McCaig. Glioblastoma Cell Migration is Directed by Electrical Signals. Exp Cell Res. 2021 Jul 14;112736. doi: 10.1016/j.yexcr.2021.112736.

Abstract

Electric field (EF) directed cell migration (electrotaxis) is known to occur in glioblastoma multiforme (GBM) and neural stem cells, with key signalling pathways frequently dysregulated in GBM. One such pathway is EGFR/PI3K/Akt, which is down-regulated by peroxisome proliferator activated receptor gamma (PPARγ) agonists. We investigated the effect of electric fields on primary differentiated and glioma stem cell (GSCs) migration, finding opposing preferences for anodal and cathodal migration, respectively. We next sought to determine whether chemically disrupting Akt through PTEN upregulation with the PPARγ agonist, pioglitazone, would modulate electrotaxis of these cells. We found that directed cell migration was significantly inhibited with the addition of pioglitazone in both differentiated GBM and GSCs subtypes. Western blot analysis did not demonstrate any change in PPARγ expression with and without exposure to EF. In summary we demonstrate opposing EF responses in primary GBM differentiated cells and GSCs can be inhibited chemically by pioglitazone, implicating GBM EF modulation as a potential target in preventing tumour recurrence.

https://pubmed.ncbi.nlm.nih.gov/34273404/

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Heisenberg uncertainty of spatially gated electromagnetic fields

Vladimir Y Chernyak, Shaul Mukamel. Heisenberg uncertainty of spatially gated electromagnetic fields. J Chem Phys. 2021 May 7;154(17):174110. doi: 10.1063/5.0045352.

Abstract

A Heisenberg uncertainty relation is derived for spatially-gated electric ΔE and magnetic ΔH field fluctuations. The uncertainty increases for small gating sizes, which implies that in confined spaces, the quantum nature of the electromagnetic field must be taken into account. Optimizing the state of light to minimize ΔE at the expense of ΔH and vice versa should be possible. Spatial confinements and quantum fields may alternatively be realized without gating by interaction of the field with a nanostructure. Possible applications include nonlinear spectroscopy of nanostructures and optical cavities and chiral signals.

https://pubmed.ncbi.nlm.nih.gov/34241063/

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Reflection Properties of the Human Skin From 40 to 110 GHz: A Confirmation Study

Andreas Christ, Adrian Aeschbacher, Fereshteh Rouholahnejad, Theodoros Samaras, Bernadetta Tarigan, Niels Kuster. Reflection Properties of the Human Skin From 40 to 110 GHz: A Confirmation Study. Bioelectromagnetics. 2021 Jul 21. doi: 10.1002/bem.22362.

Abstract

Several recent theoretical dosimetric studies above 6 GHz apply generic layered skin models. For this frequency range, new experimental phantoms for over-the-air performance of wireless devices were proposed that simulate the impedance matching effects of the stratum corneum layer (SCL) with a low-loss coating layer. The aim of this study was to verify the skin models by comparing their reflection coefficients S11 with measurements of 37 human volunteers (21 males, 16 females, 5-80 years) at 21 body locations (10 at palm, 11 at arm/face) with different SCL thicknesses, using waveguides covering frequencies from 40 to 110 GHz. Such measurements were also carried out with the phantom material. The statistical analysis showed strong evidence that S11 depends on the SCL thickness and no evidence that S11 depends on sex. The measured S11 values for thin and thick skin can be represented by SCL layers of 15 and 140 µm, respectively. These values correspond well to the assumptions of previous studies. (The cohort did not include volunteers doing heavy manual work.) The phantom material mimics the matching effect of the SCL with deviations from the waveguide measurements of less than 0.85 dB (22%), which confirms the suitability of layered phantoms to represent the electromagnetic reflection/absorption of human skin

https://pubmed.ncbi.nlm.nih.gov/34289515/

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Electromagnetic Field Exposure in Kindergarten Children: Responsive Health Risk Concern

Shiva Raj Acharya, Yong Chul Shin, Deog Hwan Moon, Sandip Pahari. Electromagnetic Field Exposure in Kindergarten Children: Responsive Health Risk Concern. Front Pediatr. 2021 Jul 5;9:694407. doi: 10.3389/fped.2021.69.

Abstract

Long-term exposure to physical agents can be detrimental to children due to their vulnerability. This study aimed to assess and compare the electromagnetic field (EMF) exposure level around the kindergartens from the underground transmission line (UGTL). We investigated randomly selected 24 kindergartens based on the location of the UGTL. The EMF emission levels were measured using an EMDEX II (Electric and Magnetic Digital Exposure Meter). The maximum mean value of the EMF emission level was 13.5 mG around the kindergartens and 17.7 mG from the point of UGTL to kindergartens. EMF emission level around the kindergartens was significantly associated with the location of the UGTL (t = -7.35, P < 0.001). These estimates are not trivial, as long-term exposure to EMF among kindergarten children can lead to different health problems. Routine monitoring of EMF emission levels is recommended including the awareness of EMF exposure to public citizens.

Open access paper: https://www.frontiersin.org/articles/10.3389/fped.2021.694407/full

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Radiofrequency Exposure Levels from Mobile Phone Base Stations in Outdoor Environments and an Underground Shopping Mall in Japan

Teruo Onishi, Miwa Ikuyo, Kazuhiro Tobita, Sen Liu, Masao Taki, Soichi Watanabe. Radiofrequency Exposure Levels from Mobile Phone Base Stations in Outdoor Environments and an Underground Shopping Mall in Japan. Int. J. Environ. Res. Public Health 2021, 18(15), 8068; doi: 10.3390/ijerph18158068.

(This article belongs to the Special Issue Occupational and General Public Exposure to Electromagnetic Fields)

Abstract

Recent progress in wireless technologies has made human exposure to electromagnetic fields (EMFs) increasingly complex. The situation can increase public concerns related to possible health effects due to EMF exposure. Monitoring EMF exposure levels and characterizing them are indispensable for risk communications of human exposure to EMFs. From this background, a project on the acquisition, accumulation, and applications of EMF exposure monitoring data in Japan was started in 2019. One of the objectives of this project is to obtain a comprehensive picture of EMF exposure in actual daily lives. In 2019 and 2020, we measured the electric field (E-field) strength from mainly mobile phone base stations in the same areas as those in measurements conducted in 2006 and 2007 by the Ministry of Internal Affairs and Communications (MIC), Japan, and compared the data to investigate the time-course of the EMF environment. The number of measured points was 100 (10 × 10 grids) in an area of 1 km × 1 km in two urban and two suburban areas, and that in an underground shopping mall was 158. This large-scale study is the first in Japan. As a result, we found that the measured E-field strengths tended to be higher in 2019 and 2020 than those in 2006 and 2007, especially in the mall. However, the median ratios to the Japanese radio wave protection guideline values for urban areas and malls are lower than −40 dB.

Excerpts

"Measurement results were compared with limits in general environments in the radio wave protection guidelines in Japan, as shown in Table 2. The E-field strength in the radio wave protection guidelines is proportional to the square root of the frequency in between 300 MHz and 1.5 GHz and is constant at 61.4 V/m (155.76 dBμV/m) at frequencies above 1.5 GHz [25]. The minimum E-field strength in the guidelines at the target frequency of this measurement is 44.1 V/m (152.89 dBμV/m). Therefore, the ratio to the guideline value in each frequency band and the sum of squares were calculated. A measurement of 0 dB means the same level as the limits. As shown in Table 2, the maximum ratios in the urban areas and the mall are about 10 times higher than those in the suburban areas; however, they were lower than −20 dB from the level of the Japanese guidelines. If we focus on the median value, the ratio is approximately on the order of the −40 dB from the limit."

"The results of E-field strength measurements in mobile phone base stations, which are one of the main sources of EMF exposure in the general environment, namely in outdoor environments and an underground shopping mall in Japan in 2019 and 2020, have been presented. The measurements were conducted in the same areas as those conducted by MIC, Japan, in 2006 and 2007.

As a result, we found that the total median E-field strengths in the urban areas are about 7 dB larger than those in the suburban areas. The E-field strengths in the urban areas also tend to be larger than those in the suburban areas in individual frequency bands. For the shopping mall, it is clear that the differences in E-field strengths between daytime and night-time are marginal. The E-field strengths in the 2000 and 3500 MHz bands are larger

than those in other bands. The E-field strengths in the 2400 MHz ISM band are the same as those in the 2000 MHz band, whereas the median E-field strengths in the 5000 MHz ISM bands are 5–9 dB smaller.

The measured results were compared with the Japanese radio wave protection guidelines. As a result, we found amounts lower than the limits by −20 dB. If the median E-field strength is focused on, the ratio is approximately on the order of −40 dB with respect to the limit. Compared with the previous data in 2006 and 2007, it is clear that the E-field strengths in both outdoor environments and the mall increased, especially in the mall, whose ratio of the E-field strength in 2007 to that in 2020 is 20.3 dB. Although the present measurement conditions are not precisely the same as those in the previous measurements, it is useful to investigate the time-course of EMFs in various environments. Additionally, the E-field strengths we obtained in outdoor environments are slightly smaller than those in another country.

Since our measurements were carried out before the start of 5G commercial service, the exposure level at the frequency band used in 5G was not included. However, measurements of exposure levels for 5G and new radio waves used will be continued. Due to the limited time and space of the measurements in this study, exposure level data under various conditions of daily life will be accumulated in the future."

Open access paper: https://www.mdpi.com/1660-4601/18/15/8068

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Epigenetic dysregulation in various types of cells exposed to extremely low-frequency magnetic fields (Review)

Gianfranco Giorgi, Brunella Del Re. Epigenetic dysregulation in various types of cells exposed to extremely low-frequency magnetic fields. Cell Tissue Res. 2021 Jul 21. doi: 10.1007/s00441-021-03489-6.

Abstract

Epigenetic mechanisms regulate gene expression, without changing the DNA sequence, and establish cell-type-specific temporal and spatial expression patterns. Alterations of epigenetic marks have been observed in several pathological conditions, including cancer and neurological disorders. Emerging evidence indicates that a variety of environmental factors may cause epigenetic alterations and eventually influence disease risks. Humans are increasingly exposed to extremely low-frequency magnetic fields (ELF-MFs), which in 2002 were classified as possible carcinogens by the International Agency for Research on Cancer. This review summarizes the current knowledge of the link between the exposure to ELF-MFs and epigenetic alterations in various cell types. In spite of the limited number of publications, available evidence indicates that ELF-MF exposure can be associated with epigenetic changes, including DNA methylation, modifications of histones and microRNA expression. Further research is needed to investigate the molecular mechanisms underlying the observed phenomena.

https://pubmed.ncbi.nlm.nih.gov/34287715/

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Effect of the Electromagnetic Field (EMF) Radiation on Transcriptomic Profile of Pig Myometrium during the Peri-Implantation Period-An In Vitro Study

Ewa Monika Drzewiecka, Wiktoria Kozlowska, Lukasz Paukszto, Agata Zmijewska, Pawel Jozef Wydorski, Jan Pawel Jastrzebski, Anita Franczak. Effect of the Electromagnetic Field (EMF) Radiation on Transcriptomic Profile of Pig Myometrium during the Peri-Implantation Period-An In Vitro Study. Int J Mol Sci. 2021 Jul 7;22(14):7322. doi: 10.3390/ijms22147322.

Abstract

The electromagnetic field (EMF) affects the physiological processes in mammals, but the molecular background of the observed alterations remains not well established. In this study was tested the effect of short duration (2 h) of the EMF treatment (50 Hz, 8 mT) on global transcriptomic alterations in the myometrium of pigs during the peri-implantation period using next-generation sequencing. As a result, the EMF treatment affected the expression of 215 transcript active regions (TARs), and among them, the assigned gene protein-coding biotype possessed 90 ones (differentially expressed genes, DEGs), categorized mostly to gene ontology terms connected with defense and immune responses, and secretion and export. Evaluated DEGs enrich the KEGG TNF signaling pathway, and regulation of IFNA signaling and interferon-alpha/beta signaling REACTOME pathways. There were evaluated 12 differentially expressed long non-coding RNAs (DE-lnc-RNAs) and 182 predicted single nucleotide variants (SNVs) substitutions within RNA editing sites. In conclusion, the EMF treatment in the myometrium collected during the peri-implantation period affects the expression of genes involved in defense and immune responses. The study also gives new insight into the mechanisms of the EMF action in the regulation of the transcriptomic profile through lnc-RNAs and SNVs.

https://pubmed.ncbi.nlm.nih.gov/34298942/

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Magnetic Field Affects Growth and Yield of Sunflower Under Different Moisture Stress Conditions

Ananta Vashisth, Neetu Meena, Prameela Krishnan. Magnetic Field Affects Growth and Yield of Sunflower Under Different Moisture Stress Conditions. Bioelectromagnetics. 26 June 2021/ doi: 10.1002/bem.22354

Abstract

Magnetic field treatments of seeds have shown significant effects on the enhancement of crop growth. Soil moisture stress is the major constraint in the production of the sunflower crop. Therefore, the experiment was conducted to investigate the effect of a 200 mT magnetic field for 2 h on crop growth, and yield of sunflower crops raised from magnetically treated seeds sown under different moisture stress conditions. Results showed that plants from magnetically treated seeds had higher leaf area index, shoot length, number of leaves, chlorophyll content, biomass, 1000-seed mass, and seed yield as compared with untreated. Radiation use efficiency and water productivity were significantly higher in plants raised from magnetically treated seeds than

untreated seeds. Crop raised from magnetically treated seeds had 6.2% more seed yield, 7.1% more protein, and oil content as compared with crops raised from untreated seeds. Hence, it may be concluded that exposure of dry sunflower seeds to the static magnetic field of 200 mT for 2 h could be used for improving crop growth and yield under different moisture stress conditions.

https://onlinelibrary.wiley.com/doi/10.1002/bem.22354

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Changes in Body Temperature of Small Mammals and Birds in a Few Minutes Range as Reflection of Environmental Influences

M E Diatroptov. Changes in Body Temperature of Small Mammals and Birds in a Few Minutes Range as Reflection of Environmental Influences. Bull Exp Biol Med. 2021 Jul 23. doi: 10.1007/s10517-021-05234-z.

Abstract

The study examined the changes in intraperitoneal body temperature of laboratory mice, Jungar hamsters, European greenfinch Chloris chloris, and starlings. In a few minutes range, these changes significantly correlated not only between the animals of the same species, but also between the different classes such as birds and mammals, which were isolated from each other and maintained under different illumination regimen. This phenomenon indicates some external influence(s) on the central mechanisms of the thermal control system not related to illumination regiment. In 80% cases, the phases of most pronounced rhythms of body temperature oscillating with the periods of 8-9 and 12-13 min coincided with those of geomagnetic field within the accuracy of ±1 min. However, the amplitude of body temperature oscillations did not depend on the amplitude of geomagnetic field (GMF) oscillations. Synchronicity of the changes in body temperature and GMF was observed at the amplitude of GMF oscillation of 0.4 nT, which is extremely low value. In contrast, there was no reaction of body temperature to greater (6-10 nT) but irregular and abrupt perturbations of GMF.

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Methods and Experiments for Sensing Variations in Solar Activity and Defining Their Impact on Heart Variability

Michael Hanzelka, Jiří Dan, Zoltán Szabó, Zdeněk Roubal, Přemysl Dohnal, Radim Kadlec. Methods and Experiments for Sensing Variations in Solar Activity and Defining Their Impact on Heart Variability. Sensors (Basel). 2021 Jul 14;21(14):4817. doi: 10.3390/s21144817.

Abstract

This paper evaluates variations in solar activity and their impact on the human nervous system, including the

manner in which human behavior and decision-making reflect such effects in the context of (symmetrical) social interactions. The relevant research showed that solar activity, manifesting itself through the exposure of the Earth to charged particles from the Sun, affects heart variability. The evaluation methods focused on examining the relationships between selected psychophysiological data and solar activity, which generally causes major alterations in the low-level electromagnetic field. The investigation within this paper revealed that low-level EMF changes are among the factors affecting heart rate variability and, thus, also variations at the spectral level of the rate, in the VLF, (f = 0.01-0.04 Hz), LF (f = 0.04-0.15 Hz), and HF (f = 0.15 až 0.40 Hz) bands. The results of the presented experiments can also be interpreted as an indirect explanation of sudden deaths and heart failures.

https://pubmed.ncbi.nlm.nih.gov/34300557/

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Effects of communicating uncertainty descriptions in hazard identification, risk characterization, and risk protection

Peter Wiedemann, Franziska U Boerner, Frederik Freudenstein. Effects of communicating uncertainty descriptions in hazard identification, risk characterization, and risk protection. PLoS One. 2021 Jul 13;16(7):e0253762. doi: 10.1371/journal.pone.0253762.

Abstract

Uncertainty is a crucial issue for any risk assessment. Consequently, it also poses crucial challenges for risk communications. Many guidebooks advise reporting uncertainties in risk assessments, expecting that the audience will appreciate this disclosure. However, the empirical evidence about the effects of uncertainty reporting is sparse and inconclusive. Therefore, based on examples of potential health risks of electromagnetic fields (EMF), three experiments were conducted analysing the effects of communicating uncertainties separately for hazard identification, risk characterisation and risk protection. The setups aimed to explore how reporting and how explaining of uncertainty affects dependent variables such as risk perception, perceived competence of the risk assessors, and trust in risk management. Each of the three experiments used a 2x2 design with a first factor presenting uncertainty descriptions (as used in public controversies on EMF related health effects) or describing a certainty conditions; and a second factor explaining the causes of uncertainties (by pointing at knowledge gaps) or not explaining them. The study results indicate that qualitative uncertainty descriptions regarding hazard identification reduce the confidence in the professional competencies of the assessors. In contrast, a quantitative uncertainty description in risk characterisation-regarding the magnitude of the risk-does not affect any of the dependent variables. Concerning risk protection, trust in exposure limit values is not affected by qualitative uncertainty information. However, the qualitative description of uncertainty regarding the adequacy of protection amplifies fears. Furthermore, explaining this uncertainty results in lower text understandability.

Conclusions

Our experiments provide several implications for reporting uncertainties. They show that informing about uncertainties is not always a means for improving trust and credibility. Science skeptics and activists with a particular political agenda might instrumentalize uncertainty for spreading distrust in science, primarily when uncertainty refers to hazard identification. Risk communicators should be aware that admitting uncertainty is a double-edged sword. Laypersons might attribute it to the lack of professional expertise.

Further research should focus on the issues of cognitive resources and prior beliefs. It should focus on how the recipients interpret the specific social context in which the information is given and how the recipients' cognitive resources, motivations to process information, and their prior beliefs influence uncertainty information interpretation. These issues could be tackled by dual-process theories developed in judgment and decision-making [53]. Recipients might understand the same information differently depending on whether the information is processed by elaborative or heuristic cognition. Furthermore, prior beliefs shape the interpretation of uncertainties in risk assessment. This issue can be tackled by theories that explain how motivated reasoning influences judgments and opinions about uncertainty information [54].

Finally, we would like to stress the importance of the performative goal of informing about uncertainty. It makes a massive difference whether uncertainty is used to raise fears and distrust in science or honestly report the limits of evidence-based knowledge. Further research should pay more attention to this subject. New studies could learn from the analysis of the politicization of science [16] that has focused on how uncertainty is exploited for undermining trust in science.

Open access paper: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0253762

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Effects of pulsed electromagnetic fields on tumor cell viability: a meta-analysis of in vitro randomized controlled experiments

Guangzhou An, Meilun Shen, Juan Guo, Xia Miao, Yuntao Jing, Keying Zhang, Ling Guo, Junling Xing. Effects of pulsed electromagnetic fields on tumor cell viability: a meta-analysis of in vitro randomized controlled experiments. Electromagn Biol Med. 2021 Jul 26;1-8. doi: 10.1080/15368378.2021.1958341.

Abstract

Malignant tumor treatment remains a big challenge till now, and expanding literature indicated that pulsed electromagnetic fields (PEMF) is promising in tumor treatment with the advantage of safety and being economical, but it is still controversial on whether PEMF could affect the tumor cell viability. Therefore, we conducted the meta-analysis to evaluate effects of PEMF on tumor cell viability. The PubMed, EMBASE, Web of Science, and Cochrane Library databases were searched for studies published up to February 2021. Studies on the direct effects of PEMF on tumor cell viability, determined using colorimetric analysis, were included. Two authors extracted the data and completed the quality assessment. A meta-analysis was performed to calculate the absorbance values and 95% confidence intervals (CIs) using random-effects models. Seven studies, including 32 randomized controlled experiments, were analyzed. Compared with the control group, tumor cell viability in

the PEMF exposure group was obviously lower (SMD, -0.67; 95% CI: -1.12 to -0.22). The subgroup meta-analysis results showed that PEMF significantly reduced epithelial cancer cell viability (SMD, -0.58; 95% CI: -0.92 to -0.23) but had no influence on stromal tumor cell viability (SMD, -0.93; 95% CI: -0.21 to 0.15). Our study demonstrated that PEMF could inhibit tumor cell proliferation to some extent, but the risk of bias and high heterogeneity (I2 > 75%) weakened the strength of the conclusions drawn from the analysis.

https://pubmed.ncbi.nlm.nih.gov/34311647/

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Health Council of the Netherlands and evaluation of the fifth generation, 5G, for wireless communication and cancer risks

Lennart Hardell. Health Council of the Netherlands and evaluation of the fifth generation, 5G, for wireless communication and cancer risks. World J Clin Oncol 2021; 12(6): 393-403 doi: 10.5306/wjco.v12.i6.393.

Abstract

Currently the fifth generation, 5G, for wireless communication is about to be rolled out worldwide. Many persons are concerned about potential health risks from radiofrequency radiation. In September 2017, a letter was sent to the European Union asking for a moratorium on the deployment until scientific evaluation has been made on potential health risks (http://www.5Gappeal.eu). This appeal has had little success. The Health Council of the Netherlands released on September 2, 2020 their evaluation on 5G and health. It was largely based on a World Health Organization draft and report by the Swedish Radiation Safety Authority, both criticized for not being impartial. The guidelines by the International Commission on Non-Ionizing Radiation Protection were recommended to be used, although they have been considered to be insufficient to protect against health hazards (http://www.emfscientist.org). The Health Council Committee recommended not to use the 26 GHz frequency band until health risks have been studied. For lower frequencies, the International Commission on Non-Ionizing Radiation Protection guidelines were recommended. The conclusion that there is no reason to stop the use of lower frequencies for 5G is not justified by current evidence on cancer risks as commented in this article. A moratorium is urgently needed on the implementation of 5G for wireless communication.

Core Tip: In this comment, guidelines for radiofrequency radiation are discussed in relation to a recent evaluation by the Health Council of the Netherlands. The Committee recommends that for the deployment of 5G the frequency band 26 GHz should not be used. For lower frequencies, the International Commission on Non-Ionizing Radiation Protection guidelines are recommended. However, these guidelines are not based on an objective evaluation of health risks, which is discussed in this paper.

Conclusion

In conclusion regarding cancer, current scientific evidence clearly demonstrates an increased risk for glioma and acoustic neuroma for use of mobile and/or cordless phones. In this review other tumor types and health endpoints are not discussed. The increased risk for brain and head tumors is based on human cancer epidemiology studies and is supported by similar tumor types found in animal studies. In fact, these animal studies confirmed the earlier results in case-control studies on increased tumor risk for use of wireless phones (both mobile and cordless phones). Mechanistic aspects on carcinogenesis come from laboratory findings on, e.g., the increase of reactive oxygen species [5] and DNA damage [4]. The current evaluation by the Health

Council of the Netherlands is based on a WHO draft and SSM report. It also recommends using ICNIRP guidelines, considered to be insufficient to protect against health hazards, such as cancer, by the majority of the scientists in this field (https://www.emfscientist.org). The report does not represent a thorough, balanced, objective, and up-to-date evaluation of cancer risks and other hazardous effects from RF radiation. It is also strikingly contradictory as it concludes that serious health effects such as cancer and birth defects are "possible." Yet it has no objection to the roll-out of 5G and recommends that later studies are performed to study health outcomes such as cancer and birth defects. Thus, no lessons are learned from existing observations on increased cancer risks [49]. The conclusion by the Commission that there is no reason to stop the use of lower frequencies for 5G up to 3.5 GHz because of no "proven adverse health effects," merely reflects the biased conclusions by ICNIRP dominated groups. Thus that conclusion must be dismissed, and new guidelines for previous and new frequencies must be established considering the new technology, the different propagation pattern for 5G, and increased RF radiation. A moratorium is urgently required on the implementation of 5G for wireless communication [13]. Ultimately, wired solutions are preferred.

Open access paper: https://www.wjgnet.com/2218-4333/full/v12/i6/393.htm

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The Critical Importance of Molecular Biomarkers and Imaging in the Study of Electrohypersensitivity. A Scientific Consensus International Report

Belpomme, Dominique, George L. Carlo, Philippe Irigaray, David O. Carpenter, Lennart Hardell, Michael Kundi, Igor Belyaev, Magda Havas, Franz Adlkofer, Gunnar Heuser, Anthony B. Miller, Daniela Caccamo, Chiara De Luca, Lebrecht von Klitzing, Martin L. Pall, Priyanka Bandara, Yael Stein, Cindy Sage, Morando Soffritti, Devra Davis, Joel M. Moskowitz, S. M.J. Mortazavi, Martha R. Herbert, Hanns Moshammer, Gerard Ledoigt, Robert Turner, Anthony Tweedale, Pilar Muñoz-Calero, Iris Udasin, Tarmo Koppel, Ernesto Burgio, and André Vander Vorst. 2021. "The Critical Importance of Molecular Biomarkers and Imaging in the Study of Electrohypersensitivity. A Scientific Consensus International Report" *International Journal of Molecular Sciences* 22(14):7321. doi:10.3390/ijms22147321.

Abstract

Clinical research aiming at objectively identifying and characterizing diseases via clinical observations and biological and radiological findings is a critical initial research step when establishing objective diagnostic criteria and treatments. Failure to first define such diagnostic criteria may lead research on pathogenesis and etiology to serious confounding biases and erroneous medical interpretations. This is particularly the case for electrohypersensitivity (EHS) and more particularly for the so-called "provocation tests", which do not investigate the causal origin of EHS but rather the EHS-associated particular environmental intolerance state with hypersensitivity to man-made electromagnetic fields (EMF). However, because those tests depend on multiple EMF-associated physical and biological parameters and have been conducted in patients without having first defined EHS objectively and/or endpoints adequately, they cannot presently be considered to be valid pathogenesis research methodologies. Consequently, the negative results obtained by these tests do not preclude a role of EMF exposure as a symptomatic trigger in EHS patients. Moreover, there is no proof that EHS symptoms or EHS itself are caused by psychosomatic or nocebo effects. This international consensus report pleads for the acknowledgement of EHS as a distinct neuropathological disorder and for its inclusion in the WHO International Classification of Diseases.

Open access paper: https://www.mdpi.com/1422-0067/22/14/7321

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Review of the scientific evidence on the individual sensitivity to electromagnetic fields (EHS)

Dariusz Leszczynski. Review of the scientific evidence on the individual sensitivity to electromagnetic fields (EHS). Rev Environ Health. 2021 Jul 6. doi: 10.1515/reveh-2021-0038.

Abstract

Part of the population considers themselves as sensitive to the man-made electromagnetic radiation (EMF) emitted by powerlines, electric wiring, electric home appliance and the wireless communication devices and networks. Sensitivity is characterized by a broad variety of non-specific symptoms that the sensitive people claim to experience when exposed to EMF. While the experienced symptoms are currently considered as a real life impairment, the factor causing these symptoms remains unclear. So far, scientists were unable to find causality link between symptoms experienced by sensitive persons and the exposures to EMF. However, as presented in this review, the executed to-date scientific studies, examining sensitivity to EMF, are of poor quality to find the link between EMF exposures and sensitivity symptoms of some people. It is logical to consider that the sensitivity to EMF exists but the scientific methodology used to find it is of insufficient quality. It is time to drop out psychology driven provocation studies that ask about feelings-based non-specific symptoms experienced by volunteers under EMF exposure. Such research approach produces only subjective and therefore highly unreliable data that is insufficient to prove, or to disprove, causality link between EHS and EMF. There is a need for a new direction in studying sensitivity to EMF. The basis for it is the notion of a commonly known phenomenon of individual sensitivity, where individuals' responses to EMF depend on the genetic and epigenetic properties of the individual. It is proposed here that new studies, combining provocation approach, where volunteers are exposed to EMF, and high-throughput technologies of transcriptomics and proteomics are used to generate objective data, detecting molecular level biochemical responses of human body to EMF.

Final conclusions

– Problems and solutions for EHS research are summarized in Figure 2.
– Over the last 30 years, a sizable number of research studies has examined causality link between EMF exposures and EHS symptoms.
– The majority of the studies did not find any link between EMF and EHS.
– The EHS studies have examined acute effects but did not have capability to examine delayed EMF responses.
– The major problem is that scientists do not know whether EHS volunteers have indeed correct self-diagnosis of EHS or whether the diagnosis is incorrect and experimental groups are contaminated, to unknown degree, by non-EHS persons. In extreme situation, the small group of volunteers used in research study might have no EHS persons at all.
– Recently, research on EHS has drifted into direction of nocebo as the cause of EHS, what is incorrect.
– Instead of studying obvious impact of nocebo, or likes of medical students' disease, research should focus on finding suitable biochemical and biophysical markers that could be used, in combination with single individual-focused provocation studies, to determine the sources of the EHS symptoms.
– The opinion that there is no causality link between EHS and EMF is unproven. This opinion, expressed by the World Health Organization EMF Project, the International Commission on Non-Ionizing Radiation Protection, International Committee on Electromagnetic Safety and numerous governmental organizations, should be

revised because the scientific research data
is of insufficient quality to be used as a proof of the lack of causality

https://www.degruyter.com/document/doi/10.1515/reveh-2021-0038/html

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Nonmalignant meningioma and vestibular schwannoma incidence trends in the United States, 2004-2017

Diana R Withrow, Susan S Devesa, Dennis Deapen, Valentina Petkov, Alison L Van Dyke, Margaret Adamo, Terri S Armstrong, Mark R Gilbert, Martha S Linet. Nonmalignant meningioma and vestibular schwannoma incidence trends in the United States, 2004-2017. Cancer. 2021 Jun 23. doi: 10.1002/cncr.33553.

Abstract

Background: Given concerns about risks associated with the growing use of mobile phones over recent decades, the authors analyzed temporal trends in incidence rates of nonmalignant meningioma and vestibular schwannoma in the United States.

Methods: The incidence of nonmalignant meningioma and vestibular schwannoma among adults in the Surveillance, Epidemiology, and End Results 18 registries during 2004 through 2017 was evaluated according to the method of diagnosis: microscopically (MC) or radiographically confirmed (RGC). Annual percent changes (APCs) and 95% CIs were estimated using log-linear models.

Results: Overall meningioma rates (n = 108,043) increased significantly from 2004 to 2009 (APC, 5.4%; 95% CI, 4.4%-6.4%) but subsequently rose at a slower pace through 2017 (APC, 1.0%; 95% CI, 0.6%-1.5%). Rates for MC meningiomas changed little from 2004 to 2017 (APC, -0.3%; 95% CI, -0.7%, 0.1%) but rose rapidly for RGC meningiomas until 2009 (APC, 9.5%; 95% CI, 7.8%-11.1%) and rose more modestly thereafter (APC, 2.3%; 95% CI, 1.5%-3.0%). Overall vestibular schwannoma rates (n = 17,475) were stable (APC, 0.4%; 95% CI, -0.2%, 1.0%), but MC vestibular schwannoma rates decreased (APC, -1.9%; 95% CI, -2.7%, -1.1%), whereas RGC vestibular schwannoma rates rose (2006-2017: APC, 1.7%; 95% CI, 0.5%-3.0%). For each tumor, the trends by diagnostic method were similar for each sex and each racial/ethnic group, but RGC diagnosis was more likely in older patients and for smaller tumors. Meningioma trends and the proportion of RGC diagnoses varied notably by registry.

Conclusions: Overall trends obscured differences by diagnostic method in this first large, detailed assessment, but the recent stable rates argue against an association with mobile phone use. Variation among registries requires evaluation to improve the registration of these nonmalignant tumors.

Lay summary: The etiology of most benign meningiomas and vestibular schwannomas is poorly understood, but concerns have been raised about whether mobile phone use contributes to risk of developing these tumors. Descriptive studies examining temporal trends could provide insight; however, globally, few registries collect these nonmalignant cases. In the United States, reporting benign meningiomas and vestibular schwannomas became required by law in 2004. This was the first large, systematic study to quantify and characterize incidence trends for meningioma and vestibular schwannoma according to whether the tumors were diagnosed microscopically or only radiographically. Differential trends across registries and by diagnostic method suggest that caution should be used when interpreting the patterns.

https://pubmed.ncbi.nlm.nih.gov/34160068/

Excerpts

"Etiologic factors for most benign meningiomas and vestibular schwannomas (acoustic neuromas) are poorly understood, but concerns have long been raised about whether mobile phone use may initiate or promote the occurrence of these central nervous system (CNS) tumors. 1, 2 Analytic epidemiologic studies assessing mobile phone use and the risk of meningiomas have shown no association for a duration of use >10 years (see Supporting Table 1). For vestibular schwannomas, long-term mobile phone use has not been consistently linked with risk, but there is heterogeneity among investigations, and elevated risks were observed in a few studies for a duration of use >10 years (see Supporting Table 2). 2"

"The evaluation of a statistical association between mobile phone use and risk of meningioma or vestibular schwannoma was not feasible because of the descriptive epidemiologic study methods used, along with a lack of detailed data on the history, frequency, and hours per day, per week, or per month of mobile phone use from patients with benign brain tumors and from an appropriate comparison group."

"The potentially large impact of these nonetiologic factors on the incidence trends and the modest increases in meningiomas and stable vestibular schwannoma rates in recent years argue against a substantial effect of the huge increases in mobile phone use on underlying disease risk. This conclusion assumes, however, that the latency period is not many decades in length."

My comment: Although the case-control research examining the association between mobile phone use and meningioma yields mixed results, this study found that the incidence of meningioma in the U.S. was still increasing from 2009 on, just at a slower pace.

The results from the epidemiologic research examining the association between mobile phone use and acoustic neuroma is more consistent; however, the latency for tumor identification can be 20 or more years.

The smartphone started to become popular in the U.S. in 2007 with the first iPhone and in 2008 with Android phones. In many smartphones the cellular transmission antennas are located in the bottom of the handset so the neck, not the head, is likely to receive the greatest microwave radiation exposure among those who place the phone by their ear. Two case-control studies found an association between thyroid cancer and mobile phone use, and thyroid cancer incidence has been rapidly increasing in many countries including the U.S.

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Immunity and electromagnetic fields

Piotr Piszczek, Karolina Wójcik-Piotrowicz, Krzysztof Gil, Jolanta Kaszuba-Zwoińska. Immunity and electromagnetic fields. Environ Res. 2021 Jun 11;111505. doi: 10.1016/j.envres.2021.111505.

Abstract

Despite many studies, the question about the positive or negative influence of electromagnetic fields (EMF) on living organisms still remains an unresolved issue. To date, the results are inconsistent and hardly comparable between different laboratories. The observed bio-effects are dependent not only on the applied EMF itself, but on many other factors such as the model system tested or environmental ones. In an organism, the role of the

defense system against external stressors is played by the immune system consisting of various cell types. The immune cells are engaged in many physiological processes and responsible for the proper functioning of the whole organism. Any factor with an ability to cause immunomodulatory effects may weaken or enhance the response of the immune system. This review is focused on a wide range electromagnetic fields as a possible external factor which may modulate the innate and/or adaptive immunity. Considering the existing databases, we have compiled the bio-effects evoked by EMF in particular immune cell types involved in different types of immune response, with the common mechanistic models and mostly activated intracellular signaling cascade pathways.

https://pubmed.ncbi.nlm.nih.gov/34126050/

Highlights

• Immune system cells are influenced by exposure to EMFs.
• EMFs might modulate effector activities of immune response.
• Bio-effectiveness is related to the frequency range of EMFs and cell types.
• Cellular changes might be enhanced by synergic effects of EMFs and other stressors.

Conclusions

Currently it is extremely difficult to select an intracellular mechanism that could play a dominant role in viability and/or effector activities modulation of various types of immune cells under EMF exposure in a wide range of parameters. The large number of results obtained for various EMF parameters and experimental conditions do not allow for a simple comparison of findings across different laboratories. Nevertheless, most of the studies are in agreement that:

(i) there is no generally accepted physical and/or biological mechanism of EMF action independently on type of the studies (i.e., in vivo/in vitro);
(ii) there is lack of conclusive evidence of EMF genotoxic effects;
(iii) findings concerning intracellular effects such as EMF-induced modulation of: gene expression, heat-shock proteins level, surface of cell membrane and cell morphology, signal transduction pathways, ions homeostasis and level of ROS cannot be excluded;
(iv) significant bio-effects are noticed for simultaneous EMF exposure with other cell stimuli (synergic effects);
(v) the response of various immune cells differs in an EMF type-dependent manner;
(vi) multidirectional research on immune cell cultures are certainly needed to be continued to understand potential risk of EMF exposure;
(vii) the influence of EMF on the innate immunity seems to be interesting issue in the context of aging process (Pawelec et al., 2020).

In summary, EMF seem to be a promising tool for modulation of various immune cell signaling pathways and immune system responses. Moreover, the studies concerning the action of electromagnetic fields alone or combined with medicaments are embedded in the mainstream of interests of EMF-related research in medicine and health care.

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Male cellular telephone exposure, fecundability, and semen quality: results from two preconception cohort studies

E E Hatch, S K Willis, A K Wesselink, E M Mikkelsen, M L Eisenberg, G J Sommer, H T Sorensen, K J Rothman, L A Wise. Male cellular telephone exposure, fecundability, and semen quality: results from two preconception cohort studies. Hum Reprod. 2021 Apr 20;36(5):1395-1404. doi: 10.1093/humrep/deab001.

Abstract

Study question: To what extent is exposure to cellular telephones associated with male fertility?

Summary answer: Overall, we found little association between carrying a cell phone in the front pants pocket and male fertility, although among leaner men (BMI <25 kg/m2), carrying a cell phone in the front pants pocket was associated with lower fecundability.

What is known already: Some studies have indicated that cell phone use is associated with poor semen quality, but the results are conflicting.

Study design, size, duration: Two prospective preconception cohort studies were conducted with men in Denmark (n = 751) and in North America (n = 2349), enrolled and followed via the internet from 2012 to 2020.

Participants/materials, setting, methods: On the baseline questionnaire, males reported their hours/day of carrying a cell phone in different body locations. We ascertained time to pregnancy via bi-monthly follow-up questionnaires completed by the female partner for up to 12 months or until reported conception. We used proportional probabilities regression models to estimate fecundability ratios (FRs) and 95% confidence intervals (CIs) for the association between male cell phone habits and fecundability, focusing on front pants pocket exposure, within each cohort separately and pooling across the cohorts using a fixed-effect meta-analysis. In a subset of participants, we examined selected semen parameters (semen volume, sperm concentration and sperm motility) using a home-based semen testing kit.

Main results and the role of chance: There was little overall association between carrying a cell phone in a front pants pocket and fecundability: the FR for any front pants pocket exposure versus none was 0.94 (95% CI: 0.0.83-1.05). We observed an inverse association between any front pants pocket exposure and fecundability among men whose BMI was <25 kg/m2 (FR = 0.72, 95% CI: 0.59-0.88) but little association among men whose BMI was ≥25 kg/m2 (FR = 1.05, 95% CI: 0.90-1.22). There were few consistent associations between cell phone exposure and semen volume, sperm concentration, or sperm motility.

Limitations, reasons for caution: Exposure to radiofrequency radiation from cell phones is subject to considerable non-differential misclassification, which would tend to attenuate the estimates for dichotomous comparisons and extreme exposure categories (e.g. exposure 8 vs. 0 h/day). Residual confounding by occupation or other unknown or poorly measured factors may also have affected the results.

Wider implications of the findings: Overall, there was little association between carrying one's phone in the front pants pocket and fecundability. There was a moderate inverse association between front pants pocket cell phone exposure and fecundability among men with BMI <25 kg/m2, but not among men with BMI ≥25 kg/m2. Although several previous studies have indicated associations between cell phone exposure and lower sperm motility, we found few consistent associations with any semen quality parameters.

Study funding/competing interest(s): The study was funded by the National Institutes of Health, grant number R03HD090315. In the last 3 years, PRESTO has received in-kind donations from Sandstone Diagnostics (for

semen kits), Swiss Precision Diagnostics (home pregnancy tests), Kindara.com (fertility app), and FertilityFriend.com (fertility app). Dr. L.A.W. is a fibroid consultant for AbbVie, Inc. Dr. H.T.S. reports that the Department of Clinical Epidemiology is involved in studies with funding from various companies as research grants to and administered by Aarhus University. None of these studies are related to the current study. Dr. M.L.E. is an advisor to Sandstone Diagnostics, Ro, Dadi, Hannah, and Underdog. Dr. G.J.S. holds ownership in Sandstone Diagnostics Inc., developers of the Trak Male Fertility Testing System. In addition, Dr. G.J.S. has a patent pending related to Trak Male Fertility Testing System issued.

https://pubmed.ncbi.nlm.nih.gov/33564831/

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Smart devices/mobile phone in patients with epilepsy? A systematic review

Ali A Asadi-Pooya, Nafiseh Mirzaei Damabi, Marzieh Rostaminejad, Mina Shahisavandi, Anahita Asadi-Pooya. Smart devices/mobile phone in patients with epilepsy? A systematic review. Acta Neurol Scand. 2021 Jun 28. doi: 10.1111/ane.13492.

Abstract

We systematically reviewed the existing literature on the safety of the use of smartphone, mobile phone/Internet, and Wi-Fi by people with epilepsy (PWE), according to the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. Scopus, MEDLINE, and Google Scholar from the inception to April 9, 2021 were searched. These key words were used "epilepsy" OR "seizure" AND "Mobile Phone" OR "Cell Phone" OR "Smartphone" OR "Wi-Fi" OR "Electromagnetic" OR "Radiation." The primary search yielded 7766 studies; 33 studies were related. In total, 19 manuscripts were based on animal/computational studies and 14 articles reported human investigations. Among animal studies, 10 articles suggested detrimental effects by electromagnetic fields (EMFs) on brain function/seizure activity, while nine studies negated this hypothesis. Among human studies, seven studies suggested detrimental effects by EMFs on brain function/seizure activity, while seven studies negated this hypothesis. None of the studies provided a good level of evidence. In one human study, all seven patients with epilepsy and abnormal EEG during the sham exposure, had an increase in the number of epileptic events with exposure to mobile phone radiation. In another study of the detrimental effects of smart technology device overuse among school students, an association was found between reporting seizures and the hours of smart technology device use. While high-quality evidence on the safety of the use of smartphone, mobile phone/Internet, and Wi-Fi in PWE is lacking, prudent use of these technologies, including using wired hand-free sets or other exposure-reducing measures is recommended.

https://pubmed.ncbi.nlm.nih.gov/34180044/

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Low-SAR Antenna Design and Implementation for Mobile Phone Applications

Bao Lu, Bo Pang, Wei Hu, Wen Jiang. Low-SAR Antenna Design and Implementation for Mobile Phone Applications. IEEE Access. 30 June 2021. doi: 10.1109/ACCESS.2021.3093720.

Abstract

This paper presents a novel approach for designing low-SAR (specific absorption rate) terminal antenna. First of all, the relationship between the magnetic field and the SAR value is deduced by using the electric field formula of SAR and Maxwell's equations. Then, by using the boundary conditions of the medium, the interaction mechanism between the radiated magnetic field of the antenna and the magnetic field inside human tissue is studied. Next, the relationship between the surface current and the radiated magnetic field of antenna is constructed. The approach of reducing the antenna radiated magnetic field is proposed by directly adjusting the antenna surface current, so that the SAR of human tissues is reduced. Finally, two low-SAR antennas are designed according to the proposed approach. The simulation and measurement results of the two low-SAR antennas show that the -6 dB bandwidth of both antennas is 2.4-2.49 GHz, which can meet the 2.4 G WLAN frequency band. At the same time, compared with the reference antenna, the peak values of 10 g average SAR of two antennas are reduced by more than 30%. In addition, the measured efficiencies of the two low-SAR antennas are higher than 40% in the operating frequency range. The validity of the proposed approach is proved by the simulation and measurement results of the antenna, which can be used to guide the SAR reduction design of mobile terminal antennas.

Open access paper: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9468878

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Magnetic Interference on Cardiac Implantable Electronic Devices From Apple iPhone MagSafe Technology

Fahd Nadeem, Arismendy Nunez Garcia, Cao Thach Tran, and Michael Wu. Magnetic Interference on Cardiac Implantable Electronic Devices From Apple iPhone MagSafe Technology. Journal of the American Heart Association. Jun 2, 2021. doi: 10.1161/JAHA.121.020818.

Abstract

Background Magnet wireless charging is being utilized increasingly in current generation smartphones. Apple's MagSafe is a proprietary wireless charging technology with an array of magnets that has the capacity to generate magnet fieldstrength >50 gauss (G). We hypothesize that there is clinically significant magnet interference caused by Apple's MagSafe technology on cardiac implantable electronic devices (CIED).

Methods and Results This study has an in vivo and an ex vivo component. The in vivo component consists of consecutive patients who presented to the electrophysiology laboratory with previously implanted CIEDs. The iPhone 12 Pro Max was directly placed on the skin over the pocket of these patients and the effect was studied by device interrogation. For the ex vivo component of the study, CIEDs from major device companies were tested for magnetic interference caused by iPhone 12 Pro Max through unopened packages. We found that iPhone 12 Pro Max resulted in clinically identifiable magnet interference in 3/3 (100%) participants in vivo and in 8/11 (72.7%) devices ex vivo.

Conclusions Apple's iPhone 12 Pro Max MagSafe technology can cause magnet interference on CIEDs and has the potential to inhibit lifesaving therapy.

https://www.ahajournals.org/doi/10.1161/JAHA.121.020818

Excerpt

Magnet mode activation had been shown to occur in CIED's with exposure to a magnetic field as little as 10 G.9 The magnetic field strength of the iPhone 12 Pro Max can be greater than 50 G when in direct contact with the magnetometer. In our ex vivo study, we were able to trigger magnet reversion by placing the iPhone 12 Pro Max at up to 1.5 cm from certain CIED. The difference in magnet response to the iPhone 12 Pro Max among different devices is likely attributed to different hall-sensor magnet sensitivity as all of the devices were susceptible to the standard donut magnet. Boston Scientific Accolade MRI pacemaker for example requires a magnet stronger than 70 G to activate magnet mode.10

Our case series has several clinical implications. People often put their smartphones in a breast pocket over a device which can be in close proximity to CIEDs. This can lead to asynchronous pacing or disabling of anti-tachycardic therapies. Our study adds to the growing literature demonstrating EMI from magnets in several common technological products such as smart tablets, E-cigarettes, fitness watch wristbands, and wireless headphones.11, 12, 13, 14

Our case series has several limitations. Our sample size is small and we tested on selected device types and the results of our study may not be generalizable. A large scale study should be performed to confirm our findings.

In conclusion, this report highlights the importance of public awareness regarding an interaction between CIEDs and a recently released smartphone model with magnetic charging capability. Although the Food and Drug Administration website states that cellphones do not pose a significant health risk for patients with these devices, they do acknowledge that certain precautions may be advisable.15 Based on the variability of interactions with respect to different smartphone models, patients are advised to consult with a heart rhythm specialist regarding recommendations specific to their smartphone and CIED.

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Generational Risk of Colon and Rectal Cancer in Recent Birth Cohorts under Age 40 - the Hypothetical Role of Radiofrequency Radiation from Cell Phones

Devra L Davis, Aaron M. Pilarcik, Anthony B. Miller. Generational Risk of Colon and Rectal Cancer in Recent Birth Cohorts under Age 40 - the Hypothetical Role of Radiofrequency Radiation from Cell Phones. Ann Gastroenterol Dig Dis, 3(1): 09-16. 2020.

Abstract

To determine if there are shifts in patterns of cancer, rates of disease can be evaluated in terms of Generational Risk (GR), comparing those born recently with those born decades earlier. Using data from the U.S. Centers for Disease Control and Prevention (CDC), the U.S. Surveillance Epidemiology and End-Results (SEER) Program and Iranian cancer registries, increases in GR of colon and rectal cancer in those under age 50 are presented. For the U.S. those born in the 1990s have a doubled risk of colon cancer (GR=2) and a fourfold increase in rectal cancer (GR=4) by the time they reach age 24 compared to those born six decades ago. Experimental studies have determined that the colon and rectum of Sprague-Dawley rats are exquisitely sensitive to both ionizing and non-ionizing radiofrequency radiation (RFR), expressing significant differences in patterns of methylation of a number of well-identified proteins and other biomarkers predictive of cancer risk. Modeling of nonionizing exposures also indicates that absorption of RFR into the colon and rectum from cell phones stored in the pocket exceeds current test limits by up to 5-fold. French government tests of phones positioned next to the body report exposures to non-ionizing radiation that are up to 11 times more than current guidelines. Based on these findings, it is prudent to develop policies to reduce direct exposures to RFR from cell phones, as occurs when

they are kept next to the body, and to promote advances in hardware and software that reduce direct exposures to RFR.

Open access paper: https://www.somatopublications.com/increased-generational-risk-of-colon-and-rectal-cancer-in-recent-birth-cohorts-under-age-40-the-hypothetical-role-of-radiofrequency-radiation-from-cell-phones.pdf

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The non-thermal biological effects and mechanisms of microwave exposure

X. Zhao, G. Dong, C. Wang. The non-thermal biological effects and mechanisms of microwave exposure. Int J Radiation Research. 19(3):475-486. July 2021. doi: 10.18869/acadpub.ijrr.19.2.475.

Abstract

The purpose of this article was to present a brief review of pertinent information regarding the effects of microwave radiation on biological systems. Researchers have been intrigued by the interaction of electromagnetic fields (EMFs) and various life processes since the 18th century. Microwaves refer to the oscillation of an EMF with a wavelength of 1 mm to 1 m, which penetrates matter to varying degrees. With the widespread and ever-increasing use of microwaves, such as cellular telephones and other wireless technologies, great attention and research has been paid to the potential adverse biological effects. It is well recognized that microwaves affect the biological functions of living organisms at both the cellular and molecular levels, and can lead to the appearance of toxicity, genotoxicity and transformation. However, until now no satisfactory mechanism has been proposed to explain the biological effects of these fields. Therefore, increasing attention should be focused on the biological effects of microwaves in the future, especially since microwaves have extensive applications in various fields.

https://ijrr.com/article-1-3716-en.html

Conclusions

During recent years there has been increasing public concern regarding the biological effects of microwave radiation emissions from wireless communications. The number of reports on the effects induced by microwave radiation in various cellular and molecular systems continues to increase, attracting public attention toward microwave radiation protection. However, until now no satisfactory mechanism has been proposed to explain the biological effects of these fields. The theories and hypotheses that explain some of the local physiological phenomena have limitations, making it difficult to formulate a specific diagnostic criteria and specific methods of prevention and treatment.

Currently, physical protection is the main measure of EMR protection, including protective clothing with metal wires. In addition, medical interventions through the use of antioxidants are also beneficial for protection against EMR, though specific drugs are lacking. Possible medications include melatonin (28), carnitine, caffeic acid phenethyl ester (CAPE) (59), vitamin C (60) and different kinds of Chinese medicines (61).

Whether mobile phones or other wireless technologies are harmful to humans is still controversial, but research increasingly suggests that they are unlikely to cause brain cancers in adults (62) or affect learning and memory processes (63, 64). In addition, some studies have even found that microwaves emitted from mobile phones can

induce adaptive responses that make animals more resistant to ionizing radiation (65). That said, efforts should be made to minimize microwave radiation exposure by remaining remote from TV towers, radar stations and other strong radiation areas. Furthermore, while mobile phone use has not been linked to brain cancer, long-term use may be harmful to the eyes (66) and brain (67). Thus, mobile devices should be kept at a safe distance from the head and, if possible, earphones should be used.

Microwave radiation may also be emitted from microwave ovens, which are widely used for food preparation in daily life. A commonly used frequency in such ovens is 2450 MHz (68). In general, microwave ovens may be considered a safe form of cooking (68); however, improper use can damage the eyes or even result in scald injuries and burns (69). As a safety precaution, a safe distance should be maintained from microwave ovens when in use. Thus, some studies suggest that although current literature lacks definitive evidence associating male infertility with cell phone exposure, limitation of exposure to the possible harmful effects of cell phone, laptop, and microwave ovens is recommended (70).

In conclusion, although the biological effects of microwaves are controversial, future studies regarding the non-thermal effects and mechanisms of microwave radiation are likely to progress our understanding, as well as our comprehension of temporary biological effects that may have long-term impacts on microbial cells, animals and humans. An increased number of studies are paying attention to the biological effects of microwaves and they are expected to increase in number in the future since microwaves have extensive applications in various fields.

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A review of protocols and guidelines addressing the exposure of occupants to electromagnetic field radiation (EMFR) in buildings

Shabnam Monadizadeh, Charles J. Kibert, Jiaxuan Li, Junghoon Woo, Ashish Asutosh, Samira Roostaie, Maryam Kouhirostami. A review of protocols and guidelines addressing the exposure of occupants to electromagnetic field radiation (EMFR) in buildings. Journal of Green Building. (2021) 16 (2): 55–81. doi: 10.3992/jgb.16.2.55.

Highlights

- A comprehensive review of increasing electromagnetic field radiation (EMFR) impacts on building occupant health
- Scientific evidence identifying adverse effects of EMFR
- Governments and public health agencies are creating regulations to reduce EMFR exposure
- National and international regulations with respect to the thresholds they set to protect human health
- Provides a robust foundation for researchers to use in additional studies of EMFR impacts in various built environment scenarios

Abstract

A significant share of the technology that has emerged over the past several decades produces electromagnetic field (EMFR) radiation. Communications devices, household appliances, industrial equipment, and medical equipment and devices all produce EMFR with a variety of frequencies, strengths, and ranges. Some EMFR, such as Extremely Low Frequency (ELF), Radio Frequency (RF), and Ionizing Range (IR) radiation have been shown to have harmful effects on human health. Depending on the frequency and strength of the radiation, EMFR can have health effects at the cellular level as well as at brain, nervous, and cardiovascular levels. Health authorities have enacted regulations locally and globally to set critical values to limit the adverse effects of EMFR. By

introducing a more comprehensive field of EMFR study and practice, architects and designers can design for a safer electromagnetic (EM) indoor environment, and, as building and construction specialists, will be able to monitor and reduce EM radiation. This paper identifies the nature of EMFR in the built environment, the various EMFR sources, and its human health effects. It addresses European and US regulations for EMFR in buildings and provides a preliminary action plan. The challenges of developing measurement protocols for the various EMFR frequency ranges and determining the effects of EMFR on building occupants are discussed. This paper argues that a mature method for measuring EMFR in building environments and linking these measurements to human health impacts will foster occupant health and lead to the adequate development of safeguards for occupants of buildings in future research.

https://doi.org/10.3992/jgb.16.2.55

Dissertation (open access): https://ufdc.ufl.edu/UFE0052666/00001

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Exposure to radiofrequency electromagnetic fields: Comparison of exposimeters with a novel body-worn distributed meter

Anke Huss, Stefan Dongus, Reza Aminzadeh, ArnoThielens, Matthias van den Bossche, Patrick Van Torre, René de Seze, Elisabeth Cardis, Marloes Eeftens, Wout Joseph, Roel Vermeulen, MartinRöösli. Exposure to radiofrequency electromagnetic fields: Comparison of exposimeters with a novel body-worn distributed meter. Environment International. 156, November 2021, 106711. doi: 10.1016/j.envint.2021.106711

Highlights

- Personal exposimeters are often used for RF-EMF measurements, but have shortcomings.
- We developed a novel on-body calibrated device with distributed sensors (BWDM).
- BWDM is designed to minimize body shielding and to use frequency specific antennas.
- We measured RF-EMF exposures in parallel with three types of devices.
- Exposimeters provide slightly lower exposures but rank averaged exposures accurately.

Abstract

Background Exposure to radiofrequency electromagnetic fields (RF-EMF) is often measured with personal exposimeters, but the accuracy of measurements can be hampered as carrying the devices on-body may result in body shielding. Further, the compact design may compromise the frequency selectivity of the sensor. The aim of this study was to compare measurements obtained using a multi-band body-worn distributed-exposimeter (BWDM) with two commercially available personal exposimeters (ExpoM-RF and EmeSpy 200) under real-life conditions.

Conclusion

Our device comparisons are informative for the interpretation of existing epidemiological research results and may help future studies regarding how to design improved exposure assessment strategies and how to interpret RF-EMF exposure values reported in the scientific literature. Overall, within the currently applied frequency bands, our study indicates that using one single exposimeter results in slightly lower exposures than measured by a BWDM, most likely due to body shielding, but rank exposure levels reliably. Body shielding could probably

at least be in part mitigated by using two exposimeters, on opposite sides of the body (Bhatt et al., 2016). Given their easier handling and relatively compact size, exposimeters thus represent valuable tools to assess population exposure to RF-EMF.

Open access paper: https://www.sciencedirect.com/science/article/pii/S0160412021003366?via%3Dihub

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Compliance Assessment of the Epithelial or Absorbed Power Density Below 10 GHz Using SAR Measurement Systems

Theodoros Samaras, Andreas Christ, Niels Kuster. Compliance Assessment of the Epithelial or Absorbed Power Density Below 10 GHz Using SAR Measurement Systems. Bioelectromagnetics. 2021 Jun 15. doi: 10.1002/bem.22355.

Abstract

The introduction of new dosimetric quantities, in particular, epithelial or absorbed power density for frequencies above 6 GHz, in exposure guidelines and safety standards requires the development of new experimental assessment procedures for compliance testing. In this study, we propose to approximate the peak spatial-average absorbed power density (psSab) using the same measured data and algorithms that are used for determining the peak spatial-average specific absorption rate psSAR, which is currently limited to frequencies up to 10 GHz. The uncertainty component for the transformation of psSAR to psSab was evaluated as less than 0.55 dB (13.5%) for any source as close as 0.02λ from the tissue simulating media. The approach is easy to implement and allows determining compliance with the basic restrictions of the latest safety guidelines. In the next project, we will expand dosimetric probes, phantoms, and procedures for frequencies above 10 GHz.

https://pubmed.ncbi.nlm.nih.gov/34130354/

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Effect of Microwave Radiation on Experimental Tumor Growth at Different Intensity Levels

Vladimir F. Pyankov; Olga V. Kryukova; Alexey F. Kopylov; Gennady M. Aldonin; Yuri P. Salomatov. Effect of Microwave Radiation on Experimental Tumor Growth at Different Intensity Levels. 2021 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering (ElConRus). 26-29 Jan. 2021. doi: 10.1109/ElConRus51938.2021.9396077.

Abstract

The radiophysical installation designed to study the effect of microwave radiation on biological objects, with an operating frequency of 915 MHz, was used to influence mice with Ehrlich ascites carcinoma. The laboratory animals were exposed to microwave EM radiation of different intensity. The experimental results obtained revealed the dependence of the tumor growth on the intensity of the microwave radiation exposure.

https://ieeexplore.ieee.org/abstract/document/9396077

Excerpts

It is shown that the EM radiation exerts a particularly strong impact on the rate of the EAC growth during the first stage of the tumor growth. The highest rate of tumor growth was detected in the animals of the control group, the next was the group exposed to the radiation of 100 μW/cm^2, and the lowest rate was observed in the group exposed to 10 μW/cm^2. The differences in the tumor growth rate are smoothed over upon reaching the number of 15 thousand cells. Thus, the death of animals with EAC which were exposed to radiation depends on the dose of the microwave radiation....

The data presented in the paper evidences that even in the case of low intensity the effect of microwave EM radiation on an organism with tumor can influence the tumor growth, shifting the stages of its development and, thus, this may influence the life expectancy of animals.

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Moderate exercise training as an effective strategy to reduce the harmful effects of cell phone radiation on Wistar rat's semen quality

HA Akbari, AA Gaeini. Moderate exercise training as an effective strategy to reduce the harmful effects of cell phone radiation on Wistar rat's semen quality. Int J Radiation Research. 19(2):317-323. 2021. doi: 10.18869/acadpub.ijrr.19.2.317.

Abstract

Background: The purpose of this study was to evaluate the impact of moderate exercise training as an effective strategy to attenuate the harmful effects of electromagnetic radiation emitted from a cell phone on Wistar Rat's semen quality.

Materials and Methods: Twenty four male Wistar rats (10 weeks old) were randomly assigned to groups: control group, exercise group, radiation group, and radiation plus exercise group. The animals in radiation and radiation plus exercise groups were exposed to radiofrequency electromagnetic radiation of a cell phone 3 hours/day for 28 days. The animals in exercise and radiation plus exercise groups performed moderate exercise training six days a week for 28 days. At the same time, the control and exercise groups exposed to a mobile phone in switch off. Basic parameters of testes weight, sperm count, motility, progressivity, morphology, and viability assessed.

Results: Exposure to the cell phone for 28 days significantly reduced sperm count, progressivity, and normal morphology. Exercise alone caused a significant increase in sperm progressivity only. Radiation plus exercise caused a significant increase in sperm progressivity and morphology compared with the radiation group.

Conclusion: Moderate exercise training may attenuate the harmful effects of exposure to cell phone radiation and enhance sperm quality and the fertility status of men.

https://ijrr.com/article-1-3646-en.html

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Acute effects of 2.856 GHz and 1.5 GHz microwaves on spatial memory abilities and CREB-related pathways

Shengzhi Tan, Hui Wang, Xinping Xu, Li Zhao, Jing Zhang, Ji Dong, Binwei Yao, Haoyu Wang, Yanhui Hao, Hongmei Zhou, Yabing Gao, Ruiyun Peng. Acute effects of 2.856 GHz and 1.5 GHz microwaves on spatial memory abilities and CREB-related pathways. Sci Rep. 2021 Jun 11;11(1):12348. doi: 10.1038/s41598-021-91622-4.

Abstract

This study aimed to evaluate the acute effects of 2.856 GHz and 1.5 GHz microwaves on spatial memory and cAMP response element binding (CREB)-related pathways. A total of 120 male Wistar rats were divided into four groups: a control group (C); 2.856 GHz microwave exposure group (S group); 1.5 GHz microwave exposure group (L group); and 2.856 and 1.5 GHz cumulative exposure group (SL group). Decreases in spatial memory abilities, changes in EEG, structural injuries, and the downregulation of phosphorylated-Ak strain transforming (p-AKT), phosphorylated-calcium/calmodulin-dependent protein kinase II (p-CaMKII), phosphorylated extracellular signal regulated kinase (p-ERK) and p-CREB was observed 6 h after microwave exposure. Significant differences in the expression of p-CaMKII were found between the S and L groups. The power amplitudes of the EEG waves (θ, δ), levels of structural injuries and the expression of p-AKT, p-CaMK II, p-CREB, and p-ERK1/2 were significantly different in the S and L groups compared to the SL group. Interaction effects between the 2.856 and 1.5 GHz microwaves were found in the EEG and p-CREB changes. Our findings indicated that 2.856 GHz and 1.5 GHz microwave exposure induced a decline in spatial memory, which might be related to p-AKT, p-CaMK II, p-CREB and p-ERK1/2.

https://pubmed.ncbi.nlm.nih.gov/34117282/

The power density in all three RF conditions was 10 milliwatts per square centimeter.

Excerpt

In terms of the molecular level, differences in the expression of p-CaMKII/CaMKII between 2.856 GHz and 1.5 GHz were found, which suggests the different sensitivities of the signal pathways to microwaves with different frequencies. Interaction effects of the two microwave frequencies were found for the changes in p-CREB/CREB. The accumulative exposure of the 2.856 GHz and 1.5 GHz microwaves aggravated the downregulation of p-CREB/CREB. Previous studies used combined exposure to communication microwaves (849 MHz and 1.95 GHz), but none of these studies analyzed the interaction effects[53,54,55,56].

The present study provides new insights into the biological effects of microwave radiation. Microwaves affect multiple metabolic pathways, and the frequency played an important role in the biological effects. The results related to frequency-dependent effects suggested that microwave safety standards should be based on the frequency. Past safety standards were primarily based on radiation power, and radiation frequency was defined only in a rough range[57]. The interaction effects suggested that the biological effects caused by electromagnetic waves were much more complicated than previously thought. More attention should be given to this field.

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Electromagnetic Waves from Mobile Phones may Affect Rat Brain During Development

Dilek Akakin, Olgu Enis Tok, Damla Anil, Akin Akakin, Serap Sirvanci, Goksel Sener, Feriha Ercan. Electromagnetic Waves from Mobile Phones may Affect Rat Brain During Development.
Turk Neurosurg. 2021;31(3):412-421. doi: 10.5137/1019-5149.JTN.31665-20.2.

Abstract

Aim: To investigate the effects of electromagnetic waves (EMWs) from mobile phones (MPs) on rat brains of rats by morphological and biochemical analysis.

Material and methods: EMW was applied for two hours/day until birth in stand-by fetal and EMW fetal groups and postnatal 60th day in stand-by and EMW groups. The control group was not exposed to MP. On postnatal 60th day, brain malondialdehyde (MDA) and glutathione (GSH) levels were measured, and western blot analysis was performed to determine glial fibrillary acidic protein (GFAP) content. Hematoxylin and eosin staining and GFAP immunohistochemistry were applied. Trigeminal nerves were examined using the transmission electron microscope.

Results: In comparison to controls, rats exposed to MP in stand-by or talk modes had significantly increased neuronal damage in the cortex and hippocampus. Increased MDA levels in the EMW group and decreased GSH levels in the stand-by, EMW fetal and EMW groups were found compared with controls. Increased GFAP content in the EMW group and increased GFAP staining in the EMW fetal and EMW groups compared to controls were observed. EMW group had a significantly decreased number of myelinated axons than control animals.

Conclusion: The results of this study suggests that 1800 MHz EMWs (SAR=1.79 W/kg) exposure in the prenatal and early postnatal life may lead to trigeminal nerve damage in addition to oxidative stress-induced neuronal degeneration and astroglial activation in the rat brain. Effects seem to be mode related, being more detrimental in groups exposed to MP during talk mode.

Open access paper: http://www.turkishneurosurgery.org.tr/pdf/pdf_JTN_2485.pdf

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Residential exposure to electromagnetic fields and risk of amyotrophic lateral sclerosis (ALS): a dose-response meta-analysis

Tommaso Filippini, Elizabeth E Hatch, Marco Vinceti. Residential exposure to electromagnetic fields and risk of amyotrophic lateral sclerosis: a dose-response meta-analysis. Sci Rep. 2021 Jun 7;11(1):11939. doi: 10.1038/s41598-021-91349-2.

Abstract

Amyotrophic lateral sclerosis (ALS) is neurodegenerative disease characterized by a fatal prognosis and still unknown etiology. Some environmental risk factors have been suggested, including exposure to magnetic fields. Studies have suggested positive associations in occupationally-exposed populations, but the link with residential exposure is still debated as is the shape of such relation. Due to recent availability of advanced biostatistical tools for dose-response meta-analysis, we carried out a systematic review in order to assess the dose-response association between ALS and residential exposure to magnetic fields. We performed an online literature searching through April 30, 2021. Studies were included if they assessed residential exposure to electromagnetic fields, based either on distance from overhead power lines or on magnetic field modelling techniques, and if they reported risk estimates for ALS. We identified six eligible studies, four using distance-based and one modelling-based exposure assessment, and one both methods. Both distance-based and particularly modelling-based exposure estimates appeared to be associated with a decreased ALS risk in the highest exposure category, although estimates were very imprecise (summary RRs 0.87, 95% CI 0.63-1.20, and 0.27, 95% CI 0.05-1.36).

Dose-response meta-analysis also showed little association between distance from power lines and ALS, with no evidence of any threshold. Overall, we found scant evidence of a positive association between residential magnetic fields exposure and ALS, although the available data were too limited to conduct a dose-response analysis for the modelled magnetic field estimates or to perform stratified analyses.

Conclusions

Overall, we found little association between exposure to magnetic fields and risk of ALS, using either distance from high-voltage overhead power lines or magnetic field modelling, although the available data were too limited to conduct a dose–response analysis for the modelled exposure studies or to perform further stratified analyses. Therefore, possible associations between magnetic fields exposure and ALS risk in selected subgroups and at very high exposure cannot be entirely ruled out.

Open access paper: https://www.nature.com/articles/s41598-021-91349-2

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Surface Electromagnetic Waves at Gradual Interfaces between Lossy Media

Igor I. Smolyaninov; Surface Electromagnetic Waves at Gradual Interfaces between Lossy Media. Progress in Electromagnetics Research. 170:177-186. 2021. doi:10.2528/PIER21043006.

Abstract

A low loss propagating electromagnetic wave is shown to exist at a gradual interface between two lossy conductive media. Such a surface wave may be guided by a seafloor-seawater interface, and it may be used in radio communication and imaging underwater. It should allow communication distances of the order of 500m at 10 kHz along a sandy seabed. Similar surface waves may also be guided by various tissue boundaries inside a human body. For example, such surface wave solutions may exist at planar interfaces between skull bones and grey matter inside a human head at 6 GHz.

Conclusion

I have demonstrated that a new kind of low loss propagating surface electromagnetic wave, an “interfacial wave”, may exist at a gradual interface between two lossy conductive media. The comparison of its properties with the more well-known surface electromagnetic wave solutions, such as surface plasmons and Zenneck waves is summarized in Table 1. Such a deep-subwavelength surface wave may be guided by a seafloor-seawater interface, and it may be used in radio communication and imaging underwater. Similar surface waves may also be guided by various tissue boundaries inside a human body. For example, such surface wave solutions may exist at planar interfaces between skull bones and grey
matter inside a human head at 6 GHz. A possibility of deep sub-wavelength SEW cavities (or “hot spots”) has been revealed in numerical simulations of SEW-related effects in human tissues. Therefore, it will be important to reexamine EM radiation safety issues associated with the potential excitation and scattering of the newly discovered surface electromagnetic waves inside a human body.

https://www.jpier.org/PIER/pier.php?paper=21043006

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Effect of the electric field at 50 Hz and variable intensities on biochemical markers in the honey bee's hemolymph

Paweł Migdał, Agnieszka Murawska, Paweł Bieńkowski, Aneta Strachecka, Adam Roman. Effect of the electric field at 50 Hz and variable intensities on biochemical markers in the honey bee's hemolymph. PLoS One. 2021 Jun 24;16(6):e0252858. doi: 10.1371/journal.pone.0252858.

Abstract

The amount of artificial electromagnetic fields of various parameters in the honey bee's environment increases globally. So far, it had been proven that exposure to an E-field at 50 Hz can cause changes in bee's behavior, alter the activity of proteases, and enzymatic antioxidants. Due to the potentially harmful effect of this factor on honey bees, we decided to investigate the activity of aspartate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALP), and the concentration of albumin and creatinine in bee's hemolymph after exposure to 50 Hz E-field. Honey bee workers were placed in wooden cages (200 × 150 × 70 mm) and exposed to the 50 Hz E-field with the intensity of <1, 5.0, 11.5, 23.0, or 34.5 kV/m for 1, 3, 6, or 12h. A homogeneous 50 Hz E-field was generated in the form of a plate capacitor. Hemolymph samples for analysis were taken immediately after the end of exposure to the E-field from 100 bees from each group. According to our study, the activity of AST, ALT, and ALP in honey bees' hemolymph decreased after exposure to 50 Hz E-field with various intensities. The decrease in AST, ALT, and ALP activity intensified with prolonged exposure time. 50 Hz E-field may cause the impairment of crucial metabolic cycles in the honey bees' organism (such as the citric acid cycle, ATP synthesis, oxidative phosphorylation, β-oxidation). Moreover, exposure to E-Field altered the concentration of creatinine and albumin, which are important non-enzymatic antioxidants. Such changes may indicate a disturbance in protein metabolism and increased muscle activity.

https://pubmed.ncbi.nlm.nih.gov/34166412/

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Role of insulin/glucagon ratio and cell redox state in the hyperglycaemia induced by exposure to a 60-Hz magnetic field in rats

Gabriel Martiñón-Gutiérrez, María Luna-Castro, Rolando Hernández-Muñoz. Role of insulin/glucagon ratio and cell redox state in the hyperglycaemia induced by exposure to a 60-Hz magnetic field in rats. Sci Rep. 2021 Jun 3;11(1):11666. doi: 10.1038/s41598-021-91228-w.

Abstract

The exposure to extremely low-frequency electromagnetic fields (EMFs) could adversely affect the endocrine system and cellular proliferative response. Nonetheless, the use of 60-Hz EMFs in the form of magneto-therapy exerts beneficial actions on human health but can also induce hyperglycaemia. Therefore, the present study was aimed to search for metabolic responses of fed or fasted male rats to a single EMF exposure. We performed a 15 min-single exposure to 60-Hz (3.8 mT, intensity) EMF, and determined serum levels of glucose, lipids, and indicators of cellular redox state and energy parameters. A single exposure to a 60-Hz EMF induced hyperglycaemia in both animal groups, and an attenuated second serum insulin peak. The 60-Hz EMF also decreased free fatty acids and lactate serum levels, oppositely increasing pyruvate and acetoacetate levels. Significant increases in blood glucose level and rat's glucose metabolism were related to a more oxidized cellular

redox state and variations in insulin and glucagon secretion. The 60-Hz EMF's effects were not modified in animals previously subjected to chronic EMFs exposure (14 days). In conclusion, increased serum glucose levels and glucose metabolism induced by a single 60-Hz EMF exposure were closely related to the cellular redox state and the insulin/glucagon ratio.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8175349/

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Effects of Long-Term Exposure of Intermediate Frequency Magnetic Fields (20 kHz, 360 µT) on the Development, Pathological Findings, and Behavior of Female Mice

Alexander Lerchl, Karen Drees, Née Grote, Isabel Gronau, Dirk Fischer, Julia Bauch, Axel Hoppe. Effects of Long-Term Exposure of Intermediate Frequency Magnetic Fields (20 kHz, 360 µT) on the Development, Pathological Findings, and Behavior of Female Mice. Bioelectromagnetics. 2021 May;42(4):309-316. doi: 10.1002/bem.22337.

Abstract

The use of magnetic fields in the intermediate-frequency (IF) range to wirelessly charge electric cars with power transfer in the kilowatt range has become increasingly widespread, leading to unavoidable stray fields in the microtesla range. Only a handful of studies have assessed the potential biological risks associated with exposure to such fields. We exposed female mice (n = 80 per group) to either 20 kHz, 360 µT (rms), or sham in Helmholtz coils to conduct a blind design study. Exposure started at 3 months of age (24 h/day). Body mass was recorded every 1-2 weeks. At 10 months of age, three behavioral tests were performed on 24 animals per group. Three months later, the mice were sacrificed and organs (brain, liver, kidney, spleen, and lung) were removed and prepared for microscopic analysis. Our findings demonstrate no differences in the development of body mass and survival rates (96% and 89%, respectively). Similarly, no significant differences were observed in tumor incidence rates. When it comes to behavioral tests, the 8-arm maze results revealed no significant differences. In contrast, the Rotarod data were significantly ($P < 0.001$) different with longer retention times seen in the exposed mice. In the open field, the number of supported rears was significantly lower ($P < 0.01$), whereas the other endpoints did not show any differences. Overall, our data reveal no adverse effects of exposure to 20 kHz, 360 µT on the development and tumor incidences, while the significant differences in the behavioral tests may indicate higher levels of alertness in mice.

https://pubmed.ncbi.nlm.nih.gov/33822410/

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Biological effects of chronic exposure of Blaptica dubia (aka Dubia roach) nymphs to static and extremely low frequency magnetic fields

Larisa Ilijin, Marija Mrdaković, Dajana Todorović, Milena Vlahović, Anja Grčić, Aleksandra Filipović, Vesna Perić-Mataruga. Biological effects of chronic exposure of Blaptica dubia (Blattodea: Blaberidae) nymphs to static and extremely low frequency magnetic fields. An Acad Bras Cienc. 2021 Jun 4;93(2):e20190118. doi: 10.1590/0001-3765202120190118.

Abstract

In this paper, we analyzed the effects of chronic exposure (5 months) to static magnetic field (110 mT; SMF) and extremely low frequency magnetic field (ELF MF; 10 mT, 50 Hz) on Blaptica dubia nymphs. We have examined acetylcholinesterase (AChE) activity and heat shock protein 70 (HSP70) level, two sensitive biomarkers of stress in terrestrial insects. Relative growth rate (RGR), as a life history trait, was estimated. AChE activity was determined spectrophotometrically and HSP70 levels were quantified using indirect non-competitive ELISA and Western blotting. Calculated RGR was significantly changed upon exposure to both types of ambiental MFs. The effects of chronic exposure of B. dubia nymphs to SMF and ELF MF (50 Hz) were observed as decreased activity of AChE. The increased level of HSP70 was present only after exposure to SMF. The strength of ELF MF was most likely below the energy level needed to induce the expression of this stress protein. Different patterns of the expression of two HSP70 isoforms, where isoform 2 was sensitive only to SMF, are most likely a possibly switch - off in the expression of constitutive and/or inducible HSP70 isoforms.

Open access paper: https://www.scielo.br/j/aabc/a/Hbdwv4Fydjmxgff6t797yzK/?lang=en

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Static Magnetic Stimulation Induces Changes in the Oxidative Status and Cell Viability Parameters in a Primary Culture Model of Astrocytes

da Costa CC, Martins LAM, Koth AP, Ramos JMO, Guma FTCR, de Oliveira CM, Pedra NS, Fischer G, Helena ES, Gioda CR, Sanches PRS, Junior ASV, Soares MSP, Spanevello RM, Gamaro GD, de Souza ICC. Static Magnetic Stimulation Induces Changes in the Oxidative Status and Cell Viability Parameters in a Primary Culture Model of Astrocytes. Cell Biochem Biophys. 2021 Jun 27. doi: 10.1007/s12013-021-01015-7

Abstract

Astrocytes play an important role in the central nervous system function and may contribute to brain plasticity response during static magnetic fields (SMF) brain therapy. However, most studies evaluate SMF stimulation in brain plasticity while few studies evaluate the consequences of SMF at the cellular level. Thus, we here evaluate the effects of SMF at 305 mT (medium-intensity) in a primary culture of healthy/normal cortical astrocytes obtained from neonatal (1 to 2-day-old) Wistar rats. After reaching confluence, cells were daily subjected to SMF stimulation for 5 min, 15 min, 30 min, and 40 min during 7 consecutive days. Oxidative stress parameters, cell cycle, cell viability, and mitochondrial function were analyzed. The antioxidant capacity was reduced in groups stimulated for 5 and 40 min. Although no difference was observed in the enzymatic activity of superoxide dismutase and catalase or the total thiol content, lipid peroxidation was increased in all stimulated groups. The cell cycle was changed after 40 min of SMF stimulation while 15, 30, and 40 min led cells to death by necrosis. Mitochondrial function was reduced after SMF stimulation, although imaging analysis did not reveal substantial changes in the mitochondrial network. Results mainly revealed that SMF compromised healthy astrocytes' oxidative status and viability. This finding reveals how important is to understand the SMF stimulation at the cellular level since this therapeutic approach has been largely used against neurological and psychiatric diseases.

https://pubmed.ncbi.nlm.nih.gov/34176101/

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Static Magnetic Field (0.2-0.4 T) Stimulates the Self-Renewal Ability of Osteosarcoma Stem Cells Through Autophagic Degradation of Ferritin

Bin Zhao, Tongyao Yu, Shenghang Wang, Jingmin Che, Liangfu Zhou, Peng Shang. Static Magnetic Field (0.2-0.4 T) Stimulates the Self-Renewal Ability of Osteosarcoma Stem Cells Through Autophagic Degradation of Ferritin. Bioelectromagnetics. 2021 Jun 3. doi: 10.1002/bem.22352.

Abstract

Static magnetic field (SMF) can alter cell fate decisions in many ways. However, the effects of SMF on cancer stem cells (CSCs) are little-known. In this particular study, we evaluate the biological effect of moderate-intensity SMF on osteosarcoma stem cells (OSCs) and try to clarify the underlying mechanisms of action. First, we demonstrated that prolonged exposure to SMF induced the proliferation and tumorsphere formation in K7M2 and MG63 OSCs. Moreover, SMF promoted the release of ferrous iron (Fe^{2+}) and provoked reactive oxygen species (ROS) in OSCs. Interestingly, SMF evidently triggered the autophagic degradation of ferritin, which is characterized by the activation of microtubule-associated protein 1 light chain 3 (LC3) and nuclear receptor co-activator 4 (NCOA4), and downregulation of ferritin heavy chain 1 (FTH1) in OSCs. Particularly, the colony-forming ability of K7M2 OSCs promoted by SMF was obviously abolished by using a small interfering RNA (siRNA) against NCOA4. Finally, treatment of the tumor-bearing mice with SMF did not affect the tumor volume or tumor mass, nor pulmonary metastasis of K7M2 OSCs, but the SMF-treated K7M2 OSCs caused a preference of pulmonary metastasis in a mouse model, which suggested that SMF might induce the metastatic characteristic of OSCs. Consequently, this paper demonstrates for the first time that the cumulative SMF exposure promoted the self-renewal ability of OSCs via autophagic degradation of ferritin, implying that ferritinophagy may be a potential molecular target for cancer.

https://pubmed.ncbi.nlm.nih.gov/34082485/

Conclusions

Our study has provided, to our knowledge, the first evidence that moderate-intensity SMF stimulated the self-renewal ability of OSCs through autophagic degradation of ferritin (Fig. 7a). The long-term exposure to moderate-intensity SMF did not affect the tumor volume or tumor mass, nor the lung metastasis in tumor-bearing mice, but the OSCs exposed to SMF did cause a preference of pulmonary metastasis in tumor-bearing mice (Fig. 7b). Finally, it is important to state that the effects of SMF on OSCs here are not directly applicable to humans and should be interpreted with caution.

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The Role of Pulsed Electromagnetic Fields on the Radical Pair Mechanism

Pablo Castello, Pablo Jimenez, Carlos F Martino. The Role of Pulsed Electromagnetic Fields on the Radical Pair Mechanism. Bioelectromagnetics. 2021 Jul 5. doi: 10.1002/bem.22358.

Abstract

In recent decades, the use of pulsed electromagnetic fields (PEMF) in therapeutics has been one of the main fields of activity in the bioelectromagnetics arena. Nevertheless, progress in this area has been hindered by the lack of consensus on a biophysical mechanism of interaction that can satisfactorily explain how low-level, non-thermal electromagnetic fields would be able to sufficiently affect chemistry as to elicit biological effects in living organisms. This specifically applies in cases where the induced electric fields are too small to generate a biological response of any consequence. A growing body of experimental observations that would explain the

nature of these effects speaks strongly about the involvement of a theory known as the radical pair mechanism (RPM). This mechanism explains how a pair of reactive oxygen species with distinct chemical fate can be influenced by a low-level external magnetic field through Zeeman and hyperfine interactions. So far, a study of the effects of complex spatiotemporal signals within the context of the RPM has not been performed. Here, we present a computational investigation of such effects by utilizing a generic PEMF test signal and RPM models of different complexity. Surprisingly, our results show how substantially different chemical results can be obtained within ranges that depend on the specific orientation of the PEMF test signal with respect to the background static magnetic field, its waveform, and both of their amplitudes. These results provide a basis for explaining the distinctive biological relevance of PEMF signals on radical pair chemical reactions.

Conclusion

Experimental observations speak strongly for the involvement of the radical pair mechanism in biological systems. For this purpose, we computationally studied whether a pulse train waveform can change the quantum singlet yields in a radical pair reaction. For a simple radical pair model, we demonstrated that the suggested reaction can be influenced by PEMFs.

This conclusion does not rule out the possibility of induced electric field effects stemming from PEMFs. However, experimental evidence suggests controversial results with the use of PEMFs that cannot be explained by the accepted mechanism of action [Barnes and Greenebaum, 2018]. Our study establishes the role of PEMF as a diagnostic tool that may indicate the involvement of magneto-sensitive radical pair reactions in biological systems. Extending this tool to determine orientation and amplitude dependence in which the input PEMF waveforms affect the reaction products can reveal the chemical nature of the radical pairs involved. Finally, using the oscillating or PEMF input waveform as a diagnostic tool to modify singlet quantum yields can easily be transferred to finding the optimal control to maximize the singlet yield. At the most fundamental level, one could investigate how a radical reaction can be controlled by perturbing spin interconversion to maximize a cost functional, the quantum singlet yield, through the selection of optimal control functions, namely the magnetic waveform.

https://pubmed.ncbi.nlm.nih.gov/34224591/

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Magnetic sensitivity of cryptochrome 4 from a migratory songbird

Xu J, Jarocha LE, Zollitsch T, Konowalczyk M, Henbest KB, Richert S, Golesworthy MJ, Schmidt J, Déjean V, Sowood DJC, Bassetto M, Luo J, Walton JR, Fleming J, Wei Y, Pitcher TL, Moise G, Herrmann M, Yin H, Wu H, Bartölke R, Käsehagen SJ, Horst S, Dautaj G, Murton PDF, Gehrckens AS, Chelliah Y, Takahashi JS, Koch KW, Weber S, Solov'yov IA, Xie C, Mackenzie SR, Timmel CR, Mouritsen H, Hore PJ. Magnetic sensitivity of cryptochrome 4 from a migratory songbird. Nature. 2021 Jun;594(7864):535-540. doi: 10.1038/s41586-021-03618-9.

Abstract

Night-migratory songbirds are remarkably proficient navigators[1]. Flying alone and often over great distances, they use various directional cues including, crucially, a light-dependent magnetic compass[2,3]. The mechanism of this compass has been suggested to rely on the quantum spin dynamics of photoinduced radical pairs in cryptochrome flavoproteins located in the retinas of the birds[4-7]. Here we show that the photochemistry of

cryptochrome 4 (CRY4) from the night-migratory European robin (Erithacus rubecula) is magnetically sensitive in vitro, and more so than CRY4 from two non-migratory bird species, chicken (Gallus gallus) and pigeon (Columba livia). Site-specific mutations of ErCRY4 reveal the roles of four successive flavin-tryptophan radical pairs in generating magnetic field effects and in stabilizing potential signalling states in a way that could enable sensing and signalling functions to be independently optimized in night-migratory birds.

https://pubmed.ncbi.nlm.nih.gov/34163056/

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The Magnetic Compass of Birds: The Role of Cryptochrome

Roswitha Wiltschko, Christine Nießner, Wolfgang Wiltschko. The Magnetic Compass of Birds: The Role of Cryptochrome.Front Physiol. 2021 May 19;12:667000. doi: 10.3389/fphys.2021.667000.

Abstract

The geomagnetic field provides directional information for birds. The avian magnetic compass is an inclination compass that uses not the polarity of the magnetic field but the axial course of the field lines and their inclination in space. It works in a flexible functional window, and it requires short-wavelength light. These characteristics result from the underlying sensory mechanism based on radical pair processes in the eyes, with cryptochrome suggested as the receptor molecule. The chromophore of cryptochrome, flavin adenine dinucleotide (FAD), undergoes a photocycle, where radical pairs are formed during photo-reduction as well as during re-oxidation; behavioral data indicate that the latter is crucial for detecting magnetic directions. Five types of cryptochromes are found in the retina of birds: cryptochrome 1a (Cry1a), cryptochrome 1b, cryptochrome 2, cryptochrome 4a, and cryptochrome 4b. Because of its location in the outer segments of the ultraviolet cones with their clear oil droplets, Cry1a appears to be the most likely receptor molecule for magnetic compass information.

Outlook

More than 50 years after the discovery of the avian magnetic compass, we finally have a concrete idea about the primary mechanism leading to the detection of directions by the magnetic field in birds: a radical pair process, with cryptochrome playing a crucial role in this process. Yet there are still several conflicting findings that have to be resolved, and a number of open questions that have to be answered.

One of the most important questions concerns the mechanisms by which the information obtained by the radical pair is transformed into a biological signal. Cryptochrome is found in the outer segments of cones, i.e., in a cell type that is also important for color vision. Is the visual information from the opsin and information on magnetic directions from cryptochrome transmitted separately or together? One might expect the latter since the cone has only one known way of transmitting information. This would mean, however, the two types of information have somehow to be separated, either already in the eyes or later in higher centers in the brain. There are speculations about possibilities (see, e.g., Bischof et al., 2011), but it will require many more considerations and experiments until we hopefully reach a complete understanding of how birds perceive the direction of the geomagnetic field.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8171495/

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Unravelling the enigma of bird magnetoreception

Eric J Warrant. Unravelling the enigma of bird magnetoreception. Nature. 2021 Jun;594(7864):497-498. doi: 10.1038/d41586-021-01596-6. doi: 10.1038/d41586-021-01596-6

No abstract.

https://pubmed.ncbi.nlm.nih.gov/34163048/

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Random Effects in Magnetobiology and a Way to Summarize Them

Vladimir N Binhi. Random Effects in Magnetobiology and a Way to Summarize Them. Bioelectromagnetics. 2021 Jul 7. doi: 10.1002/bem.22359.

Abstract

In magnetobiology, it is difficult to reproduce the nonspecific (not associated with specialized receptors) biological effects of weak magnetic fields. This means that some important characteristic of the data may be missed in standard statistical processing, where the set of measurements to be averaged belongs to the same population so that the contribution of fluctuations decreases according to the Central Limit Theorem. It has been shown that a series of measurements of a nonspecific magnetic effect contains not only the usual scatter of data around the mean but also a significant random component in the mean itself. This random component indicates that measurements belong to different statistical populations, which requires special processing. This component, otherwise called heterogeneity, is an additional characteristic that is typically overlooked, and which reduces reproducibility. The current method for studying and summarizing highly heterogeneous data is the random-effect meta-analysis of absolute values, i.e., of magnitudes, rather than the values themselves. However, this estimator-the average of absolute values-has a significant positive bias when it comes to the small effects that are characteristic of magnetobiology. To solve this problem, an improved estimator based on the folded normal distribution that gives several times less bias is proposed. We used this improved estimator to analyze the nonspecific effect of the hypomagnetic field in the Stroop test in 40 subjects and found a statistically significant meta-effect with a standardized average of magnitudes of about 0.1. It has been shown that the proposed approach can also be applied to a single study.

https://pubmed.ncbi.nlm.nih.gov/34233018/

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Effects of non-ionizing electromagnetic fields on flora and fauna, part 1. Rising ambient EMF levels in the environment

B. Blake Levitt, Henry C. Lai, Albert M. Manville. Effects of non-ionizing electromagnetic fields on flora and fauna, part 1. Rising ambient EMF levels in the environment. Rev Environ Health. 2021 May 27. doi: 10.1515/reveh-2021-0026.

Abstract

Ambient levels of electromagnetic fields (EMF) have risen sharply in the last 80 years, creating a novel energetic exposure that previously did not exist. Most recent decades have seen exponential increases in nearly all environments, including rural/remote areas and lower atmospheric regions. Because of unique physiologies, some species of flora and fauna are sensitive to exogenous EMF in ways that may surpass human reactivity. There is limited, but comprehensive, baseline data in the U.S. from the 1980s against which to compare significant new surveys from different countries. This now provides broader and more precise data on potential transient and chronic exposures to wildlife and habitats. Biological effects have been seen broadly across all taxa and frequencies at vanishingly low intensities comparable to today's ambient exposures. Broad wildlife effects have been seen on orientation and migration, food finding, reproduction, mating, nest and den building, territorial maintenance and defense, and longevity and survivorship. Cyto- and geno-toxic effects have been observed. The above issues are explored in three consecutive parts: Part 1 questions today's ambient EMF capabilities to adversely affect wildlife, with more urgency regarding 5G technologies. Part 2 explores natural and man-made fields, animal magnetoreception mechanisms, and pertinent studies to all wildlife kingdoms. Part 3 examines current exposure standards, applicable laws, and future directions. It is time to recognize ambient EMF as a novel form of pollution and develop rules at regulatory agencies that designate air as 'habitat' so EMF can be regulated like other pollutants. Wildlife loss is often unseen and undocumented until tipping points are reached. Long-term chronic low-level EMF exposure standards, which do not now exist, should be set accordingly for wildlife, and environmental laws should be strictly enforced.

https://pubmed.ncbi.nlm.nih.gov/34047144/

Conclusion

Ambient background levels of EMF have risen sharply in the last four decades, creating a novel energetic exposure that previously did not exist at the Earth's surface, lower atmospheric levels, or underwater environments. Recent decades have seen exponential increases in nearly all environments, including remote regions. There is comprehensive but outdated baseline data from the 1980s against which to compare significant new surveys from other countries which found increasing RFR levels in urban, suburban and remote areas, primarily from cell infrastructure/phone/WiFi exposures. One indicative comparison of similar sites between 1980 and today found a 70-fold (7,000%) increase in ambient RFR [149]. The increased infrastructure required for 5G networks will widely infuse the environment with new atypical exposures, as are increasing satellite systems communicating with ground-based civilian networks. The new information provides broader perspective with more precise data on both potential transient and chronic exposures to wildlife and habitats. Biological effects have been seen broadly across all taxa at vanishingly low intensities comparable to today's ambient exposures as examined in Part 2. The major question presented in Part 1 was whether increasing anthropogenic environmental EMF can cause biological effects in wildlife that may become more urgent with 5G technologies, in addition to concerns over potentially more lenient allowances being considered by major standards-setting committees at FCC and ICNIRP (examined in Part 3). There are unique signaling characteristics inherent to 5G transmission as currently designed of particular concern to non-human species. Background levels continue to rise but no one is studying cumulative effects to nonhuman species.

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Millimeter (MM) wave and microwave frequency radiation produce deeply penetrating effects: the biology and the physics

Martin L Pall. Millimeter (MM) wave and microwave frequency radiation produce deeply penetrating effects: the biology and the physics. Rev Environ Health. 2021 May 26. doi: 10.1515/reveh-2020-0165.

Abstract

Millimeter wave (MM-wave) electromagnetic fields (EMFs) are predicted to not produce penetrating effects in the body. The electric but not magnetic part of MM-EMFs are almost completely absorbed within the outer 1 mm of the body. Rodents are reported to have penetrating MM-wave impacts on the brain, the myocardium, liver, kidney and bone marrow. MM-waves produce electromagnetic sensitivity-like changes in rodent, frog and skate tissues. In humans, MM-waves have penetrating effects including impacts on the brain, producing EEG changes and other neurological/neuropsychiatric changes, increases in apparent electromagnetic hypersensitivity and produce changes on ulcers and cardiac activity. This review focuses on several issues required to understand penetrating effects of MM-waves and microwaves: 1. Electronically generated EMFs are coherent, producing much higher electrical and magnetic forces then do natural incoherent EMFs. 2. The fixed relationship between electrical and magnetic fields found in EMFs in a vacuum or highly permeable medium such as air, predicted by Maxwell's equations, breaks down in other materials. Specifically, MM-wave electrical fields are almost completely absorbed in the outer 1 mm of the body due to the high dielectric constant of biological aqueous phases. However, the magnetic fields are very highly penetrating. 3. Time-varying magnetic fields have central roles in producing highly penetrating effects. The primary mechanism of EMF action is voltage-gated calcium channel (VGCC) activation with the EMFs acting via their forces on the voltage sensor, rather than by depolarization of the plasma membrane. Two distinct mechanisms, an indirect and a direct mechanism, are consistent with and predicted by the physics, to explain penetrating MM-wave VGCC activation via the voltage sensor. Time-varying coherent magnetic fields, as predicted by the Maxwell-Faraday version of Faraday's law of induction, can put forces on ions dissolved in aqueous phases deep within the body, regenerating coherent electric fields which activate the VGCC voltage sensor. In addition, time-varying magnetic fields can directly put forces on the 20 charges in the VGCC voltage sensor. There are three very important findings here which are rarely recognized in the EMF scientific literature: coherence of electronically generated EMFs; the key role of time-varying magnetic fields in generating highly penetrating effects; the key role of both modulating and pure EMF pulses in greatly increasing very short term high level time-variation of magnetic and electric fields. It is probable that genuine safety guidelines must keep nanosecond timescale-variation of coherent electric and magnetic fields below some maximum level in order to produce genuine safety. These findings have important implications with regard to 5G radiation.

https://pubmed.ncbi.nlm.nih.gov/34043892

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Aspects on the International Commission on Non-Ionizing Radiation Protection (ICNIRP) 2020 Guidelines on Radiofrequency Radiation

Lennart Hardell, Mona Nilsson, Tarmo Koppel, Michael Carlberg. Aspects on the International Commission on Non-Ionizing Radiation Protection (ICNIRP) 2020 Guidelines on Radiofrequency Radiation. J Cancer Sci Clin Ther. 2021; 5(2): 250-285. doi: 10.26502/jcsct.5079117.

Abstract

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) published 2020 updated guidelines on radiofrequency (RF) radiation in the frequency range 100 kHz to 300 GHz. Harmful effects on human health and the environment at levels below the guidelines are downplayed although evidence is steadily increasing. Only thermal (heating) effects are acknowledged and therefore form the basis for the guidelines. Despite the increasing scientific evidence of non-thermal effects, the new ICNIRP guidelines are not lower compared with the previous levels. Expert groups from the WHO, the EU Commission and Sweden are to a large extent made up of members from ICNIRP, with no representative from the many scientists who are critical of the ICNIRP standpoint.

Excerpts

As a general rule ICNIRP, WHO, SCENIHR and SSM have for many years dismissed available studies showing harmful effects from non-thermal RF exposure and have based their conclusions mainly on studies showing no effects. Results showing risk are criticized, disregarded or not even cited while studies showing no risks are accepted as evidence of no risk in spite of severe methodological problems. Many statements by these agencies are misleading and not correct. They are easily rebutted by reading the relevant publications....

All these expert groups dominated by ICNIRP consequently reach similar conclusions that there are no health effects below ICNIRP guidelines. No representative from the scientific community that is of the opinion that there is increasing evidence of health risks below the ICNIRP guidelines, e.g. as expressed in the EMF Scientists Appeal [24], has ever been a member of the expert groups at the WHO, the EU, the SSM or ICNIRP. Certainly scientists who do not discount evidence of health effects from exposure to RF radiation that are observed at exposures below guideline levels should be represented....

ICNIRP is not representative of the scientific community since it does not include representatives from scientists that agree there is evidence of harmful effects at levels well below ICNIRPs limits although these scientists are in majority in the scientific community [24].

Conclusion

ICNIRP's conclusion [48] on cancer risks is: "In summary, no effects of radiofrequency EMFs on the induction or development of cancer have been substantiated." This conclusion is not correct and is contradicted by scientific evidence. Abundant and convincing evidence of increased cancer risks and other negative health effects are today available. The ICNIRP 2020 guidelines allow exposure at levels known to be harmful. In the interest of

public health, the ICNIRP 2020 guidelines should be immediately replaced by truly protective guidelines produced by independent scientists.

Open access paper: https://www.fortunejournals.com/abstract/aspects-on-the-international-commission-on-nonionizing-radiation-protection-icnirp-2020-guidelines-on-radiofrequency-radiation-2261.html

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The microwave auditory effect

James C. Lin. The microwave auditory effect. IEEE Journal of Electromagnetics, RF, and Microwaves in Medicine and Biology, pp 1-13, Mar 1, 2021. Digital Object Identifier: 10.1109/JERM.2021.3062826.

Abstract

The microwave auditory effect has been widely recognized as one of the most interesting and significant biological phenomena from microwave exposure. The hearing of pulsed microwaves is a unique exception to sounds encountered in human auditory perception. The hearing of microwave pulses involves electromagnetic waves. This paper reviews the research on humans and animals leading to scientific documentation the absorption of a single microwave pulse impinging on the head may be perceived as an acoustic zip, click, or knocking sound. A train of microwave pulses may be sensed as a buzz, chirp, or tune by humans. It describes neurophysiological, psychophysical, and behavioral observations from laboratory studies involving humans and animals. Mechanistic investigations show that the microwave pulse, upon absorption by tissues in the head, launches a pressure wave that travels by bone conduction to the inner ear, where it activates the cochlear receptors via the same process involved for normal sound hearing. Depending on the impinging microwave pulse power, the level of induced sound pressure could be considerably above the threshold of perception to cause tissue injury. The microwave auditory effects and pressure waves could potentially render damage to brain tissues to cause lethal or nonlethal injuries.

https://ieeexplore.ieee.org/document/9366412

Take-Home Messages

• This paper describes neurophysiological, psychophysical, and behavioral observations from laboratory studies involving human and animal subjects.
• Absorption of a single microwave pulse impinging on the head may be perceived as an acoustic zip, click, or knocking sound.
• A train of microwave pulses may be sensed as an audible buzz, chirp, or tune by humans.
• Mechanistic studies show absorption of microwave pulses by soft tissues in the head launches a thermoelastic pressure wave that travels in the brain
• Depending on the power of the impinging microwave pulses, the level of induced sound pressure could be considerably above the threshold of auditory perception.
• The microwave auditory effects and associated pressure waves could potentially render damage to brain tissues to cause lethal or nonlethal injury.

VIII. SUMMARY

The microwave auditory effect occurs from miniscule but rapid (microsecond) rise of temperature (10-6 degrees C) in the brain from absorption of pulsed microwave radiation. The sudden rise in temperature creates thermoelastic expansion of the brain matter, which can launch a pressure wave that propagates through the head and is detected by the sensory hair cells in the cochlea. The nerve signal is then relayed to the central auditory system for perception and recognition.

The preceding sections document that an audible sound originates from within the head when human subjects are exposed to pulsed microwave radiation. The auditory detection of pulsed microwaves in laboratory animals has been confirmed both in behavioral and neurophysiological studies. The site of microwave-to-sound conversion is shown to be in the brain tissue. The primary mechanism of interaction is microwave pulse-induced thermoelastic expansion of brain matter.

Depending on the power of the impinging microwave pulses, the levels of induced sound pressure in the brain could be considerably above the threshold of auditory perception, so that they may approach or exceed levels of discomfort and cause brain tissue injury. A high-power microwave pulse-generated acoustic pressure wave initiated in the brain and reverberating inside the head could bolster the initial pressure, causing injury of brain matter. Thus, it is conceivable that the microwave auditory effect or the microwave pulse-induced pressure shock wave inside the head could become a potentially lethal or nonlethal weapon against animals and humans.

The unique character of microwave-induced acoustic wave in biological tissues has prompted the exploration of its potential for application in biomedical imaging [68,69]. The principle of operation of microwave thermoacoustic tomography (MTT) and some results have been available since the early 1980's [69,70]. It was conjectured that the potential contrast advantage of microwave imaging and the resolution advantage of ultrasonic imaging could combine to make MTT imaging of biological tissues a potentially useful dual modality for diagnostic imaging. For example, the wavelength in muscle for microwaves is 17.5 mm at 2450 MHz; for ultrasonic waves, the wavelength is a mere 0.5 mm at 3 MHz. The potential gain in spatial resolution is tremendous for tissue imaging compared with relying on using microwave radiation alone. The research initiated in the 1980’s is being actively pursued in developing MTT imaging for medical diagnosis, especially for early detection of breast cancer. Indeed, currently, MTT is a subject of vigorous research both from a systems development perspective and as a dual imaging modality amenable to greater utility in a wide range of medical application scenarios [71–75].

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Microwave Thermoacoustic Tomographic (MTT) Imaging

James C. Lin. Microwave Thermoacoustic Tomographic (MTT) Imaging. Physics in Medicine and Biology. 66(10). May 12, 2021. https://doi.org/10.1088/1361-6560/abf954.

Abstract

Microwave thermoacoustic tomography (MTT) uses microwave-pulse-induced thermoelastic pressure waves to form planar or tomographic images. Since the generation and detection of thermoelastic pressure waves

depends on dielectric permittivity, specific heat, thermal expansion, and acoustic properties of tissue, microwave thermoacoustic imaging possesses the characteristic features of a duel-modality imaging system. The unique attributes of the high contrast offered by microwave absorption and the fine spatial resolution furnished by ultrasound are being explored to provide a nonionizing and noninvasive imaging modality for characterization of tissues, especially for early detection of breast cancer. This paper reviews the research being conducted in developing MTT imaging for medical diagnosis. It discusses the science of thermoelastic wave generation and propagation in biological tissues, the design of prototype MTT systems, the reconstruction of tomographic images, and the application and accomplishment of prototype MTT systems in phantom models and experimental subjects.

https://iopscience.iop.org/article/10.1088/1361-6560/abf954/pdf

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Mobile phone use and trends in the incidence of cancers of the parotid and other salivary glands

Ken Karipidis, Rohan Mate, Masoumeh Sanagou, Chris Brzozek, David Urban, Mark Elwood. Mobile phone use and trends in the incidence of cancers of the parotid and other salivary glands. Cancer Epidemiol. 2021 May 18;73:101961. doi: 10.1016/j.canep.2021.101961.

Highlights

• Adult parotid gland cancer in Australia since 2006 has decreased in males and increased in females.
• The incidence of other salivary gland cancers has remained stable.
• Mobile phone use is unlikely related to the incidence of salivary gland cancers.
• The increase in female parotid gland cancer may be attributed to possible risk factors specific to this gender.

Abstract

Background: There has been a significant increase in the use of mobile phones over the last three decades and a possible association with head cancers has been suggested, including cancers of the parotid and other salivary glands. We examined the incidence time trends of parotid and other salivary gland cancers in Australia to ascertain the influence of increased mobile phone use.

Methods: Analyses of incidence time trends were carried out using Poisson regression to estimate the annual percentage change (APC) in the incidence of salivary gland cancers of all available national registration data from 1982 to 2016, as well as specific time periods (1982-1993, 1994-2005, 2006-2016) representing changes in the prevalence of mobile phone use.

Results: The incidence of parotid gland cancer was stable for the periods 1982-1993 and 1994-2005. During 2006-2016 there was a large decrease in parotid gland cancer for males (APC: -3.71, 95 %CI: -6.66 to -0.67) and a large increase in females (4.80, 1.77-7.91) for adults aged 20-59 years. The incidence for other salivary gland cancers was stable during all the periods.

Conclusions: The results do not indicate that mobile phone use increased the incidence of parotid or other

salivary gland cancers. An increase in parotid gland cancer in females since 2006 may be attributed to other possible risk factors specific to this gender.

https://pubmed.ncbi.nlm.nih.gov/34020314/

Excerpts

Several epidemiological studies have generally not found an association between mobile phone use and parotid gland tumours [2]. However, a recent meta-analysis of three case-control studies reported a small increase in the risk [3]....

In conclusion, these results do not indicate that mobile phone use increased the incidence of parotid or other salivary gland cancers. An increase in cancer of the parotid gland in females since 2006 may be attributed to possible risk factors specific to this gender. Our study is an ecological observational investigation and its interpretation has to be cautious. These results highlight the need for further research on possible risk factors for parotid gland cancer. Better understanding of the aetiology of the disease may reveal opportunities for public health strategies to reduce the rising incidence in females.

My note: Although I agree that more research is needed, since the authors did not study mobile phone use, they have no basis for ruling this out as a possible risk factor for the increased incidence of parotid gland tumors observed in females.

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Cell phone use and the risk of glioma: are case-control study findings consistent with Canadian time trends in cancer incidence?

Paul J Villeneuve, Franco Momoli, Marie-Élise Parent, Jack Siemiatycki, Michelle C Turner, Daniel Krewski. Cell phone use and the risk of glioma: are case-control study findings consistent with Canadian time trends in cancer incidence? Environ Res. 2021 May 21;111283. doi: 10.1016/j.envres.2021.111283.

Highlights

• The possibility that the use of cell phones increases the risk of cancer remains controversial.
• We examined trends in cell phone use and incidence rates of glioma for Canada between 1992 and 2015.
• Age standardized incidence rates for glioma in Canada were relatively stable between 1992 and 2015.
• Canadian trends in glioma and cell phone use were not compatible with increased risks of glioma that have been reported in some previous case-control studies.

Abstract

Background: There remains controversy as to whether cell phones cause cancer. We evaluated whether temporal changes in cell phone use and the incidence of glioma in Canada were consistent with the hypothesis of an increased risk.

Design: We used data from the Canadian Cancer Registry to calculate annual incidence rates for glioma between 1992 and 2015. The annual number of new cell phone subscribers was determined using national industry statistics. The number of newly diagnosed gliomas was compared to the predicted number by applying risks from epidemiological studies to age-specific population estimates. Specifically, we calculated the "predicted" number of incident gliomas by determining the annual prevalence of cell phone users and years of use. These estimates were multiplied by the corresponding risk estimates to determine the predicted number of gliomas.

Results: The number of cellular subscriptions in Canada increased from nil in the early-1980s to approximately 29.5 million in 2015. In contrast, age-standardized glioma incidence rates remained stable between 1992 and 2015. The application of risk estimates from i) a recent pooled analyses of Swedish case-control studies, ii) the 13 country INTERPHONE study, and iii) the Canadian data from INTERPHONE overestimated the observed number of glioma cases diagnosed in Canada in 2015 by 49%, 85%, and 63%, respectively.

Interpretation: Predictions of glioma incidence counts using estimates of the relative risk of glioma due to cell phone use from case-control studies over-estimated the incidence rates of glioma in Canada. The absence of an elevation in incidence rates of glioma in conjunction with marked increases in cell phone use suggests that there may not be a causal link between cellphones and glioma.

https://pubmed.ncbi.nlm.nih.gov/34029549/

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Electromagnetic radiation reduction using novel metamaterial for cellular applications

Ahmed Mahfuz Tamim, Mohammad Rashed Iqbal Faruque, Mayeen Uddin Khandaker, Mohammad Tariqul Islam, David Andrew Bradley. Electromagnetic radiation reduction using novel metamaterial for cellular application. Radiation Physics and Chemistry, 178,108976. 2021. https://doi.org/10.1016/j.radphyschem.2020.108976.

Highlights

• A novel ELC resonator-based metamaterial is developed to reduce the specific absorption rate (SAR) on the mobile phone.
• Peak SAR investigated for three categories of modern smartphone usages- voice calling, messaging, and video calling.
• The proposed metamaterial can decrease a significant amount of SAR.
• Thus, the metamaterial can be helpful to protect the human head from harmful radiation.

Abstract

Excessive exposure to radiation has an adverse impact on human health, as an increase in body temperature may damage human organs or tissues, including the brain, eyes, and skin. Hence, this study assessed the effect of overexposure of radiation on the human head by analysing specific absorption rate (SAR) and reduction of SAR through the use of novel metamaterial (MTM). The SAR reduction was performed for GSM 900 MHz and

1800 MHz bands. A high-frequency electromagnetic simulator was employed throughout this study. The SAR investigation was performed on the head model for three categories of usage, namely voice calling, messaging, and video calling. This study looked into the impact on SAR of various free space distances between mobile phone and head model. A novel electric field driven LC (ELC) resonator-based MTM was used to reduce SAR. Based on the properties of the tissue, the rate of tissue absorption escalated with an increase in radiated power, especially when the distance between head and mobile phone decreased. The study outcomes signified that MTM could decrease a significant amount of SAR. This is beneficial to protect the human body from harmful radiation, wherein the distance from the device in biological effect should be maintained.

Excerpts

Even if the tissue temperature is too little even to consider causing any harm, it is associated with electric fields that may harm the biological cells by an unknown non-thermal mechanism. Table 1 lists some biological criticalness due to absorbed radiation, as reported by the World Health Organisation (WHO) (Staebler, 2017)....

In this era of 4G, 5G, and 6G, temperature and SAR values of the brain, the eyes, and the skin tissues have been greatly affected by the induced heating of 4G or 5G mobile phone radiation (Christopher et al., 2020b). Based on several techniques of SAR reduction of mobile phones (Hossain et al., 2014; Rosaline and Raghavan, 2016; Lee and Lee, 2017; Kwak et al., 2011; Faruque and Islam, 2013), using metamaterials as the middle layer appears to be an effective approach. Metamaterials (MTMs) refer to artificial metal-dielectric composite structure materials that gain its electrical properties from its structure, instead of inheriting them directly from the materials it is composed of. This material has some unique properties that are absent in naturally formed substances. These MTMs are assembled from individual elements that are significantly smaller in typical size than the electromagnetic waves working wavelength (Smith et al., 2004; Kadic et al., 2013). The recent MTM studies not only focus on the varied wideband operations (Hasan et al., 2016; Islam et al., 2019), but also look into more superior applications, including MTM antenna (Hasan et al., 2018), cloaking (Islam et al., 2016), MTM absorber (Hasan et al., 2017a), and filter (Alam et al., 2019) etc....

Conclusion

This paper presents a detailed numerical investigation of the absorbed electromagnetic radiation by the head from a modern smartphone for three usages, namely voice calling, messaging, and video calling. For SAR calculation, a novel PIFA [planar inverted-F] antenna was operated at GSM 900 MHz and 1800 MHz bands. Next, an ELC resonator-based MTM was developed and placed in the middle layer between the radiation patch and the substrate of the PIFA antenna to reduce the radiation exposure of the antenna, wherein the SAR decreased for all configurations stated in this study. It was observed that the radiation emitted from voice calling, messaging, and video calling applications had affected the inner ear, chin, and nose the most, respectively. The highest radiation absorbed by the head is when one uses the mobile phone for voice calling application. The absorbed radiation increased the temperature substantially, thus harming the biological tissues of a human. The distances between the smartphone and the different organs of the head for varying usages had been investigated as well. This highlights the fact that safety precautions should be adopted to stay safe from modern smartphone radiation.

https://www.sciencedirect.com/science/article/pii/S0969806X20302826

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Effects of electromagnetic fields on neuronal ion channels: a systematic review

Federico Bertagna, Rebecca Lewis, S Ravi P Silva, Johnjoe McFadden, Kamalan Jeevaratnam. Effects of electromagnetic fields on neuronal ion channels: a systematic review. Ann N Y Acad Sci. 2021 May 4. doi: 10.1111/nyas.14597.

Abstract

Many aspects of chemistry and biology are mediated by electromagnetic field (EMF) interactions. The central nervous system (CNS) is particularly sensitive to EMF stimuli. Studies have explored the direct effect of different EMFs on the electrical properties of neurons in the last two decades, particularly focusing on the role of voltage-gated ion channels (VGCs). This work aims to systematically review published evidence in the last two decades detailing the effects of EMFs on neuronal ion channels as per the PRISM guidelines. Following a predetermined exclusion and inclusion criteria, 22 papers were included after searches on three online databases. Changes in calcium homeostasis, attributable to the voltage-gated calcium channels, were found to be the most commonly reported result of EMF exposure. EMF effects on the neuronal landscape appear to be diverse and greatly dependent on parameters, such as the field's frequency, exposure time, and intrinsic properties of the irradiated tissue, such as the expression of VGCs. Here, we systematically clarify how neuronal ion channels are particularly affected and differentially modulated by EMFs at multiple levels, such as gating dynamics, ion conductance, concentration in the membrane, and gene and protein expression. Ion channels represent a major transducer for EMF-related effects on the CNS.

https://pubmed.ncbi.nlm.nih.gov/33945157/

Excerpts

Different effects for different fields

An extensive literature exists reporting a myriad of EMF exposure–related effects on many biological processes, ranging from cell differentiation, survival, and changes in gene expression96, 97 to effects on cell membranes and signal transduction pathways.30 However, many other studies indicated the absence of significant effects elicited by these fields.59, 61 A possible explanation for the different effects reported could be related to the fact that the way in which EMFs interact with the body depends on what combination of frequencies are used and the related wavelengths.

It is well known that the effects of exposure to EMFs differ significantly based on the exposure intensities and the exposure time, 1, 98 and because of this any reasonable comparison must be made between groups having the same experimental conditions. In this study, we found different types of EMFs employed, although the two most commonly represented categories were ELF-EMFs and RF-EMFs, in line with the well-documented biological relevance of these fields. 94, 99, 100 It is important to point out that the effects exerted by these two types of exposures are not equal due to the intrinsic electrical properties of the neuronal membrane. For

instance, electrical phenomena involving a redistribution of charges in the membrane subsequent to EMF exposure, such as counterion polarization and phospholipid reorientation, are not likely to occur in RF-EMF exposure, due to the high inertia of charged particles at this high frequency. 101

Moreover, pulsed EMFs are often reported to be more active relative to static EMFs, which are characterized by a continuous electromagnetic wave to which the cell could be more adapted,102 and they could affect the gating properties of VGCs since these proteins are intrinsically sensitive to minimal electrical variations. 100 Likewise, the effect of SMFs could similarly influence VGCs through a deformation of the membrane involving a reorientation of the phospholipid bilayer, as suggested by Rosen's study. 103 Indeed, both of the studies reviewed here that focused on SMF effects reported effects on VGCs, specifically on the gating dynamics of VGCCs47 and the inactivation dynamics of VGPCs. 46

Lastly, it is worth mentioning that the frequency-related impact of the various type of EMFs has not been totally clarified, and theories exist suggesting that only specific frequencies would relevantly interact with the cell. 104-106 However, although many different types of fields have been used, the frequencies used were similar (specifically 50 Hz for ELF-EMFs and 835 and 900 Hz for RF-EMFs).

Conclusion

The studies reviewed here show VGCs as an important transducer of the effect of EMFs in neurons, and the central role played by these proteins in the regulation of important biological processes, central in the regulation of brain physiology, sheds a light on the influence that modern exposure to EMFs could have on human health. While a diverse range of biological systems were used, cell lines were the preferred option, and VGCCs were the most studied ion channels, in line with their central role in the regulation of many physiological processes in neurons. However, many other VGCs have been shown to be affected by EMFs and the results are often conflicting. In spite of the controversy, this systematic review reports significant correlation between EMFs and multiple changes in the electrophysiological properties of diverse neuronal tissues, and these results, if interpreted well, could pave the way to a new understanding of the relationship between electromagnetic stimulation and brain functions. In conclusion, we systematically demonstrate how the complex effects of EMFs in neuronal ion channels are exerted at multiple levels and how their significance in the alteration of neuronal functions is strictly dependent on different parameters relative to the type of field used and the studied cell or tissue. Improved experimental reproducibility will be key to any advances in this field, and the development of new experimental procedures capable of measuring the small but profound way in which certain types of EMF exposure seem to affect our brain might help us to establish whether it is harmful and its therapeutic potential. We hope this work will help in improving our knowledge about the molecular dynamics of neuronal VGCs, which will be key both for any progress in the treatment of neurodegenerative diseases and for an advancement in the general understanding of the relationship between technological progress and cellular dynamics.

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Exposure of South Korean Population to 5G Mobile Phone Networks (3.4-3.8 GHz)

Brahim Selmaoui, Paul Mazet, Pierre-Baptiste Petit, Kihwea Kim, Donggeun Choi, René de Seze. Exposure of South Korean Population to 5G Mobile Phone Networks (3.4-3.8 GHz). Bioelectromagnetics. 2021 May 16. doi: 10.1002/bem.22345.

Abstract

As industrialized countries race to install and deploy 5G networks, some countries have taken the lead and already have operational 5G networks in place. South Korea is among these. In this study, we measured exposure to electromagnetic fields in South Korea to evaluate the relative contribution of 5G as compared with other frequencies such as 2G, 3G, and 4G. Results show that the emission of 5G contributes about 15% to total telecommunications emissions. The highest levels were observed in the vicinity of 5G antennas and remain below the limits set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP).

https://pubmed.ncbi.nlm.nih.gov/33998007

Excerpts

The measurements were carried out at the end of November 2019 in collaboration with the Korean institute in charge of telecommunications regulation—the National Radio Research Agency (NRRA)—6 months after the network was opened to public customers. This collaboration provided early insight into the organization of the 5G service, distinctions between the antennas of the various Korean operators, and information on the distribution of antennas in the country....

The average levels of 5G TDD LB varied with both the type of environment and the area and ranged from 20 to 560 mV/m with the ExpoM-RF dosimeter and from 20 to 70 mV/m with the EME Spy 200 dosimeter....

The maximum recorded EMF for 5G was 130 mV/m....

It appears that the contribution of 5G-NR to the overall EMF exposure is small in comparison with other frequencies. Indeed, the measurements carried out in Seoul and in different geographical areas of Naju showed that this contribution is less than 15% of the total exposure in rural and urban zones, and results were similar outside the city. The 5G exposure during the urban trip (the trip inside the city) contributed about 15% of the total exposure.

Our results show that 5G exposure levels were under the exposure limit set by the ICNIRP [International Commission on Non-Ionizing Radiation Protection [ICNIRP], 1998, 2020]. Indeed, for 5G, the threshold is 39 V/m at 700 MHz and 61 V/m at 3.5 and 26 GHz. Our data show that the maximum exposure measured on the rooftop in the vicinity of the base station was still below the threshold exposure limit set by ICNIRP, and at moving positions in the nearby street, it was far below this level (below 0.08 V/m). Our study is in line with other reports [Agence National des Fréquences [ANFR], 2020] that were published online....

Measurements over 24 h at a fixed point showed that the EMF emission from the base station is usually stable over time, at around 5 mV/m, except during rush hours, which are concentrated in the morning (around 8–9 am), where exposure increases up to 130 mV/m, and in the evening (around 6–8 pm), which shows only a two-fold increase compared to the median day and nighttime levels....

Measurements with a field meter in the vicinity of the 5G-NR base station were found to be 12 V/m (15 m from the antenna) with its baseline power. This value increased to 21 V/m when the antenna was at its maximum power at the same distance....

In our study, the results with the two different dosimeters, ExpoM-RF and EME Spy 200, present some variability. This is mainly attributed to the different sensitivity thresholds of each device when the ambient exposure is close to the measurement threshold. However, at significant exposure levels, the measured values converge....

This study, in line with other reports [ANFR, 2020; Ofcom report, 2021; Telstra report, 2021] published online, is a preliminary study because EMF measurements were carried out only 6 months after the opening of the network to the Korean public. It is likely that the 5G network was not being used to its maximum and the number of subscribers was relatively low, due to the tendency of young people to use Wi-Fi spots for free. It is necessary to continue conducting EMF measurements to monitor the overall trends in the long term. Nevertheless, it appears from this study that exposure levels from 5G were in a low range. Moreover, the fact that the radio signal beam mainly focuses on the end-users will contribute to reducing exposure in unnecessary areas. This work is part of a measurement campaign in South Korea, whose final report was published in 2019 [French Expertise Report, 2019].

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In Situ Assessment of 5G NR Massive MIMO Base Station Exposure in a Commercial Network in Bern, Switzerland

Sam Aerts, Kenneth Deprez, Davide Colombi, Matthias Van den Bossche, Leen Verloock, Luc Martens, Christer Törnevik, Wout Joseph. In Situ Assessment of 5G NR Massive MIMO Base Station Exposure in a Commercial Network in Bern, Switzerland. *Appl. Sci.* 11(8): 3592. 2021. https://doi.org/10.3390/app11083592.

Abstract

This paper describes the assessment of radiofrequency (RF) electromagnetic field (EMF) exposure from fifth generation (5G) new radio (NR) base stations in a commercial NR network in Bern, Switzerland. During the measurement campaign, four base station sites were investigated and the exposure induced by the NR massive multiple-input-multiple-output (MaMIMO) antennas was assessed at 22 positions, at distances from the base station between 30 m and 410 m. The NR base stations operated at 3.6 GHz and used codebook-based beamforming. While the actual field levels without inducing downlink traffic were very low (<0.05 V/m) due to a low traffic load and low antenna input powers of up to 8 W, setting up a maximum downlink traffic stream towards user equipment resulted in a time-averaged exposure level of up to 0.4 V/m, whereas the maximum extrapolated exposure level reached 0.6 V/m. Extrapolated to an antenna input power of 200 W, values of 4.3 V/m and 4.9 V/m, respectively, were obtained, which amount to 0.5–0.6% of the reference level recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). In Bern, it was found that the impact of the NR network on the total environmental RF exposure was very limited; with maximum downlink, it contributed 2% on average. Finally, it was also concluded that extrapolation to the maximum exposure level can

be done without prior knowledge of the radiation patterns, directly based on the measurement of the Physical Downlink Shared Channel (PDSCH) resource elements.

Conclusions

To the authors' knowledge, this study provides the first assessment of the range of actual and maximum exposure levels in a 5G NR commercial network. It was found that the impact of the investigated network on the total environmental RF-EMF exposure was small, only a few percent of the total RF-EMF exposure even in the case of 100% induced traffic. Moreover, an extrapolation method was demonstrated for which no prior information from the network provider or radio equipment manufacturer is necessary, validated using the actual antenna radiation patterns.

In the (near) future, as 5G technologies evolves (e.g., when introducing reciprocity-based beamforming and other advanced MaMIMO techniques), some aspects of the presented methodology, such as the position of the UE relative to the base station and measurement probe, the averaging time to assess Eavg, and the use of the UE to stimulate the maximum exposure scenario may also have to be amended. In addition, we are confident that the described procedure is valid also at frequencies in Frequency Range 2 (FR2), above 24 GHz ('mmWaves'), provided that the measurement settings are adjusted to account for wider channel bandwidths as well as larger SCS. However, a comprehensive in situ validation study remains essential.

Open access paper: https://www.mdpi.com/2076-3417/11/8/3592

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Individual Exposure to Environmental Radiofrequency Electromagnetic Fields in Hospitalized Preterm Neonates

Dimitri Besset, Brahim Selmaoui, Stéphane Delanaud, René de Seze, André Leke, Erwan Stéphan-Blanchard. Individual Exposure to Environmental Radiofrequency Electromagnetic Fields in Hospitalized Preterm Neonates. Bioelectromagnetics. 2021 May 16. doi: 10.1002/bem.22349.

No abstract.

https://pubmed.ncbi.nlm.nih.gov/33998013/

Excerpts

RF-EMF levels in the different frequency bands over the 3-week recording period for all infants are shown in Figure 1. For the median level, the total exposure (0.03 ± 0.01 V/m) was mainly due to the FM/TV (0.01 ± 0.01 V/m), mobile phone (UL) (0.01 ± 0.00 V/m), and DECT (0.01 ± 0.01 V/m). With regard to the P99 level, the frequency bands' relative contribution to total exposure (0.24 ± 0.11 V/m) differed; the mobile phone UL signal (0.23 ± 0.11 V/m) was higher than the DECT signal (0.044 ± 0.020 V/m). For both the median and P99 levels, all other bands were below the exposimeter's limit of detection....

The present study is the first to (i) show that preterm neonates are chronically exposed to low environmental

RF-EMF levels while in the NICU; (ii) describe the exposure's characteristics; and (iii) provide objective, quantitative exposure data. On average, the RF-EMF levels to which preterm neonates were exposed were much lower than the currently recommended 50 V/m threshold [International Commission on Non-Ionizing Radiation Protection ICNIRP, 2020] but higher than those found in the general environment of the unit [Besset et al., 2020]. DECT, mobile phone (UL), and FM/TV were the main contributors to this chronic exposure. Even though RF-EMF levels were recorded every 2 min (meaning that many peak and minimal values were probably missed), 94.1% of the infants were nevertheless transiently exposed to levels above 1 V/m (0.045 ± 0.074% of all RF-EMF values, for around 41 s per day). These peak exposures were mainly due to mobile phone UL signals. Exposure to DECT and mobile phone frequency bands suggests that neonate exposure is mainly due to human activities around them (e.g., parent attentiveness, medical care) and explains why individual exposure levels were higher than those of the NICU general environment.

These exposure profiles do not place preterm neonates at risk. However, some attention to the RF-EMF induced by human activities around the infants is needed because of their high sensitivity to the environment, physiological limitations, and increased body absorption of RF-EMF energy [Peyman, 2011] during a critical maturation period. Due to the small sample size and the specificity of the hospital environment in this study, further exposure investigations are required to confirm the present data.

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Artificial EMG (electromyogram) by WLAN exposure

Lebrecht von Klitzing. Artificial EMG (electromyogram) by WLAN exposure. Journal of Biostatistics and Biometric Applications. 6(1): 2021.

Abstract

WLAN (wireless local area network) is used as an important worldwide communication-technique. By this, always there is an electromagnetic field exposure. In contrast to the ICNIRP-safety guidelines, whereby no bioeffect is possible by these low-energetic electromagnetic fields, we found artificial signals in the nervous system in dependence on WLAN- exposure,

Open access paper: http://www.annexpublishers.com/articles/JBIA/6101-Artificial-EMG-by-WLAN-Exposure.pdf

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New ICEMAN Project Seeks Answers to Fighter Pilot Disorientation [Health Matters]

James C. Lin. New ICEMAN Project Seeks Answers to Fighter Pilot Disorientation [Health Matters], IEEE Microwave Magazine. 2021; 22 (4):13-15. DOI: 10.1109/MMM.2020.3048210.

No abstract.

Excerpt

In summary, the ambient RF–EM field levels in a typical fighter/attack aircraft's cockpit are now unclear. Quantitative surveys and measurements are necessary to allow the proper assessment of the RF–EM field's potential effects on pilots' brain activity, neurophysiology, and behavioral responses. Noticeably, fighter cockpits are subjected to strong impinging RF and/or microwave radar pulses under some operational conditions.

There are two pulsed microwave-induced auditory responses in humans and mammals when the head is exposed to high-power microwave pulses that could impact a pilot's cognitive performance and response. Both are related to microwave pulse-induced acoustic pressure waves in the head: the microwave auditory effect and the acoustically induced startle reflex and motor reaction from a sudden, unexpected, intense auditory stimulus. The startle reaction from a sudden, unexpected auditory stimulus may cause the pilot to experience SD [spatial disorientation], during which one's perception of aircraft position, motion, altitude, or attitude does not correspond to actuality.

Note that this supposition is derived from theoretic treatment along with available but limited experimental evidence. The kinds of confirmational studies that would be useful are neurophysiological and psychophysical investigations of pulsed microwave-exposed animals, including observations of the subjects' behavioral and performance responses.

https://ieeexplore.ieee.org/document/9366591

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Methodology for determining the threshold distance for estimating the main EM exposure contribution in WLAN

Marta Fernández, David Guerra. Methodology for determining the threshold distance for estimating the main EM exposure contribution in WLAN. Engineering Science and Technology, an International Journal, 2021. https://doi.org/10.1016/j.jestch.2021.05.001.

Abstract

The location of radiation sources in wireless networks is a key factor to characterize their contribution to electromagnetic exposure levels in order to deploy future networks that account for minimizing electromagnetic field levels. In relation to wireless local area networks, considering that mobile communication devices comply with the SAR (Specific Absorption Rate) limits imposed by the international standardization organizations for preserving human health, the interest is nowadays focused on the signal levels coming from the WiFi access points. This paper presents a methodology to determine the threshold distance at which the field strength levels from the AP are negligible in comparison with the radiation generated by a user equipment. The theoretical concepts, which can be applied to other technologies, were implemented by means of simulations and experimental measurements. For the simulations, actual WiFi antennas were modelled. Experimental measurements completed the results obtained in simulations, resulting in a greater number of real situations. Results showed that the threshold distance depends on the WiFi standard employed by the devices connected to the network.

Conclusions

The contribution each of the EM [electromagnetic] sources to the total exposure in wireless networks is an essential parameter for characterizing EM exposure and develop network deployments that minimize EMfield levels. This manuscript presents a methodology for determining the distance at which the EM field levels transmitted by an AP [access point] can be negligible in comparison with those transmitted by a UE [user equipment] in order to simplify the assessment of the total exposure. This can also give information about the positions in which measurements should be taken in future measurement campaigns. In the proposed methodology, the threshold distances were cal-culated for a specific distance of the UE. In this work the threshold distance was determined by means of a rigorous methodology assuming the worst case scenario, that is, full activity of the WiFinetwork, 90th percentiles, and a distance of 20 cm between the UE and the reception point. This distance allows us to perform measurements in the far field region and, it can represent scenarios in which a smartphone is placed on a desk at 20 cm from the user, or scenarios in which the exposure is due to the UE of another person. Moreover, it is consistent with the definition of portable devices, since these devices are defined as transmitting devices designed to be used so that the radiating structures of the devices are within 20 cm of the body of the user [11]. Thus, in the selected conditions the results provide the largest threshold distance when the own user or the person next to him/her is exposed to radiation coming from the UE. However, for people who are at greater dis-tances from the exposure source, the threshold distances would be longer. This way, under free space propagation conditions, threshold distances ranging from 1.64 m and 4.99 m were obtained for the cases of hotspots transmitting 160 mW with bandwidths of 80 MHz and 40 MHz, respectively. This distances can increase in multipath environments as demonstrated in Section 5.4, where a maximum threshold distance of 5.92 m was obtained. In all the cases, if the UE was placed closer to the human body, the threshold distance would be lower. This conclusion may lead to a misconcep-tion that needs to be clarified. The results point out that the higher the UE power is, the lower threshold distance to the AP is allowed. However, regarding safety as the main scope of this type of research, such threshold situations characterized by maximum power UEs and minimum distances to APs should be avoided by all means. That is, the higher the threshold distance is, the better the exposure scenario will be.

Experimental results showed that the threshold distance depends on the bandwidth employed by the communication link, which is related to the WiFi standard employed by the AP and UE. Furthermore, measurements in the whole 5 GHz WiFi band were carried out in a university environment and it was proved that WiFi signals coming from further APs have lower influence than at 2.4 GHz due to the higher attenuations suffered at higher frequencies. Finally, the threshold distances were also calculated in multipath environments. The proposed methodology ensures that WiFi APs will not be a matter of concern if the user is located at larger distances than the threshold distance. On the contrary, measurements of the radiation coming from the hotspot would be needed at shorter distances, inorder to check the compliance with the reference levels. Finally, the duration of signal transmission may be of great interest when assessing EMF exposure, especially in places where people spend many hours such as schools, universities or offices. In this regard, WiFi exposure levels at 2.4 GHz were evaluated by means of 24-hour measurements in a university environment in [14]. As can be observed inFig. 4of [14], WiFi signals transmission increased in working days compared to weekends. But even during working hours, WiFi activity and therefore AP and UE transmissions varies from one location to another inside the same building.

https://www.sciencedirect.com/science/article/pii/S2215098621001099

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Effects of 1.5 and 4.3 GHz microwave radiation on cognitive function and hippocampal tissue structure in Wistar rats

Ruiqing Zhu, Hui Wang, Xinping Xu, Li Zhao, Jing Zhang, Ji Dong, Binwei Yao, Haoyu Wang, Hongmei Zhou, Yabing Gao, Ruiyun Peng. Effects of 1.5 and 4.3 GHz microwave radiation on cognitive function and hippocampal tissue structure in Wistar rats Sci Rep. 2021 May 12;11(1):10061. doi: 10.1038/s41598-021-89348-4.

Abstract

Previous studies have shown that single-frequency microwave radiation can lead to cognitive decline in rats. However, few studies have focused on the combined effects of irradiation with different frequencies of microwaves. Our research aimed to investigate the effects of 1.5 GHz and 4.3 GHz microwave radiation, singly and in combination, on cognitive function and hippocampal tissue structure in rats. A total of 140 male Wistar rats were randomly divided into 4 groups: the S group (sham radiation group), L10 group (10 mW/cm2 1.5 GHz group), C10 group (10 mW/cm2 4.3 GHz band group) and LC10 group (10 mW/cm2 1.5 and 4.3 GHz multi-frequency radiation group). For 1-28 days after microwave radiation, we analyzed the average escape latency for the Morris water maze task, electroencephalograms, change in hippocampal tissue structure and ultrastructure, content of the Nissl body in the hippocampus, and activities of lactate dehydrogenase and succinate dehydrogenase. Compared to the S group, all exposure groups showed varying degrees of learning and memory decline and hippocampal structural damage. The results showed that 1.5 GHz and 4.3 GHz microwave radiation was able to induce cognitive impairment and hippocampal tissue damage in rats and combined radiation with both frequencies caused more serious injuries, but none of these damaging effects varied with microwave frequency.

Excerpts

The microwave pulses were delivered at 200 pps, with a pulse width of 500 ns. The peak field power densities tested with a calibrated detector and an oscilloscope for the exposure groups was 100 W/cm^2. The average field power densities were calculated to be 10 mW/cm^2 (Fig. 1A and Supplementary Fig. 1A)....

[According to Table 1, the SAR values were 3.7 W/kg for the L10 group and 3.3 W/kg for the C10 group.]

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8115682/

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Protective effects of selenium on electromagnetic field-induced apoptosis, aromatase P450 activity, and leptin receptor expression in rat testis

Sareh Khoshbakht, Fatemeh Motejaded, Sareh Karimi, Narjes Jalilvand, Alireza Ebrahimzadeh-Bideskan.

Protective effects of selenium on electromagnetic field-induced apoptosis, aromatase P450 activity, and leptin receptor expression in rat testis. Iran J Basic Med Sci. 2021 Mar;24(3):322-330. doi: 10.22038/ijbms.2021.45358.10554.

Abstract

Objectives: Electromagnetic field (EMF) emitted by mobiles may affect the male reproductive system. Selenium, as an antioxidant, may protect against electromagnetic field-induced tissue damage. Theis study aimed to investigate the effects of selenium on rat testis exposed to electromagnetic fields.

Materials and methods: Twenty-four male Wistar rats were divided into four groups, namely EM group (2100 MHZ), EM/SE group (2100 MHZ + selenium (0.2 mg/kg), SE group (selenium 0.2 mg/kg), CONT (control group). Serum LH, FSH, testosterone, leptin and aromatase levels, testis weight and volume index, sperm parameters (count and abnormal percent), seminiferous tubule diam¬eters, germinal epithelia thickness, immunoreactivity of leptin receptor and caspase-3 (for apoptotic cells in germinal epithelium) were investigated.

Results: Our results showed that serum LH, FSH, GnRH, testosterone level, sperm count, germinal epithelium thickness, and seminiferous tubule diameter were significantly declined in the EM group compared with the CONT group ($P<0.05$). However, in the EM group, the serum leptin level, sperm abnormality, aromatase enzyme level, apoptotic cells, and leptin receptor were increased compared with the CONT group ($P<0.05$). Furthermore, an increase in sperm count, germinal epithelium thickness, seminiferous diameters, serum LH, FSH, and GnRH, and testosterone levels, and a significant decrease in sperm abnormality, leptin receptor and apoptotic cells in the EM/SE group compared with the EM group were also observed ($P<0.05$).

Conclusion: This study showed that electromagnetic radiation may have detrimental impacts on the male reproductive system, which can be prevented by use of selenium.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8087852/

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Changes in growth kinetic parameters, morphology and mitotic activity of yeasts Candida guilliermondii exposed to the low-intensity waves of 51.8-GHz frequency

Seda Marutyan, Syuzan Marutyan, Liparit Navasardyan, Karlen Hovnanyan, Armen Trchounian. Changes in growth kinetic parameters, morphology and mitotic activity of yeasts Candida guilliermondii exposed to the low-intensity waves of 51.8-GHz frequency. Arch Microbiol. 2021 May 3. doi: 10.1007/s00203-021-02336-0.

Abstract

Under the influence of electromagnetic waves of millimeter range with the frequency of 51.8 GHz, changes in the morphology, growth parameters and mitotic activity of yeasts C. guilliermondii NP-4 are revealed. Filamentous and giant cells appeared in a population of exposed yeasts. The sigmoid shape of the growth curve

remained but the lag phase duration was increased by 2 h in comparison with non-exposed yeasts; accordingly, the log and stationary phases followed 2 h later. The specific growth rate in the log growth phase and colony-forming ability of exposed yeasts was decreased. It is suggested that yeasts have some response mechanisms to 51.8-GHz frequency electromagnetic waves. The results can be used to understand the response mechanisms of microorganisms to non-ionizing radiation, as well as to develop approaches to protect living organisms from it. The effect of electromagnetic waves of 51.8-GHz frequency to suppress yeasts can be applied in biotechnology and medicine.

https://pubmed.ncbi.nlm.nih.gov/33938972/

Excerpt

EHF EMR (ν = 51.8 GHz) was used in the amplitude modulation mode with a frequency of 1 Hz (signal frequency stability was 0.05%). A low-intensity EMR (flow power of 0.06 mW cm^{-2}) was applied (Hovnanyan et al. 2017; Soghomonyan and Trchounian 2018; Torgomyan et al. 2012) ....

Summarizing a comparative study of the effects of low-intensity electromagnetic waves with a frequency of 51.8 GHz on the yeast *C. guilliermondii* NP-4, it can be concluded that electromagnetic waves of the frequency of 51.8 GHz lead to changes in the morphology of yeast cells, to decreases in their growth, mitotic activity and colony-forming ability. These results increase interest in further studying the effects of EMR of other EHF on yeasts and other cells.

Based on the fact that yeasts are a convenient model for studying higher eukaryotes, it is appropriate to assume that electromagnetic waves with a frequency of 51.8 GHz will have the same overwhelming effect on the growth of higher eukaryotes. From this point of view, based on our results, it can be assumed that abuse of cellular communications is dangerous not only for microorganisms, but also for higher eukaryotes, in particular for human health.

The results can be used to elucidate the response mechanisms of living organisms to radiation stress, as well as to develop approaches for protecting living organisms from non-ionizing radiation. In addition, they can be useful in biotechnology and medicine to suppress yeast, when pathogenic species cause various diseases.

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Comparison of effects of high- and low-frequency electromagnetic fields on proliferation and differentiation of neural stem cells

Wenfang Bai, Meihui Li, Weicheng Xu, Mingsheng Zhang. Comparison of effects of high- and low-frequency electromagnetic fields on proliferation and differentiation of neural stem cells. Neurosci Lett. 2021 Jan 10;741:135463. doi: 10.1016/j.neulet.2020.135463.

Highlights

• Transcranial magnetic stimulation (TMS) has been widely applied to diagnose and treat intractable brain diseases.

• Both 50 Hz LF-EMF and HF-EMF can promote the proliferation of NSCs in vitro.
• LF-EMF can accelerate NSCs to differentiate into neurons.

Abstract

To compare the effects of high- (HF-EMF) and low-frequency electromagnetic fields (LF-EMF) on the proliferation and differentiation of neural stem cells (NSCs). NSCs were obtained from SD rat hippocampus and cultured in suspension and adherent differentiation media. NSCs were exposed to LF-EMF (5 m T, 50 Hz, 30 min daily), HF-EMF (maximum magnetic induction 2.5 T, 40 % MO, 50 Hz, 10 min daily) and no electromagnetic field. At 3 d, cell viability and quantity of NSCs in suspension were detected by CCK-8 assay and cell counting plate. Immunofluorescence staining and qRT-PCR were performed to detect the percentage of Tuj-1 and GFAP-positive NSCs and the expression of Tuj-1 and GFAP mRNA. The P3 NSCs were positive with Nestin and induced NSCs expressed Tuj-1, GFAP and oligodendrocyte markers (MBP). CCK-8 assay and cell counting showed that the OD value and quantity of LF-EMF group were significantly higher than those in other two groups (both $P < 0.05$). Compared with the control group, the OD value and quantity were significantly higher in the HF-EMF group ($P < 0.05$). Immunofluorescence staining and qRT-PCR revealed that the percentage of Tuj-1 positive cells and the expression of Tuj-1 mRNA of NSCs exposed to LF-EMF were the highest (both $P < 0.05$). The proportion of GFAP-positive NSCs and the expression of GFAP mRNA did not significantly differ among three groups (all $P> 0.05$). Both 50 Hz LF-EMF and HF-EMF can promote the proliferation of NSCs in vitro and LF-EMF can accelerate NSCs to differentiate into neurons.

https://pubmed.ncbi.nlm.nih.gov/33129846/

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Biomolecular response to hour-long ultralow field microwave radiation: An effective coarse-grained model simulation

Anang Kumar Singh, P S Burada, Anushree Roy. Biomolecular response to hour-long ultralow field microwave radiation: An effective coarse-grained model simulation. Phys Rev E. 2021 Apr;103(4-1):042416. doi: 10.1103/PhysRevE.103.042416.

Abstract

Various electronic devices, which we commonly use, radiate microwaves. Such external perturbation influences the functionality of biomolecules. In an ultralow field, the cumulative response of a molecule is expected only over a time scale of hours. To study the structural dynamics of biomolecules over hours, we adopt a simple methodology for constructing the coarse-grained structure of the protein molecule and solve the Langevin equation under different working potentials. In this approach, each amino acid residue of a biomolecule is mapped onto a number of beads, a few for the backbone, and few for the side chain, depending on the complexity of its chemical structure. We choose the force field in such a way that the dynamics of the protein molecule in the presence of ultralow radiation field of microvolt/nm could be followed over the time frame of 2 h. We apply the model to describe a biomolecule, hen egg white lysozyme, and simulate its structural evolution under ultralow strength electromagnetic radiation. The simulation revealed the finer structural details, like the extent of exposure of bioactive residues and the state of the secondary structures of the molecule, further

confirmed from spectroscopic measurements [details are available in Phys. Rev. E 97, 052416 (2018)10.1103/PhysRevE.97.052416 and briefly described here]. Though tested for a specific system, the model is quite general. We believe that it harnesses the potential in studying the structural dynamics of any biopolymer under external perturbation over an extended time scale.

https://pubmed.ncbi.nlm.nih.gov/34005990/

Summary

This article aims to address the possible effect of an hour-long ultralow radiation field on a biosystem using the CG modeling technique. We obtain an optimized CG structure of a biopolymer, by considering the complexity of the chemical structure of its constituent amino acid residues. The chosen force field could reveal the dynamics of the molecule for hours. We demonstrate the efficacy of the model to study the overall topology and few finer structural details (e.g., dynamics of specific residues and secondary structures) of the HEWL molecule over an extended duration (∼2 h) under ultralow field radiation (∼10−7V/nm). It is computationally expensive to carry out all-atom quantum mechanical simulations over the above-mentioned time frame. Surely, the given model finds limitations (e.g., the explicit solvent effect has been neglected) and requires a higher level of optimization. Nonetheless, we believe that the approach, which we followed, is quite general and may pave a way to follow the structural dynamics of other biopolymers under an external perturbation for hours, if the solvent effect can be appreciably taken into account by the random noise in the beads' motion. It will also be interesting to test other more elegant CG models, mentioned in Sec. I of this article, to probe the effect of hour-long ultralow field radiation on biomolecules. From a biology viewpoint, we demonstrate the adverse effect of the radiation field on biomolecules, even when its strength is superlow.

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Exposure to extremely low-frequency magnetic fields and childhood cancer: A systematic review and meta-analysis

GyeongAe Seomun, Juneyoung Lee, Jinkyung Park. Exposure to extremely low-frequency magnetic fields and childhood cancer: A systematic review and meta-analysis. PLoS ONE 16(5): e0251628. May 14, 2021. doi:10.1371/journal.pone.0251628.

Abstract

Background Extremely low frequency magnetic fields (ELF-MFs) are classified as a possible carcinogenic factor (Group 2B). This study assessed the association between ELF-MFs and childhood cancer through a systematic review and meta-analysis.

Methods Three databases were searched in January 2020. We conducted a meta-analysis for the association between the ELF-MFs exposure level and childhood cancer.

Results A total of 33 studies were identified. Thirty studies with 186,223 participants were included in the meta-analysis. Children exposed to 0.2-, 0.3-, and 0.4-μT ELF-MFs had a 1.26 (95% confidence interval [CI] 1.06–1.49),

1.22 (95% CI 0.93–1.61), and 1.72 (95% CI 1.25–2.35) times higher odds of childhood leukemia. In childhood brain tumors, children exposed to 0.2-μT had a 0.95 (95% CI 0.59–1.56) times higher odds, and those exposed to 0.4-μT ELF-MFs had a 1.25 (95% CI 0.93–1.61). Children exposed to 0.2- and 0.4-μT ELF-MFs had a 1.10 (95% CI 0.70–1.75) and 2.01 (95% CI 0.89–4.52) times higher odds of any childhood cancers.

Conclusions Significant associations were observed between exposure to ELF-MFs and childhood leukemia. Furthermore, a possible dose-response effect was also observed.

Excerpts

The debate on the effect of electromagnetic fields (EMFs) on the human body still continues, and several studies have investigated the effect of magnetic fields that are not well shielded by objects [1–3]. The question of whether exposure to extremely low-frequency magnetic fields (ELF-MFs) from power transmission and distribution or the use of electrical appliances is associated with an increased risk of childhood cancer has engendered scientific debate [4–6]. In 2001, the ELF-MFs were classified by the International Agency for Research on Cancer (IARC) as possibly carcinogenic (Group 2B), based on the limited clinical evidence, inadequate experimental support, and the lack of plausible mechanisms at the exposure levels that were observed in epidemiological studies [7, 8]. This classification was endorsed by the subsequent weight of evidence assessments carried out by the World Health Organization (WHO) [8]. Subsequently, clinical evidence emerged from epidemiological studies on the etiology of childhood leukemia that indicated a weak association with ELF-MFs [9–12]....

Conclusions In this large pooled analysis of more than 36,000 children diagnosed with childhood leukemia, statistically significant associations were observed between exposure to ELF-MF and childhood leukemia. Furthermore, the intensity of the association between exposure to ELF-MFs and childhood leukemia was high, as indicated by the dose–response effect.

The risk of ELF-MFs, which have been classified as a possibly carcinogenic (Group 2B) factor based on limited evidence in humans, can be ascertained through precise evidence from the integrated results of this study.

Open access paper: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0251628

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Extremely Low Frequency Electromagnetic Exposure Assessment in Schools: A Statistical Analysis of Urban and Semi-Urban Areas

Y Kiouvrekis, A Alexias, V Softa, M Alkhorayef, A Sulieman, C Tyrakis, C Kappas. Extremely Low Frequency Electromagnetic Exposure Assessment in Schools: A Statistical Analysis of Urban and Semi-Urban Areas. Radiat Prot Dosimetry. 2021 May 28; doi: 10.1093/rpd/ncab076.

Abstract

The aim of this research paper is to estimate the mean value of extremely low frequency (ELF) exposure in

schools in Greece. Detailed ELF measurements were conducted and analyzed by the Weighted Peak Method (WPM), which estimates the overall contribution of electromagnetic waves from 1 Hz to 400 kHz, including their phases. A sample of 243 schools was sampled to calculate. The mean value of ELF magnetic fields (MFs) measured in these two groups comprising 243 schools was the principal focus of interest. ELF MF measurements taken in schools situated both far from and near ELF sources had mean and maximum values well below the current International Commission on Non-Ionizing Radiation Protection (ICNIRP) standard. The mean value of ELF MFs from all sources within the sampled schools in Greece was 0.21 μT. A statistically significant difference between the mean MFs measured in the two groups of schools was found, but the MFs in both groups were much lower than the ICNIRP standard.

https://pubmed.ncbi.nlm.nih.gov/34047347

Excerpts

The median value of the MFs measured in the ELF range was 0.174 μT, which is 0.174% of the 2010 ICNRP standard (100 μT). In Figure 1, we present a typical example, and Table 1 shows the relative contribution of the harmonics....

Mean value is 0.23 μT for urban areas and 0.14 μT for semi-urban areas with s.d. of 0.23 and 0.13, respectively; the median is 0.18 for the urban area category and 0.11 for the semi-urban category, while the 25 and 75% percentiles are 0.12 μT and 0.25 μT for urban areas and 0.04 μT and 0.18 μT for the semi-urban areas, respectively (Figure 4). Similarly, concerning the WPM variable, the mean value is 1.33% for urban areas and 1.20% for semi-urban areas with s.d. of 0.18 and 0.13%, respectively; the median is 1.30% for the urban area category and 1.19% for the semi-urban category, while the 25 and 75% percentiles are 1.25 and 1.36% for urban areas and 1.10 and 1.26% for semi-urban areas, respectively (Figure 4).

Conclusions

ELF measurements (Max Peak, WPM) in schools situated both far from and near ELF sources allow for a comprehensive assessment of exposure in schools. Furthermore, statistical analysis shows that, on one hand, there is a statistically significant difference between schools in areas described as urban and semi-urban. Despite the fact that there is a statistically significant difference between the levels of MFs measured in schools two separate areas, it is negligible with regard to the current standard by virtue of it being a difference by several orders of magnitude.

What is noteworthy is that the WPM values (6–500 Hz range) of the urban and semi-urban schools were found to be approximately an order of magnitude higher than that recorded in WPM frequency range (1 Hz–400 kHz). This is because in semi-urban and urban areas, the mode frequency is 50 Hz due to the power grid. While in terms of the MAX PEAK value, it also makes sense to be different and there is a statistically significant difference, as we are referring to an instantaneous value of each measurement point, which may have been affected but without affecting the final value of the point.

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Identification of Environmental and Experimental Factors Influencing Human Perception of DC and AC Electric Fields

Kathrin Jankowiak, Sarah Driessen, Andrea Kaifie, Simon Kimpeler, Thomas Krampert, Thomas Kraus, Dominik Stunder, Michael Kursawe. Identification of Environmental and Experimental Factors Influencing Human Perception of DC and AC Electric Fields. Bioelectromagnetics. 2021 May 11. doi: 10.1002/bem.22347.

Abstract

As part of the energy transition in Germany, high-voltage direct current (HVDC) lines producing DC electric fields (EF) are in planning. Since the human perception of DC EF was rarely investigated in the past, we aimed to identify environmental and experimental factors influencing the human perception of direct current (DC) EF, alternating current (AC) EF, and the co-exposure of DC EF and AC EF (hybrid EF) under whole-body exposure. Additionally, first estimates of DC EF and AC EF perception thresholds as well as differences in human perception of DC EF and AC EF concerning the type of sensation experienced and the affected body part were evaluated. A highly sophisticated exposure lab was built to expose participants to various EF strengths and ask for their assessment concerning the presence of an EF. To estimate the individual perception thresholds of 11 participants, the signal detection theory as well as the single-interval-adjustment matrix procedure were applied. Relative humidity could be identified as an environmental factor influencing the perception of AC EF and DC EF in different ways. An appropriate ramp slope and an exposure duration for future studies could be elaborated. Additionally, perception thresholds were lower under hybrid EF exposure than under DC EF or AC EF exposure alone. Cutaneous sensations evoked under DC EF and AC EF exposure were individually different and attributed to various parts of the body. Several environmental and experimental factors influencing the human perception of EF could be identified and provide an essential basis for a large-scale study.

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Comparison of ELF-EMFs stimulation with current stimulation on the regulation of LTP of SC-CA1 synapses in young rat hippocampus

Yu Zheng, Wenjun Zhao, Xiaoxu Ma, Lei Dong, Lei Tian, Mei Zhou. Comparison of ELF-EMFs stimulation with current stimulation on the regulation of LTP of SC-CA1 synapses in young rat hippocampus. Int J Radiat Biol. 2021 May 10;1-21. doi: 10.1080/09553002.2021.1928781.

Abstract

Background: Long-term potentiation (LTP) is an important functional indicator for studying synaptic plasticity. Extremely low frequency electromagnetic fields (ELF-EMFs) are a physical means to regulate LTP. Time-varying magnetic fields induce induced currents. It is unknown which of the two parameters is the key factor when LTP is regulated by the magnetic field.New Method: A method is proposed for calculating the current value induced by ELF-EMFs. Then, a comparison of ELF-EMFs stimulation (100 Hz/2 mT and 200 Hz/2 mT) with current stimulation (0.1 μA and 0.2 μA) on the regulation of theta-burst or high-frequency stimulation (TBS/HFS)-LTP was performed.

Results: The LTP after ELF-EMFs and μA current regulation was significantly reduced compared with the corresponding value in the control group. The regulatory effect of 100 Hz/2 mT ELF-EMFs on LTP was stronger than 200 Hz/2 mT. However, the regulatory level of the currents (0.1 μA, 0.2 μA) was similar; the effect of 0.1 μA current was similar to that of 100 Hz/2 mT ELF-EMFs, while 0.2 μA had a stronger regulatory effect than that of 200 Hz/2 mT on HFS-LTP.Comparison with Existing Methods: Most of the existing methods were used to calculate the induced current in human models, while a calculation model of the induced current in the rat brain slice induced by ELF-EMFs was established in this work, which is more accurate than the existing methods.

Conclusions: This work demonstrated that both current and ELF EMFs stimulation reduced LTP. However, their effect was not exactly the same, indicating that the regulatory effect of ELF-EMFs on LTP is not entirely deriving from the induced current, since its magnetic mechanism might have played a certain role.

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Magnetic field-induced Ca 2+ intake by mesenchymal stem cells is mediated by intracellular Zn 2+ and accompanied by a Zn 2+ influx

Alp Özgün, Bora Garipcan. Magnetic field-induced Ca 2+ intake by mesenchymal stem cells is mediated by intracellular Zn 2+ and accompanied by a Zn 2+ influx. Biochim Biophys Acta Mol Cell Res. 2021 May 22;119062. doi: 10.1016/j.bbamcr.2021.119062.

Highlights

- Magnetic field-induced oxidative stress is not derived from mitochondrial activity.
- Ca^{2+} intake under magnetic field exposure is accompanied by Zn^{2+} intake.
- Magnetic field-evoked cation intake depends on availability of intracellular Zn^{2+}.
- 2-APB-sensitive pathways are major gateways for cation influx induced by magnetic fields.

Abstract

Chronic exposure to magnetic fields (MFs) has a diverse range of effects on biological systems but definitive molecular mechanisms of the interaction remain largely unknown. One of the most frequently reported effects of MF exposure is an elevated concentration of intracellular Ca2+ through disputed pathways. Other prominent effects include increased oxidative stress and upregulation of neural markers through EGFR activation in stem cells. Further characterization of cascades triggered by MF exposure is hindered by the phenotype diversity of biological models used in the literature. In an attempt to reveal more mechanistic data in this field, we combined the most commonly used biological model and MF parameters with the most commonly reported effects of MFs. Based on clues from the pathways previously defined as sensitive to MFs (EGFR and Zn2+-binding enzymes), the roles of different types of channels (voltage gated Ca2+ channels, NMDA receptors, TRP channels) were inquired in the effects of 50 Hz MFs on bone marrow-derived mesenchymal stem cells. We report that, an influx of Zn2+ accompanies MF-induced Ca2+ intake, which is only attenuated by the broad-range inhibitor of

TRP channels and store-operated Ca2+ entry (SOCE), 2-Aminoethoxydiphenyl borate (2-APB) among other blockers (memantine, nifedipine, ethosuximide and gabapentin). Interestingly, cation influx completely disappears when intracellular Zn2+ is chelated. Our results rule out voltage gated Ca2+ channels as a gateway to MF-induced Ca2+ intake and suggest Zn2+-related channels as a new focus in the field.

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Rare-Earth Magnets Influence Movement Patterns of the Magnetically Sensitive Nudibranch Tritonia exsulans in Its Natural Habitat

Russell C Wyeth, Theora Holden, Hamed Jalala, James A Murray. Rare-Earth Magnets Influence Movement Patterns of the Magnetically Sensitive Nudibranch Tritonia exsulans in Its Natural Habitat. Biol Bull. 2021 Apr;240(2):105-117. doi: 10.1086/713663.

Abstract

The nudibranch Tritonia exsulans (previously Tritonia diomedea) is known to have behaviors and neurons that can be modified by perturbations of the Earth's magnetic field. There is no definitive evidence for how this magnetic sense is used in nature. Using an exploratory approach, we tested for possible effects of magnetic perturbations based on underwater video of crawling patterns in the slugs' natural habitat, with magnets of varying strength deployed on the substrate. For analysis, we used a paired comparison of tracks of animals between segments 25-50 cm distant from the magnets and segments of the same tracks 0-25 cm from the magnets, to determine whether any differences depended on the strength of the magnet. Most track measurements (length, displacement, velocity, and tortuosity) showed no such differences. However, effects were observed for the changes in track headings between successive points. These results showed that tracks had relatively higher heading variability when they moved closer to stronger magnets. We suggest that this supports a hypothesis that T. exsulans continuously uses a magnetic sense to help maintain straight-line navigation. Further specific testing of the hypothesis is now needed to verify this new possibility for how animals can benefit from a compass sense.

https://pubmed.ncbi.nlm.nih.gov/33939940/

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Manmade Electromagnetic Fields and Oxidative Stress—Biological Effects and Consequences for Health

David Schuermann, Meike Mevissen. Manmade Electromagnetic Fields and Oxidative Stress—Biological Effects and Consequences for Health. Int. J. Mol. Sci. 2021, 22(7), 3772; https://doi.org/10.3390/ijms22073772

(This article belongs to the Special Issue Molecular Mechanisms of Genotoxicity)

Abstract

Concomitant with the ever-expanding use of electrical appliances and mobile communication systems, public and occupational exposure to electromagnetic fields (EMF) in the extremely-low-frequency and radiofrequency range has become a widely debated environmental risk factor for health. Radiofrequency (RF) EMF and extremely-low-frequency (ELF) MF have been classified as possibly carcinogenic to humans (Group 2B) by the International Agency for Research on Cancer (IARC). The production of reactive oxygen species (ROS), potentially leading to cellular or systemic oxidative stress, was frequently found to be influenced by EMF exposure in animals and cells. In this review, we summarize key experimental findings on oxidative stress related to EMF exposure from animal and cell studies of the last decade. The observations are discussed in the context of molecular mechanisms and functionalities relevant to health such as neurological function, genome stability, immune response, and reproduction. Most animal and many cell studies showed increased oxidative stress caused by RF-EMF and ELF-MF. In order to estimate the risk for human health by manmade exposure, experimental studies in humans and epidemiological studies need to be considered as well.

Conclusions

The majority of recent animal studies on increased ROS production and oxidative stress caused by EMF were aimed at investigations of the nervous system and reproduction. Analogously, in cell studies, neurons or neuron-like cells were most frequently used. Animal studies on oxidative stress and possible impairment of reproduction at different stages (sperm maturation, very early stages of pregnancy such as implantation, and effects in newborns and after a few weeks of EMF exposure to the mother animals during pregnancy) follow in second place. These animal studies were supported by some cell studies, mainly in mouse cell lines of the male reproductive system and in sperm. Overall, more cells than animal studies were published, using, in addition to the above-mentioned cell types of the nervous and reproductive system, immune and cancer cells, as well as isolated cells from the skin and epithelia. For this report, animal and cell studies were included, according to their quality and research question, in order to give an informative overview of the available studies; however, this is not a systematic review.

In summary, indications for increased oxidative stress caused by RF-EMF and ELF-MF were reported in the majority of the animal studies and in more than half of the cell studies. Investigations in Wistar and Sprague-Dawley rats provided consistent evidence for oxidative stress occurring after RF-EMF exposure in the brain and testes and some indication of oxidative stress in the heart. Observations in Sprague-Dawley rats also seem to provide consistent evidence for oxidative stress in the liver and kidneys. In mice, oxidative stress induced by RF-EMF was predominantly demonstrated in the brain and testes, as well as in liver, kidneys, and ovaries. These observations were made with a variety of cell types, exposure times, and dosages (SAR or field strengths), within the range of the regulatory limits and recommendations. Certainly, some studies were subject to methodological uncertainties or weaknesses or are not very comprehensive regarding exposure time, dose, number, and quantitative analysis of the biomarkers used, to name a few. A trend is emerging, which becomes clear even when taking these methodological weaknesses into account, i.e., that EMF exposure, even in the low dose range, may well lead to changes in cellular oxidative balance. Organisms and cells are able to react to oxidative stress, and many observations after EMF exposure point to an adaptation after a recovery phase. Adverse conditions, such as diseases (diabetes, neurodegenerative diseases), compromise the body’s defense mechanisms, including antioxidant protection mechanisms, and individuals with such pre-existing conditions are

more likely to experience health effects. The studies show that very young or old individuals can react less efficiently to oxidative stress, which of course also applies to other stressors that cause oxidative stress. Further investigations under standardized conditions are necessary to better understand and confirm these phenomena and observations.

Open access paper: https://www.mdpi.com/1422-0067/22/7/3772

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Science, Politics, and Groupthink [Health Matters]

James C. Lin. Science, Politics, and Groupthink [Health Matters]. *IEEE Microwave Magazine*. **22**(5):24-26. Apr 1, 2021. **DOI:** 10.1109/MMM.2021.3056975.

Abstract

Discusses how the COVID-19 health pandemic worldwide was complicated by not only health and medical concerns, but the inclusion of politics, conspiracy theories, and social media.

https://ieeexplore.ieee.org/document/9393739

In his latest column Professor Emeritus Lin criticizes the ICNIRP, the non-profit organization which the WHO relies upon for non-ionizing electromagnetic fields (EMF) exposure guidelines that it promotes worldwide. As you may know, this column is important not only because Professor Lin is one of the most respected EMF scientists in the world, he is the first scientist who has served on the ICNIRP Commission (2004 - 2016; chair of the committee on Physics & Engineering, 2008-2012; chair of the Radio Frequency group, 2012-2015) to challenge the credibility of ICNIRP's EMF exposure guidelines.

Excerpts

"Recently, a privately constituted group, with self-appointed membership, published a set of guidelines for limiting exposure to RF electromagnetic fields in the 100-kHz and 300-GHz frequency range [7]. The proposed guidelines were primarily based on the tissue-heating potentials of RF radiation to elevate animal body temperatures to greater than 1° C. While recognizing that the two aforementioned studies used large numbers of animals, best laboratory practice, and animals exposed for the entirety of their lives, the private group preferred to quibble with alleged “chance differences” between treatment conditions and the fact that the measured animal body core temperature changes reached 1° C, implying that a 1° C body core temperature rise is carcinogenic, ignoring the RF exposure. The group then pronounced that, when considered either in isolation or within the context of other animal carcinogenicity research, these findings do not provide evidence that RF radiation is carcinogenic.

Furthermore, the group noted that, even though many epidemiological studies of RF radiation associated with mobile phone use and cancer risk had been performed, studies on brain tumors, acoustic neuroma, meningioma, and parotid gland tumors had not provided evidence of an increased cancer risk. It suggested that, although somewhat elevated odds ratios were observed, inconsistencies and limitations, including recall or

selection bias, precluded these results from being considered for setting exposure guidelines. The simultaneous penchant to dismiss and criticize positive results and the fondness for and eager acceptance of negative findings are palpable and concerning.

In contrast, the IARC's evaluation of the same epidemiological studies ended up officially classifying RF radiation as possibly carcinogenic to humans [2], [3].

An understandable question that comes to mind is this: How can there be such divergent evaluations and conclusions of the same scientific studies? Humans are not always rational or as transparent as advertised, and scientists are not impervious to conflicts of interest and can be driven by egocentric motivations. Humans frequently make choices and decisions that defy clear logic.

Science has never been devoid of politics, believe it or not...."

"Cellular mobile communication and associated wireless technologies have proven, beyond any debate, their direct benefit to humans. However, as for the verdict on the health and safety of billions of people who are exposed to unnecessary levels of RF radiation over extended lengths of time or even over their lifetimes, the jury is still out. When confronted with such divergent assessments of science, the ALARA—as low as reasonably achievable—practice and principle should be followed for RF health and safety."

[7] "ICNIRP guidelines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz)," Health Phys., vol. 118, no. 5, pp. 483–524, 2020.

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Background document to the advisory report 5G and health (Health Council of the Netherlands)

Health Council of the Netherlands. Background document to the advisory report 5G and health. Background document to 5G and health. The Hague: Health Council of the Netherlands, 2020; publication no. 2020/16Ae

Introduction

In this background document to the advisory report 5G and health, drafted by the Electromagnetic Fields Committee of the Health Council of the Netherlands, chapter 2 contains the search strategies used by the committee for the different topics. In chapter 3 the in- and exclusion criteria of the WHO are presented. In chapter 4 the committee gives an overview of the relevant publications on diseases and conditions, and in chapter 5 of the relevant publications on biological processes.

Open access background document report:
https://www.healthcouncil.nl/binaries/healthcouncil/documents/advisory-reports/2020/09/02/5g-and-health/Background-document-to-the-advisory-report-5G-and-health.pdf

Open access advisory report: https://www.healthcouncil.nl/binaries/healthcouncil/documents/advisory-reports/2020/09/02/5g-and-health/Advisory-report-5G-and-health.pdf

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IEEE C95.3-2021 - IEEE Approved Draft Recommended Practice for Measurements and Computations of EMF with Respect to Human Exposure to Such Fields, 0 Hz-300 GHz

Institute of Electrical and Electronics Engineers. IEEE C95.3-2021 - IEEE Approved Draft Recommended Practice for Measurements and Computations of Electric, Magnetic and Electromagnetic Fields with Respect to Human Exposure to Such Fields, 0 Hz-300 GHz. 2021.

Standard Details

Best practices are described for the development, validation, and application of methods for the computation and measurement of relevant metrics characterizing human exposure to electric and/or magnetic fields (collectively, electromagnetic fields) over the frequency range of 0 Hz to 300 GHz. This recommended practice is a replacement for IEEE Std C95.3™-2002 and IEEE Std C95.3.1™-2010, extensively revising the contents from those and harmonizing with IEEE Std C95.1™-2019. Detailed methodology is not described; rather, requirements for best practice are expressed through guidance and references to other documents and standards. Examples are included to clarify the guidance. This recommended practice is intended for professional users who are familiar with basic electromagnetic field theory and practice and for persons involved in specifying or implementing critical hazard assessments or surveys such as those described in IEEE Std C95.7™-2014.

https://standards.ieee.org/standard/C95_3-2021.html

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Radiation Protection Standard for Limiting Exposure to Radiofrequency Fields - 100 kHz to 300 GHz (ARPANSA)

Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). Radiation Protection Standard for Limiting Exposure to Radiofrequency Fields - 100 kHz to 300 GHz. 2021, Radiation Protection Series S-1 (Rev. 1)

No abstract.

Open access report: https://www.arpansa.gov.au/sites/default/files/rps_s-1.pdf

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The Effect of GSM Electromagnetic Field Exposure on the Waking Electroencephalogram: Methodological Influences

Anna Dalecki, Adam Verrender, Sarah P Loughran, Rodney J Croft. The Effect of GSM Electromagnetic Field Exposure on the Waking Electroencephalogram: Methodological Influences. Bioelectromagnetics. 12 April 2021.https://doi.org/10.1002/bem.22338.

Abstract

Although there is consistent evidence that exposure to radiofrequency electromagnetic fields (RF-EMF) increases the spontaneous resting alpha spectral power of the electroencephalogram (EEG), the reliability of this

evidence is uncertain as some studies have also failed to observe this effect. The present study aimed to determine whether the effect of RF-EMF exposure on EEG alpha power depends on whether EEG is derived from eyes open or closed conditions and assessed earlier (<5-min) versus later (>25-min) in the exposure interval. Thirty-six adults participated in three experimental sessions, each involving one exposure: "Sham," "Low," and "High" RF-EMF corresponding to peak spatial specific absorption rates averaged over 10 g of 0, 1, and 2 W/kg, respectively. Resting EEG was recorded at baseline (no exposure), during, and after exposure. Alpha power increase was found to be greater for the eyes open than eyes closed EEG during both the High ($P = 0.04$) and Low ($P = 0.04$) RF-EMF exposures. There was also a trend toward it being larger at the end, versus the start of the "High" 30-min exposure ($P < 0.01$; eyes open condition). This suggests that the use of eyes closed conditions, and insufficient RF-EMF exposure durations, are likely explanations for the failure of some studies to detect an RF-EMF exposure-related increase in alpha power, as such methodological choices decrease signal-to-noise ratios and increase type II error.

https://pubmed.ncbi.nlm.nih.gov/33847008/

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Simulated mobile communication frequencies (3.5 GHz) emitted by a signal generator affects the sleep of Drosophila melanogaster

Yahong Wang, Hongying Zhang, Ziyan Zhang, Boqun Sun, Chao Tang, Lu Zhang, Zhihao Jiang, Bo Ding, Yanyan Liao, Peng Cai. Simulated mobile communication frequencies (3.5 GHz) emitted by a signal generator affects the sleep of Drosophila melanogaster. Environ Pollut. 2021 Apr 5;283:117087. doi: 10.1016/j.envpol.2021.117087.

Abstract

With the rapid development of science and technology, 5G technology will be widely used, and biosafety concerns about the effects of 5G radiofrequency radiation on health have been raised. Drosophila melanogaster was selected as the model organism for our study, in which a 3.5 GHz radiofrequency radiation (RF-EMR) environment was simulated at intensities of 0.1 W/m2, 1 W/m2, and 10 W/m2. The activity of parent male and offspring (F1) male flies was measured using a Drosophila activity monitoring system under short-term and long-term 3.5 GHz RF-EMR exposure. Core genes associated with heat stress, the circadian clock and neurotransmitters were detected by QRT-PCR technology, and the contents of GABA and glutamate were detected by UPLC-MS. The results show that short-term RF-EMR exposure increased the activity level and reduced the sleep duration while long-term RF-EMR exposure reduced the activity level and increased the sleep duration of F1 male flies. Under long-term RF-EMR, the expression of heat stress response-related hsp22, hsp26 and hsp70 genes was increased, the expression of circadian clock-related per, cyc, clk, cry, and tim genes was altered, the content of GABA and glutamate was reduced, and the expression levels of synthesis, transport and receptor genes were altered. In conclusion, long-term RF-EMR exposure enhances the heat stress response of offspring flies and then affects the expression of circadian clock and neurotransmitter genes, which leads to decreased activity, prolonged sleep duration, and improved sleep quality.

Highlights

• This study was simulating the most representative 3.5 GHz radio frequency radiation band of 5G in environment.

•This study was exploring the impact on the activity and sleep of organism under long-term RF-EMR.

• This study provided a reference for the hidden health effects brought by the development of science and technology.

https://pubmed.ncbi.nlm.nih.gov/33894629/

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The Adverse Effect of Mobile Phone Radiations on Dorsal Root Ganglion of Albino Rats

Faisal Taufiq, Mohammed Bhilal Babu, Aqeel Ahmad, Mohammed Eajaz, Ahmed Shariff, Noureldaim Elnoman Elbadawi, Semmal Syed Meerasa. The Adverse Effect of Mobile Phone Radiations on Dorsal Root Ganglion of Albino Rats. Journal of Pharmaceutical Research International, 19 March 2021. Pages 54-60. DOI: 10.9734/jpri/2021/v33i1331266.

Abstract

Objectives: To assess the effect of Mobile Phone Radio Frequency Electromagnetic Radiation (RF-EMR) on the histological structure of dorsal root ganglia in albino rats.

Methods: Twenty-four albino rats divided into one control and three experimental groups were studied for four weeks. The experimental groups were exposed to three different levels of RF-EMR through complete missed calls of 80,120 and160 calls per day respectively, using a GSM mobile phone of 0.9 GHz to1.8 GHz in silent mode. The dorsal root ganglia of the sacrificed Rats were examined under light and transmission electron microscope (TEM).

Results: Dorsal root ganglions of exposed rats showed considerable histological changes like reduction in cell size, condensation of cytoplasm, peripherally located heterochromatin nucleus, loss of nucleolus and densely packed myelinated nerve fibers. No such changes were observed in control rats.

Conclusion: Dorsal root ganglionic cells showed enduring and continuous changes when exposed to RF-EMR. The severity of histomorphological changes was dose-dependent, which increased constantly with radiation dosage increment. It might be fair to conclude that degenerative changes in the Dorsal Root Ganglion of the spinal cord, could be attributed to the long-term exposure to RF-EMR.

Open access paper: https://www.journaljpri.com/index.php/JPRI/article/view/31266

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Effects of mobile phone emissions on human red blood cells

Aniket Chowdhury, Yashveer Singh, Uttam Das, Deepak Waghmare, Raktim Dasgupta, Shovan Kumar Majumder. Effects of mobile phone emissions on human red blood cells. J Biophotonics. 2021 Apr 19;e202100047. doi: 10.1002/jbio.202100047.

Abstract

Raman spectroscopy was performed on GSM 900 MHz and 1800 MHz mobile phone signal exposed red blood cells (RBCs). The observed changes in the Raman spectra of mobile signal exposed RBCs compared to unexposed control suggest reduced hemoglobin-oxygen affinity for the exposed cells. The possible mechanism may involve activation of the voltage gated membrane Ca2+ channels by the mobile phone emissions resulting in an increase in the levels of adenosine triphosphate (ATP) and 2,3-diphosphoglycerate (2,3-DPG) in cells via altered metabolic activities. Further studies carried out with fluorescent Ca2+ indicator confirmed increased intracellular Ca2+ level in the exposed cells. Since intracellular ATP level influences the shape and mechanics of RBCs, exposed cells were studied using diffraction phase microscopy and optical tweezers. Detectable changes in shape and mechanical properties were observed due to mobile signal exposure.

https://pubmed.ncbi.nlm.nih.gov/33871929/

Excerpts

The RBC samples were exposed to mobile phone signal by keeping a commercial mobile handset (Nokia 105) in close proximity (~ few mm) of the glass cover slip. The handset was kept on call mode throughout the exposure time.

In the present study the SAR for the handset used is 1.501 W/kg which is less than the permissible limit of 1.6 W/kg prescribed in most parts of the world. The power density level from the typical GSM handsets is ~ 10-4 mW/cm2 [33] and our mobile handset has no additional features like Global Positioning System (GPS), WiFi, Bluetooth etc. that may unwantedly add to the effect of basic GSM signals.

... thermal effects on blood samples due to low level microwave radiation from the handset should be negligible.

Further, an estimate of the power density at a distance of 100 meters (R) from a mobile network tower, typically emitting (Pt) ~ 100W, shows the radiation density is about 10-4 mW/cm2. Such radiation exposure from network towers for people residing nearby will be of con-
tinuous nature [34] and closely resembles the pattern and level of exposure considered in present experiments. Such radiation exposure from network towers for people residing nearby will be of continuous nature [34] and closely resembles the pattern and level of exposure considered in present experiment.

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Antenna/Human Body Coupling in 5G Millimeter-Wave Bands: Do Age and Clothing Matter?

G. Sacco, D. Nikolayev, R. Sauleau, M. Zhadobov. Antenna/Human Body Coupling in 5G Millimeter-Wave Bands: Do Age and Clothing Matter? IEEE Journal of Microwaves, doi: 10.1109/JMW.2021.3063256.

Abstract

With the fast development of 5th generation (5G) mobile networks and prominence of the personal area networks and human-centered communications, people of all ages are increasingly exposed in the upper part of the microwave spectrum. In some exposure scenarios, presence of a textile between the radiating source and skin can affect the power absorption. This study investigates, for the first time, the effect of ageing and impact of textile on the power deposition in a skin-equivalent model under near-field exposure induced by multi-beam radiating structures at 26 GHz and 60 GHz. An array of four Yagi antennas has been used as a representative example of 5G reconfigurable antennas. The maximum increase of the averaged absorbed power density with respect to the averaged value for adults is observed at 70 year (8.8% at 26 GHz and 6.9% at 60 GHz). The strongest decrease is for 5-years-old children (−4.5% at 26 GHz and -3.7% at 60 GHz). In presence of a textile, the absorbed power density can increase or decrease depending on the textile properties (thickness and permittivity) and on the thickness of the air gap between textile and skin. With cotton and wool (considered as representative textile materials) the maximum increase of the averaged absorbed power density is about 40% compared to the bare skin.

Excerpts

"At microwave frequencies, the difference in exposure levels between children and adults was investigated [3]–[5]. It was demonstrated that, up to 5.6 GHz, the whole-body-average specific absorption rate (SAR) in children can go beyond the exposure limits [6], [7] by 40%–45% whereas remaining below these limits for adults (given the same incident field) [5], [8]. A more recent study [9] investigated the whole-body average SAR using the child models specified by the Commission on Radiological Protection (ICRP) instead of the scaled adult phantoms."

"This study deals with the electromagnetic exposure under near-field conditions considering typical reconfigurable antennas at 26 GHz and 60 GHz. For the first time, the analysis is performed taking into account biological tissue permittivity variations with age and presence of a textile in proximity or in contact with skin."

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9393791

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Artificial EMG (Electromyogram) by WLAN-Exposure

L. von Klitzing. Artificial EMG by WLAN-Exposure. J Biostat Biometric App 6(1):101. 2021.

Abstract

WLAN (wireless local area network) is used as an important worldwide communication-technique. By this, always there is an electromagnetic field exposure. In contrast to the ICNIRP-safety guidelines, whereby no bioeffect is possible by these low-energetic electromagnetic fields, we found artificial signals in the nervous system in dependence on WLAN- exposure.

Open access letter: http://www.annexpublishers.com/articles/JBIA/6101-Artificial-EMG-by-WLAN-Exposure.pdf

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30 Hz, Could It Be Part of a Window Frequency for Cellular Response? (Review)

Olga García-Minguillán, Ceferino Maestú. 30 Hz, Could It Be Part of a Window Frequency for Cellular Response? Int J Mol Sci. 2021 Mar 31;22(7):3642. doi: 10.3390/ijms22073642

Abstract

Many exogenous and endogenous risk factors have been proposed as precursors of brain tumors, including the exposure to non-ionizing electromagnetic fields. Nevertheless, there is still a debate among the scientific community about the hazard of the effects produced by non-ionizing radiation (NIR) because conflicting results have been found (number of articles reviewed >50). For that reason, to provide new evidence on the possible effects produced by exposure to NIR, we performed different studies with several combinations of extremely low frequencies, times, and field intensities in tumoral and non-tumoral cells. The results of our studies showed that cell viability was frequency dependent in glioblastoma cells. In fact, our results revealed that a frequency of 30 Hz-or even other frequencies close to 30 Hz-could constitute a window frequency determinant of the cellular response in tumoral and non-tumoral cells.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8036499/

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Response to “Cancerogenic effects of radiofrequency radiation: A statistical reappraisal”

Fiorella Belpoggi, Laura Falcioni, Simona Panzacchi, Daria Sgargi, Daniele Mandrioli. Response to “Cancerogenic effects of radiofrequency radiation: A statistical reappraisal." Environmental Research. 197, 2021,111067. https://doi.org/10.1016/j.envres.2021.111067.

No abstract.

https://www.sciencedirect.com/science/article/pii/S0013935121003613

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Activation of matrix metalloproteinases and FoxO3a in HaCaT keratinocytes by radiofrequency electromagnetic field exposure

Ju Hwan Kim, Dong-Jun Kang, Jun-Sang Bae, Jai Hyuen Lee, Sangbong Jeon, Hyung-Do Choi, Nam Kim, Hyung-Gun Kim, Hak Rim Kim. Activation of matrix metalloproteinases and FoxO3a in HaCaT keratinocytes by radiofrequency electromagnetic field exposure. Sci Rep. 2021 Apr 7;11(1):7680. doi: 10.1038/s41598-021-87263-2.

Abstract

As the skin is the largest body organ and critically serves as a barrier, it is frequently exposed and could be physiologically affected by radiofrequency electromagnetic field (RF-EMF) exposure. In this study, we found that 1760 MHz RF-EMF (4.0 W/kg specific absorption rate for 2 h/day during 4 days) exposure could induce intracellular reactive oxygen species (ROS) production in HaCaT human keratinocytes using 2',7'-dichlorofluorescin diacetate fluorescent probe analysis. However, cell growth and viability were unaffected by RF-EMF exposure. Since oxidative stress in the skin greatly influences the skin-aging process, we analyzed the skin senescence-related factors activated by ROS generation. Matrix metalloproteinases 1, 3, and 7 (MMP1, MMP3, and MMP7), the main skin wrinkle-related proteins, were significantly increased in HaCaT cells after RF-EMF exposure. Additionally, the gelatinolytic activities of secreted MMP2 and MMP9 were also increased by RF-EMF exposure. FoxO3a (Ser318/321) and ERK1/2 (Thr 202/Tyr 204) phosphorylation levels were significantly increased by RF-EMF exposure. However, Bcl2 and Bax expression levels were not significantly changed, indicating that the apoptotic pathway was not activated in keratinocytes following RF-EMF exposure. In summary, our findings show that exposure to 1760 MHz RF-EMF induces ROS generation, leading to MMP activation and FoxO3a and ERK1/2 phosphorylation. These data suggest that RF-EMF exposure induces cellular senescence of skin cells through ROS induction in HaCaT human keratinocytes.

Conclusion

In conclusion, exposure to 1760 MHz RF-EMF at 4 W/kg SAR induced intracellular ROS generation, which then stimulated MMPs (MMP1, 2, 3, 7, and 9) and activated the ERK1/2 (phospho-ERK1/2) and FoxO3a (phospho-FoxO3a) signaling pathways in HaCaT cells. Our results suggest that these changes induced by RF-EMF exposure would contribute to skin-aging processes.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8027011/

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1800 MHz Radiofrequency Electromagnetic Field Impairs Neurite Outgrowth Through Inhibiting EPHA5 Signaling

Chunhai Chen, Qinglong Ma, Ping Deng, Min Lin, Peng Gao, Mindi He, Yonghui Lu, Huifeng Pi, Zhixin He, Chao Zhou, Yanwen Zhang, Zhengping Yu, Lei Zhang. 1800 MHz Radiofrequency Electromagnetic Field Impairs Neurite Outgrowth Through Inhibiting EPHA5 Signaling. Front Cell Dev Biol. 2021 Apr 12. **9**:657623. doi:10.3389/fcell.2021.657623.

Abstract

The increasing intensity of environmental radiofrequency electromagnetic fields (RF-EMF) has increased public concern about its health effects. Of particular concern are the influences of RF-EMF exposure on the development of the brain. The mechanisms of how RF-EMF acts on the developing brain are not fully understood. Here, based on high-throughput RNA sequencing techniques, we revealed that transcripts related

to neurite development were significantly influenced by 1800 MHz RF-EMF exposure during neuronal differentiation. Exposure to RF-EMF remarkably decreased the total length of neurite and the number of branch points in neural stem cells-derived neurons and retinoic acid-induced Neuro-2A cells. The expression of Eph receptors 5 (EPHA5), which is required for neurite outgrowth, was inhibited remarkably after RF-EMF exposure. Enhancing EPHA5 signaling rescued the inhibitory effects of RF-EMF on neurite outgrowth. Besides, we identified that cAMP-response element-binding protein (CREB) and RhoA were critical downstream factors of EPHA5 signaling in mediating the inhibitory effects of RF-EMF on neurite outgrowth. Together, our finding revealed that RF-EMF exposure impaired neurite outgrowth through EPHA5 signaling. This finding explored the effects and key mechanisms of how RF-EMF exposure impaired neurite outgrowth and also provided a new clue to understanding the influences of RF-EMF on brain development.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8075058/

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Maternal Use of Induction Heating Cookers During Pregnancy and Birth Outcomes: The Kyushu Okinawa Maternal and Child Health Study

Akiko Tokinobu, Keiko Tanaka, Masashi Arakawa, Yoshihiro Miyake. Maternal Use of Induction Heating Cookers During Pregnancy and Birth Outcomes: The Kyushu Okinawa Maternal and Child Health Study. Bioelectromagnetics. 2021 Apr 12. doi: 10.1002/bem.22339.

Abstract

The effects of exposure to intermediate-frequency electromagnetic fields (IF-EMFs) during pregnancy on birth outcomes are uncertain. We investigated the association between the use of induction heating (IH) cookers, which are major sources of IF-EMFs, during pregnancy and preterm birth (PTB), low birth weight (LBW), small-for-gestational-age (SGA), and birth weight, using data from a prebirth cohort study in Japan. Study participants were 1,565 mothers with singleton pregnancies and the babies born from these pregnancies. We collected the data presented here using self-administered questionnaires. An adjustment was made for maternal age, region of residence, number of children, family structure, maternal education, maternal employment, maternal alcohol intake, smoking during pregnancy, maternal body mass index, baby's sex, and gestational age at birth. IH cooker use during pregnancy was independently associated with a reduced risk of PTB: the adjusted odds ratio was 0.28 (95% confidence interval: 0.07-0.78). IH cooker use during pregnancy was not associated with LBW, SGA, or birth weight. This is the first study to show that IH cooker use during pregnancy is independently inversely associated with PTB.

https://pubmed.ncbi.nlm.nih.gov/33846994/

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Effects of Long-Term Exposure of Intermediate Frequency Magnetic Fields (20 kHz, 360 µT) on the Development, Pathological Findings, and Behavior of Female Mice

Alexander Lerchl, Karen Drees Née Grote, Isabel Gronau, Dirk Fischer, Julia Bauch, Axel Hoppe. Effects of Long-Term Exposure of Intermediate Frequency Magnetic Fields (20 kHz, 360 µT) on the Development, Pathological Findings, and Behavior of Female Mice. Bioelectromagnetics. 2021 Apr 6. doi: 10.1002/bem.22337.

Abstract

The use of magnetic fields in the intermediate-frequency (IF) range to wirelessly charge electric cars with power transfer in the kilowatt range has become increasingly widespread, leading to unavoidable stray fields in the microtesla range. Only a handful of studies have assessed the potential biological risks associated with exposure to such fields. We exposed female mice (n = 80 per group) to either 20 kHz, 360 µT (rms), or sham in Helmholtz coils to conduct a blind design study. Exposure started at 3 months of age (24 h/day). Body mass was recorded every 1-2 weeks. At 10 months of age, three behavioral tests were performed on 24 animals per group. Three months later, the mice were sacrificed and organs (brain, liver, kidney, spleen, and lung) were removed and prepared for microscopic analysis. Our findings demonstrate no differences in the development of body mass and survival rates (96% and 89%, respectively). Similarly, no significant differences were observed in tumor incidence rates. When it comes to behavioral tests, the 8-arm maze results revealed no significant differences. In contrast, the Rotarod data were significantly ($P < 0.001$) different with longer retention times seen in the exposed mice. In the open field, the number of supported rears was significantly lower ($P < 0.01$), whereas the other endpoints did not show any differences. Overall, our data reveal no adverse effects of exposure to 20 kHz, 360 µT on the development and tumor incidences, while the significant differences in the behavioral tests may indicate higher levels of alertness in mice.

Excerpts

Our results indicate that exposure to IF-MF does not increase the risk of pathological findings. However, in this study, only brain, liver, kidney, spleen, and lung tissue were analyzed for neoplastic lesions; the OECD guidelines recommend that some 40 tissues should be analyzed. Another potential limitation of our study is the relatively short exposure period of 10 months (OECD recommends 24 months of treatment). Yet another, but unavoidable, limitation was that for technical reasons the exposure could not be performed during the behavioral experiments. This is because interference of the strong magnetic field with the equipment (CCD camera or Rotarod) would inevitably have led to the person performing the experiment knowing whether or not the animals were being exposed....

It is also pertinent to understand the limitations of animal models as predictors of human biology. Therefore, the comparability and applicability of the results to humans need to be verified. Furthermore, this study only examined female mice and it is well-established that sex plays a crucial role in terms of cancer incidence, prognosis, and mortality [Zhu et al., 2019]. Therefore, further long-term studies that include male animals are needed to investigate the biological impact of IF-MF exposure....

Taken together, the data presented in this study indicate some behavioral effects in the exposed animals, while no differences were observed in growth and tumorigenesis between exposed and control mice. The potentially increased stress levels must be regarded as mild since they did not cause a drop in body mass, which is a very sensitive parameter for stress in rodents [Jeong et al., 2013]. Therefore, the overall results do not indicate that chronic exposure to 20 kHz magnetic fields at 360 µT poses a health risk. The overall conclusion of this study as well as of data from the literature is that there is a lack of evidence that IF-MF exposure contributes to any significant behavioral changes or influences growth or malignancy in the female mice model.

My note: According to Table 1, the exposed mice had a total of 17 pathological findings vs. 11 in the control mice.

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Classification of the Laptop's Extremely Low Frequency Magnetic Field With Alternating Current and Battery

Dejan Tanikić, Alessia Amelio. Classification of the Laptop's Extremely Low Frequency Magnetic Field With Alternating Current and Battery. 2021 20th International Symposium INFOTEH-JAHORINA (INFOTEH). 17-19 March 2021.DOI: 10.1109/INFOTEH51037.2021.9400677

Abstract

The magnetic field exposure of the laptop users represents an important task to be researched. This paper proposes an artificial neural network model for the prediction of the extremely low-frequency magnetic field produced by laptops. It is based on measurement data of 10 laptops and a 3-input vector representing typical laptop characteristics. The novelty of the proposed model is that it is created in order to predict the level of the magnetic field emission produced by a laptop when it is powered by both alternating current and battery. Then, the obtained data are classified by the self-organizing map method to describe the safe or dangerous level of a laptop. At the end, a few suggestions are proposed for a safer use of the laptops.

https://ieeexplore.ieee.org/document/9400677

Excerpts

The magnetic field is measured at 18 measurement points in the laptop's neighbourhood. These points are at the top (T1…T9) and at the bottom (B1…B9) of the laptop [6], [10].

Also, we measured the magnetic field 10 cm away from the proposed measurement points, i.e. outside the laptops. The obtained levels of the magnetic field were around or below 0.01 µT. Hence, they can be considered as a background magnetic field.

The general conclusion is that the value of the magnetic field is almost 2 times higher when the laptops are AC powered. The predicted values of the magnetic field of the 10 laptops were used to divide the laptops in 5 (4) clusters, which represent the grade of the magnetic field of each laptop. Furthermore, if we compare the ELF

magnetic field emission and the classes extracted by the clustering process, we can obtain the results given in Tables 3–4 for AC and battery powered laptops, respectively.

This paper proposed a new ANN model for estimating the ELF magnetic field emission based on the measurement of 10 laptops. The measurement of the magnetic field was performed at the top and at the bottom of each laptop which was AC and battery powered. Then, from the ANN predicted data, a SOM based clustering was performed. The obtained classification was used to clearly define a level ranking of the laptops according to their ELF magnetic field emission. In the end, important suggestions for a safer use of the laptops were proposed. In the future, we are planning to extend the analysis to the tablet devices

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Honey Bee Proteolytic System and Behavior Parameters under the Influence of an Electric Field at 50 Hz and Variable Intensities for a Long Exposure Time

Paweł Migdał, Agnieszka Murawska, Aneta Strachecka, Paweł Bieńkowski, Adam Roman. Honey Bee Proteolytic System and Behavior Parameters under the Influence of an Electric Field at 50 Hz and Variable Intensities for a Long Exposure Time. Animals (Basel). 2021 Mar 18;11(3):863. doi: 10.3390/ani11030863.

Abstract

The effect of an artificial electromagnetic field on organisms is a subject of extensive public debate and growing numbers of studies. Our study aimed to show the effect of an electromagnetic field at 50 Hz and variable intensities on honey bee proteolytic systems and behavior parameters after 12 h of exposure. Newly emerged worker bees were put into cages and exposed to a 50 Hz E-field with an intensity of 5.0 kV/m, 11.5 kV/m, 23.0 kV/m, or 34.5 kV/m. After 12 h of exposure, hemolymph samples were taken for protease analysis, and the bees were recorded for behavioral analysis. Six behaviors were chosen for observation: walking, flying, self-grooming, contact between individuals, stillness, and wing movement. Bees in the control group demonstrated the highest number of all behavior occurrences, except flying, and had the lowest protease activity. Bees in the experimental groups showed a lower number of occurrences of walking, self-grooming, and contacts between individuals than the control bees and had significantly higher protease activity than the control bees (except that of alkaline proteases in the 23.0 kV/m group).

Simple Summary

The amount of electromagnetic field (EMF) in the environment emitted by electrical and electronic devices, mobile phone masts, or power lines is constantly increasing. Honey bees can be exposed to the EMF in the environment, and the influence of this factor on bees is still under consideration. Studying the impact of EMF on honey bees can give valuable information about whether it poses a threat to them. The honey bee is an important pollinator, playing a significant role in maintaining biodiversity and food production. Our research showed that a 50 Hz electric field at various intensities reduced the number of occurrences of walking, contacts between individuals, and self-grooming, and increased the activity of proteases, which are involved in the immune system response.

Conclusions

The amount of artificial electromagnetic field in the environment is constantly increasing, thus the honey bee is exposed to this factor. In our study, bees in the control group demonstrated the highest number of all behavior occurrences, except flying, and had the lowest activity of all types of proteases. Bees in the experimental groups showed a lower number of walking, self-grooming, and contact between individual occurrences than control bees and had higher protease activity than control bees. Our results show that an E-field is potential harmful factor to the honey bee. However, we do not know if the changes in behavior and protease activity of the honey bee after E-field exposure persist and for how long. It would be important to investigate behavior parameters and biochemical markers at different time intervals after the end of exposure to an E-field. It can be helpful to determine the interaction between the biochemical marker activity and behavioral parameters. Such an observation could provide a better understanding of the immune response of the honey bee exposing to environmental stressors.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8003097/

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Extremely Low-Frequency Electromagnetic Fields Entrain Locust Wingbeats

Sebastian Shepherd, Christopher W Jackson, Suleiman M Sharkh, Hitoshi Aonuma, Eugenio E Oliveira, Philip L Newland. Extremely Low-Frequency Electromagnetic Fields Entrain Locust Wingbeats. Bioelectromagnetics. 2021 Apr 6. doi: 10.1002/bem.22336.

Abstract

Extremely low-frequency electromagnetic fields (ELF EMFs) have been shown to impact the behavior and physiology of insects. Recent studies have highlighted the need for more research to determine more specifically how they affect flying insects. Here, we ask how locust flight is affected by acute exposure to 50 Hz EMFs. We analyzed the flights of individual locusts tethered between a pair of copper wire coils generating EMFs of various frequency using high-speed video recording. The mean wingbeat frequency of tethered locusts was 18.92 ± 0.27 Hz. We found that acute exposure to 50 Hz EMFs significantly increased absolute change in wingbeat frequency in a field strength-dependent manner, with greater field strengths causing greater changes in wingbeat frequency. The effect of EMFs on wingbeat frequency depended on the initial wingbeat frequency of a locust, with locusts flying at a frequency lower than 20 Hz increasing their wingbeat frequency, while locusts flying with a wingbeat frequency higher than 20 Hz decreasing their wingbeat frequency. During the application of 50 Hz EMF, the wingbeat frequency was entrained to a 2:5 ratio (two wingbeat cycles to five EMF cycles) of the applied EMF. We then applied a range of ELF EMFs that were close to normal wingbeat frequency and found that locusts entrained to the exact frequency of the applied EMF. These results show that exposure to ELF EMFs lead to small but significant changes in wingbeat frequency in locusts. We discuss the biological implications of the coordination of insect flight in response to electromagnetic stimuli.

https://pubmed.ncbi.nlm.nih.gov/33822398/

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Current progress on the effect of mobile phone radiation on sperm quality: an updated systematic review and meta-analysis of human and animal studies

Gang Yu, Zhiming Bai, Song Chao, Qing Cheng, Gang Wang, Zeping Tang, Sixing Yang. Current progress on the effect of mobile phone radiation on sperm quality: an updated systematic review and meta-analysis of human and animal studies. Environmental Pollution. 30 March 2021. https://doi.org/10.1016/j.envpol.2021.116952.

Highlights

- Mobile phone use was related to sperm quality decline of men in some areas.
- Mobile phone RF-EMR directly impaired mature sperm of men in vitro.
- Mobile phone RF-EMR affected some parameters of sperm quality in experiment animals.
- Experiment conditions affected pooled results of animal experiments.
- More studies should be conducted to investigate this issue in new era.

Abstract

Potential suppression of fertility due to mobile phone radiation remains a focus of researchers. We conducted meta-analyses on the effects of mobile phone radiation on sperm quality using recent evidence and propose some perspectives on this issue. Using the MEDLINE/PubMed, Embase, WOS, CENTRAL, and ClinicalTrials.gov databases, we retrieved and screened studies published before December 2020 on the effects of mobile phone use/mobile phone RF-EMR on sperm quality. Thirty-nine studies were included. Data quality and general information of the studies were evaluated and recorded. Sperm quality data (density, motility, viability, morphology, and DFI) were compiled for further analyses, and we conducted subgroup, sensitivity, and publication bias analyses. The pooled results of human cross-sectional studies did not support an association of mobile phone use and a decline in sperm quality. Different study areas contributed to the heterogeneity of the studies. In East Europe and West Asia, mobile phone use was correlated with a decline in sperm density and motility. Mobile phone RF-EMR exposure could decrease the motility and viability of mature human sperm in vitro. The pooled results of animal studies showed that mobile phone RF-EMR exposure could suppress sperm motility and viability. Furthermore, it reduced sperm density in mice, in rats older than 10 weeks, and in rats restrained during exposure. Differences regarding age, modeling method, exposure device, and exposure time contributed to the heterogeneity of animal studies. Previous studies have extensively investigated and demonstrated the adverse effects of mobile phone radiation on sperm. In the future, new standardized criteria should be applied to evaluate potential effects of mobile phone RF-EMR dosages. Further sperm-related parameters at the functional and molecular levels as well as changes in biological characteristics of germ cells should be evaluated. Moreover, the impact of mobile phone RF-EMR on individual organs should also be examined.

Conclusion

The results of our meta-analysis indicated that in East Europe and West Asia, mobile phone use is associated with a decline in human sperm density and motility. Mobile phone RF-EMR can reduce motility and viability of

mature human sperm *in vitro*, and it can also reduce sperm motility and viability in male animals and decrease sperm density of sexually mature restrained rats. Some important factors that affect the results of animal experiments are study setup and radiation device as well as age and exposure time. Our study is an extension of previous studies and has scientific value for future studies on effects of mobile phone RF-EMR associated with sperm quality.

https://www.sciencedirect.com/science/article/abs/pii/S0269749121005340

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Protocol for personal RF-EMF exposure measurement studies in 5th generation telecommunication networks

Maarten Velghe, Sam Aerts, Luc Martens, Wout Joseph, Arno Thielens. Protocol for personal RF-EMF exposure measurement studies in 5th generation telecommunication networks. Environ Health. 2021 Apr 1;20(1):36. doi: 10.1186/s12940-021-00719-w.

Abstract

Background: The general population is exposed to Radio-Frequency Electromagnetic Fields (RF-EMFs) used by telecommunication networks. Previous studies developed methods to assess this exposure. These methods will be inadequate to accurately assess exposure in 5G technologies or other wireless technologies using adaptive antennas. This is due to the fact that 5G NR (new radio) base stations will focus actively on connected users, resulting in a high spatio-temporal variations in the RF-EMFs. This increases the measurement uncertainty in personal measurements of RF-EMF exposure. Furthermore, a user's exposure from base stations will be dependent on the amount of data usage, adding a new component to the auto-induced exposure, which is often omitted in current studies.

Goals: The objective of this paper is to develop a general study protocol for future personal RF-EMF exposure research adapted to 5G technologies. This protocol will include the assessment of auto-induced exposure of both a user's own devices and the networks' base stations.

Method: This study draws from lessons learned from previous RF-EMF exposure research and current knowledge on 5G technologies, including studies simulating 5G NR base stations and measurements around 5G NR test sites.

Results: To account for auto-induced exposure, an activity-based approach is introduced. In survey studies, an RF-EMF sensor is fixed on the participants' mobile device(s). Based on the measured power density, GPS data and movement and proximity sensors, different activities can be clustered and the exposure during each activity is evaluated. In microenvironmental measurements, a trained researcher performs measurements in predefined microenvironments with a mobile device equipped with the RF-EMF sensor. The mobile device is programmed to repeat a sequence of data transmission scenarios (different amounts of uplink and downlink data transmissions). Based on simulations, the amount of exposure induced in the body when the user device is at a certain location relative to the body, can be evaluated.

Conclusion: Our protocol addresses the main challenges to personal exposure measurement introduced by 5G NR. A systematic method to evaluate a user's auto-induced exposure is introduced.

https://pubmed.ncbi.nlm.nih.gov/33794922/

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Nonuniform Exposure to the Cornea from Millimeter Waves

Kenneth R Foster, Ilkka Laakso, Steven Chalfin. Nonuniform Exposure to the Cornea from Millimeter Waves. Health Phys. 2021 May 1;120(5):525-531. doi: 10.1097/HP.0000000000001376.

Abstract

This study examines the nonuniform exposure to the cornea from incident millimeter waves at 94-100 GHz. Two previous studies measured temperature increases in the rhesus cornea exposed to brief (1-6 s) pulses of high-fluence millimeter waves (94 GHz), one of which also estimated thresholds for corneal damage (reported as ED50, the dose resulting in a visible lesion 50% of the time). Both studies noted large variations in the temperature increase across the surface of the cornea due to wave interference effects. This study examines this variability using high-resolution simulations of mm-wave absorption and temperature increase in the human cornea from exposures to plane wave energy at 100 GHz. Calculations are based on an earlier study. The simulations show that the peak temperature increases in the cornea from short exposures (up to 10 s) to high-intensity mm-wave pulses are 1.7-2.8 times the median increase depending on the polarization of the incident energy. A simple one-dimensional "baseline" model provides a good estimate of the median temperature increase in the cornea. Two different estimates are presented for the thresholds for producing thermal lesions, expressed in terms of the minimum fluence of incident 100 GHz pulses. The first estimate is based on thresholds for thermal damage from pulsed infrared energy, and the second is based on a thermal damage model. The mm-wave pulses presently considered far exceed current IEEE or ICNIRP exposure limits but may be produced by some nonlethal weapons systems. Interference effects due to wave reflections from structures in and near the eye result in highly localized variations in energy absorbed in the cornea and surrounding facial tissues and are important to consider in a hazard analysis for exposures to intense pulsed millimeter waves.

https://pubmed.ncbi.nlm.nih.gov/33760769/

Discussion

Both IEEE C95.1-2019 and ICNIRP (2020) specifically limit the fluence of brief, high intensity mm-wave pulses to avoid excessive temperature rises. The limits discussed below refer to power densities measured outside the body, which are defined in ICNIRP 2020 as “reference levels” and in IEEE as “exposure reference levels.” For 2-s pulses of mm-waves, IEEE C95.1-2019 (IEEE 2019) has fluence limits of 0.28 and 1.4 kJ m−2 for persons in unrestricted or restricted environments (equivalent to general public and occupational limits). The corresponding limits in ICNIRP (2020) (for 100 GHz pulses) are 1.7 and 8.6 kJ m−2 for general public and occupational exposures, respectively. All of the exposures in Table 2 far exceed these limits.

Exposures summarized in Table 2 would be acutely painful (Beuerman and Talenian 1979) and would trigger blink reflexes in most (but perhaps not all) awake subjects that would protect them from corneal damage. However, interference effects will also cause nonuniform absorption patterns away from the cornea, which is apparent in Fig. 1. In their corneal damage studies on rabbits, Kojima et al. (2009) noted significant thermal damage to the eyelids as well, to the extent that the eyelids had to be held open with tape during exposure to obtain reproducible corneal damage data. When analyzing potential hazards from the Active Denial nonlethal weapons system or other sources of intense mm-wave exposures, local enhancements in exposure due to interference effects over an appropriate range of subjects and exposure parameters would need to be considered.

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Protection of the population health from electromagnetic hazards - challenges resulting from the implementation of the 5G network planned in Poland

Marek Zmyślony, Paweł Bieńkowski, Alicja Bortkiewicz, Jolanta Karpowicz, Jarosław Kieliszek, Piotr Politański, Konrad Rydzyński. [Protection of the population health from electromagnetic hazards - challenges resulting from the implementation of the 5G network planned in Poland] [Article in Polish]. Med Pr. 2020 Jan 20;71(1):105-113. doi: 10.13075/mp.5893.00867.

Abstract in English

There is an ongoing discussion about electromagnetic hazards in the context of the new wireless communication technology - the fifth generation (5G) standard. Concerns about safety and health hazards resulting from the influence of the electromagnetic field (EMF) emitted by the designed 5G antennas have been raised. In Poland, the level of the population's exposure to EMF is limited to 7 V/m for frequencies above 300 MHz. This limitation results from taking into account the protective measures related not only to direct thermal hazards, but also to diversified indirect and long-term threats. Many countries have not established legal requirements in this frequency range, or they have introduced regulations based on recommendations regarding protection against direct thermal risks only (Council Recommendation 1999/519/EC). For such protection, the permissible levels of electric field intensity are 20-60 V/m (depending on the frequency). This work has been created through an interdisciplinary collaboration of engineers, biologists and doctors, who have been for many years professionally dealing with the protection of the biosphere against the negative effects of EMF. It presents the state of knowledge on the biological and health effects of the EMF emitted by mobile phone devices (including millimeter waves which are planned to be used in the 5G network). A comparison of the EU recommendations and the provisions on public protection being in force in Poland was made against this background. The results of research conducted to date on the biological effects of the EMF radiofrequency emitted by mobile telecommunication devices, operating with the frequencies up to 6 GHz, do not allow drawing any firm conclusions; however, the research evidence is strong enough for the World Health Organization to classify EMF as an environmental factor potentially carcinogenic to humans. **At the moment, there is a shortage of adequate scientific data to assess the health effects of exposure to electromagnetic millimeter waves, which are planned to be used in the designed 5G devices. Nevertheless, due to the fact that there are data indicating the**

existence of biophysical mechanisms of the EMF influence that may lead to adverse health effects, it seems necessary to use the precautionary principle and the ALARA principle when creating environmental requirements for the construction and exploitation of the infrastructure of the planned 5G system.

http://medpr.imp.lodz.pl/Ochrona-zdrowia-ludnosci-przed-zagrozeniami-elektromagnetycznymi-wyzwania-wynikajace,114069,0,2.html

See also:

Bieńkowski, Paweł, Marek Zmyślony, Jolanta Karpowicz, Piotr Politański, Alicja Bortkiewicz, Jarosław Kieliszek, and Konrad Rydzyński. [Conditionings of population exposure to electromagnetic fields associated with the rational use of 5G radiocommunication networks in Poland] [Article in Polish]. *Medycyna Pracy* 71 no. 2 (2020): 245-253. doi:10.13075/mp.5893.00920.

http://medpr.imp.lodz.pl/Uwarunkowania-ekspozycji-ludnosci-na-pole-elektromagnetyczne-zwiazane-z-uzytkowaniem,114070,0,2.html

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Cellular Phone User's Age or the Duration of Calls Moderate Autonomic Nervous System? A Meta-Analysis

Styliani A Geronikolou, Ölle Johansson, George Chrousos, Christina Kanaka-Gantenbein, Dennis Cokkinos. Cellular Phone User's Age or the Duration of Calls Moderate Autonomic Nervous System? A Meta-Analysis. Adv Exp Med Biol. 2020;1194:475-488. doi: 10.1007/978-3-030-32622-7_46.

Abstract

Background: The European Health Risk Assessment Network on Electromagnetic Fields Exposure (EFHRAN) reported in 2012: "Children and adolescents represent the first generation of Europeans to be exposed to diffuse EMF since their conception and birth, thus, they are expected to be more sensitive to these fields." On the other hand, the body's physiologic processes are regulated by the autonomic nervous system (ANS) in a way that warrants further elucidation.

Objective: Age and duration of exposure are investigated for modifying the variance of the reported effects of mobile/cellular phone call (CPC) on ANS indexed, herein, by the heart rate variability (HRV).

Method: Five studies targeted to 124 healthy subjects (aged 15.3-28.4 years (24.3 ± 5.2), who have been recorded in supine position before and/or sham versus real exposure (to a CPC lasting 5-32 minutes), are included in this meta-analysis. Age and duration of a CPC are evaluated as predictors in two separate meta-regressions.

Results: The meta-analysis identified a heterogeneity I2 = 63.2% for all outcomes and I2 = 65.2% for sympathovagal balance. Thus, we performed meta-regressions: for the sympathovagal balance rather than the combined parameters effect, the goodness of fit model presents significance only for age - the residual sum of

squares compared to chi-square distribution (QR) is 4.24 for age (p = 0.12) - while, for minutes of exposure, QR = 8.2805 (p = 0.016).

Conclusions: The sympathovagal balance - indispensible for health/homeostasis maintenance - is strongly predicted by age. Minutes of exposure did not affect overall HRV or sympathovagal balance. The results endorse/validate the EFHRAN 2012 suggestion for future research targeting to youngsters.

https://pubmed.ncbi.nlm.nih.gov/32468564/

Excerpt

... the effect of age is higher in younger ages (adolescence) and decreases as age increases (Figs. 2a and 3a). This result supports the caution already expressed that the risk for children and adolescents from radiofrequencies exposure needs to be extensively investigated (Akselrod et al. 1981; Hjortskov et al. 2004). Our finding may be either explained in terms of development or in terms of accumulated exposure of each individual to electromagnetic fields even since conception (exposome). Indeed, potential health effects from this technology expansion in pediatric and adolescent populations are suggested by the European Health Risk Assessment Network on Electromagnetic Fields Exposure in its 2012 report (Nam et al. 2011; Morgan et al. 2014a): “These groups represent the first generation of Europeans to be exposed to diffuse EMF fields since conception and birth, thus, are expected to be more sensitive to these fields.”

Conclusively, our analysis suggests that (a) minutes of exposure (minutes of speaking on the mobile phone) do not affect the autonomic nervous system of the heart or its sympathovagal balance, (b) age synergizes with other variables (exposome, SAR) so as to explain combined HRV parameter effects, and (c) the sympathovagal balance is strongly predicted by age, implying that adolescents’ autonomic nervous system seems to be more vulnerable to the CPC exposure. Additionally, risk assessment analysis of the additive effects of continuous exposure (exposome) is strongly suggested.

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What is the radiation before 5G? A correlation study between measurements in situ and in real time and epidemiological indicators in Vallecas, Madrid

Isabel López, Nazario Félix, Marco Rivera,Adrián Alonso, Ceferino Maestú. What is the radiation before 5G? A correlation study between measurements in situ and in real time and epidemiological indicators in Vallecas, Madrid. Environ Res. 2021 Mar;194:110734. doi: 10.1016/j.envres.2021.110734.

Abstract

Background: Exposure of the general population to electromagnetic radiation emitted by mobile phone base stations is one of the greater concerns of residents affected by the proximity of these structures due to the possible relationship between radiated levels and health indicators.

Objectives: This study aimed to find a possible relationship between some health indicators and electromagnetic

radiation measurements.

Methods: A total of 268 surveys, own design, were completed by residents of a Madrid neighborhood surrounded by nine telephone antennas, and 105 measurements of electromagnetic radiation were taken with a spectrum analyzer and an isotropic antenna, in situ and in real - time, both outside and inside the houses.

Results: It was shown statistically significant p - values in headaches presence ($p = 0.010$), nightmares ($p = 0.001$), headache intensity ($p < 0.001$), dizziness frequency ($p = 0.011$), instability episodes frequency ($p = 0.026$), number of hours that one person sleeps per day ($p < 0.001$) and three of nine parameters studied from tiredness. Concerning cancer, there are 5.6% of cancer cases in the study population, a percentage 10 times higher than that of the total Spanish population.

Discussion: People who are exposed to higher radiation values present more severe headaches, dizziness and nightmares. Moreover, they sleep fewer hours.

https://pubmed.ncbi.nlm.nih.gov/33434609/

Highlights

• People who are exposed to higher radiation values present more severe headaches, dizziness and nightmares.
• The methodology for obtaining electromagnetic radiation measurements should be reviewed.
• The population continues to receive radiation peaks in distances greater than 200 m, no one is free from exposure.

Conclusion

In conclusion, the data obtained shows that there is a relationship between the power density of radiation that a person receives at home every day and the presence of headaches, as well as the presence of sleep disorders. People who receive higher doses of radiation sleep less hours and have nightmares at night. In addition, these people suffer from headaches with greater intensity and are more prone to dizziness. In this study, indicators like fainting episodes, presence of tachycardias or instability cannot be related. No conclusive results were found for fatigue, since, out of nine parameters studied, only a statistically significant relationship was found in three of them. The study of how electromagnetic fields affect health, should not only be done in relation to cancer, but also health indicators related to day to day. The methodology for obtaining electromagnetic radiation measurements should be reviewed, the averaged radiation measurements that are described in the CENELEC standard are not the most appropriate, they should be carried out in a narrow band and with maximum peak measurements.

The measured intensity depends fundamentally on the direction of the fundamental radiation beam and not so much on the distance to the antenna. In the beam direction, differences are found in the presence of pathologies with respect to distances, when these are greater than 200 m. Even at this distance, the population continues to receive radiation peaks, so that no one is free from exposure to these radiation sources.

The need for this study is related to the situation before 5G in terms of electromagnetic radiation rates. This study may be compared with the new radiant procedures that will be adopted in a short time.

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Electromagnetic pollution alert: Microwave radiation and absorption in human organs and tissues

Nantakan Wongkasem. Electromagnetic pollution alert: Microwave radiation and absorption in human organs and tissues. Electromagn Biol Med. 2021 Feb 10;1-18. doi: 10.1080/15368378.2021.1874976.

Abstract

Electromagnetic radiation from communication and electronic devices, networks, systems and base stations has drawn concern due to excessive global usage with increasing power and operating frequency level. Numerous previous researches only focus on how the radiation from certain frequency ranges of particular devices could harm specific human organs and tissues, resulting in distinct symptoms. In this research, electromagnetic propagation and properties in 14 human organs and tissues were analyzed and investigated based on the organs and tissues' electromagnetic and mechanical parameters, and chemical composition. Counting the organs and tissues as electromagnetic materials, their permittivity and conductivity, computed by a 4-Cole-Cole mode, directly respective to the operating frequency, are interrelated to wave behavior and hence influence the organs' response. Tests were conducted in 1 GHz to 105 GHz system settings, covering most microwave frequency uses: 2.4 GHz of 4G-LTE, Wi-Fi, Bluetooth, ZigBee and the 5G ranges: 28 GHz of 5G-mmW and 95 GHz of 5G-IoT. Trial human organs and tissues were placed in the wave propagation direction of 2.4 GHz and 28 GHz dipole antennas, and a waveguide port operating from 95 to 105 GHz. The quantitative data on the effects of 5G penetration and dissipation within human tissues are presented. The absorbance in all organs and tissues is significantly higher as frequency increases. As the wave enters the organ-tissue model, the wavelength is shortened due to the high organ-tissue permittivity. Skin-Bone-Brain layer simulation results demonstrate that both electric and magnetic fields vanish before passing the brain layer at all three focal frequencies of 2.4 GHz, 28 GHz and 100 GHz.

https://pubmed.ncbi.nlm.nih.gov/33566706/

Excerpts

At a cellular tower or a cell site, an effective-radiated power (ERP) of up to 500 W per radio channel or transmitter, depending on the tower height, was permitted by the Federal Communications Commission (FCC) (Haripriya 2020b). The majority of cellular or Personal Communications Services (PCS) cell sites in urban and suburban areas operate at an ERP of 100 W per channel or less. An ERP of 100 W corresponds to an actual-radiated power of 5–10 W, depending on the type of antenna used (Stutzman and Thiele 2012). As with all forms of EM energy, the power density from a cellular or PCS transmitter decays proportionally to 1/R2 as the distance from the cell site increases. Therefore, for a common 40 W of the power density of about 10 mW/m2 at 100 m from the antenna tower, the power density will be 1 mW/m2, as the distance increases to 300 m away from the base station and the device will receive 1μW, based on the effective antenna area of 0.001 m2. Having

several mobile phones active in the same area, the total EM radiation can get close to 2 W, the same level as the maximum power radiation of 5 mW/cm2 at 2 inches from the microwave oven surface permitted by federal regulations (Haripriya 2020c). Besides the aforementioned cellular emission, there is also EM radiation from wireless networks, smart and wearable devices, unceasingly scattering around, whether or not you are connected to their networks....

Conclusion

Eight human organ and tissue models (blood, brain, breast, eye bulb, heart, kidney, liver and lung), while tested with electromagnetic excitation from 2.4 GHz and 28 GHz dipole antennas, and 95–105 GHz waveguide ports, show that the wavelength of the E- and H-fields propagating inside the models is shortened or the wave frequency is accelerating, approximately 5–8 times. The lowest propagation frequency is found in the lung model, where the permittivity and conductivity are lowest among those of the eight studied models. The E-field intensity boosts significantly as the EM source frequency increases, approximately 10 times between 2.4 GHz and 28 GHz. The E-field intensity (from 95 GHz to 105 GHz radiation) rises from 3.89% (in the brain) to 4.86% (in the liver). The field intensity dramatically decreases as the wave propagates passing the model, indicating high wave attenuation from the material absorption.

The EM absorbance is found to be greater than 60% in all 14 organ and tissue models. At 100 GHz, the bone (83.01%), urinary bladder wall (82.95%), lung (80.02%), liver (68.18%), brain (66.18%) and eye bulb (64.46%) present the highest absorbance level. The absorbance increases significantly as the frequency increases, for instance, 43.78% at 2.4 GHz, 51.95% at 28 GHz and 66.16% at 100 GHz in the brain model. The transmittance in all models is below e-20 level. At all three operating frequencies: 2.4 GHz, 28 GHz and 100 GHz, the E- and H-fields vanish before passing through the brain layer of the Skin-Bone-Brain layered model. The overall layer absorbance is greatly elevated at all 3 frequencies: 69.18% at 2.4 GHz, 65.69% at 28 GHz and 71.49% at 100 GHz. The reflectance is around 30%, while the transmittance is significantly low. The scattering behavior and multiple absorbing possibility is observed. The absorbance is inversely proportional to the permittivity and conductivity of human organs and tissues. There is no clear correlation between the EM absorbance and heat transfer and generation rate. The models confirm that the higher the frequency, the greater the attenuation. Penetration is therefore reduced with increasing frequency. However, on the other hand, the absorption level increases with frequency. The results quantitatively validate the classic effects of the increase in frequency in terms of penetration and dissipation in human tissues and organs.

Further study of the EM radiation and propagation, either on specific complete human parts, for example, an eye bulb with cornea, anterior chamber, pupil, iris, lens, ciliary and vitreous body, macular, retina, choroid and optic nerve, or the whole human body, will definitely provide more insight and correlation of the EM radiation and its effects amid all human organs

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Empirical and Modeling Approach for Environmental Indoor RF-EMF Assessment in Complex High-Node Density Scenarios: Public Shopping Malls Case Study

Mikel Celaya-Echarri, Leyre Azpilicueta, Victoria Ramos, Peio Lopez-Iturri, Francisco Falcone. Empirical and Modeling Approach for Environmental Indoor RF-EMF Assessment in Complex High-Node Density Scenarios: Public Shopping Malls Case Study. IEEE Access. 22 March 2021.

Abstract

This work provides an intensive and comprehensive in-depth study from an empirical and modeling approach of the environmental radiofrequency electromagnetic fields (RF-EMF) radiation exposure in public shopping malls, as an example of an indoor high-node user density context aware environment, where multiple wireless communication systems coexist. For that purpose, current personal mobile communications (2G-5G FR 1) as well as Wi-Fi services (IEEE 802.11n/ac) have been precisely analyzed in order to provide clear RF-EMF assessment insight and to verify compliance with established regulation limits. In this sense, a complete measurements campaign has been performed in different countries, with frequency-selective exposimeters (PEMs), providing real empirical datasets for statistical analysis and allowing discussion and comparison regarding current health effects and safety issues between some of the most common RF-EMF exposure safety standards: ICNIRP 2020 (Spain), IEEE 2019 (Mexico) and a more restrictive regulation (Poland). In addition, environmental RF-EMF exposure assessment simulation results, in terms of spatial E-field characterization and Cumulative Distribution Function (CDF) probabilities, have been provided for challenging incremental high-node user dense scenarios in worst case conditions, by means of a deterministic in-house 3D Ray-Launching (3D-RL) RF-EMF safety simulation technique, showing good agreement with the experimental measurements. Finally, discussion highlighting the contribution and effects of the coexistence of multiple heterogenous networks and services for the environmental RF-EMF radiation exposure assessment has been included, showing that for all measured results and simulated cases, the obtained E-Field levels are well below the exposure limits established in the internationally accepted standards and guidelines. In consequence, the obtained results and the presented methodology could become a starting point to establish the RF-EMF assessment basis of future complex heterogeneous 5G FR 2 developments on the millimeter wave (mmWave) frequency range, where massive high-node user density networks are expected.

Excerpt

It must be clearly remarked that, in the current state of knowledge, the results of scientific and epidemiological research have shown that in case of exposures at E-field levels below of far below the ICNIRP limits, there is no evidence of a relationship between exposure to radiofrequency fields produced by wireless technologies and potential adverse health effects. However, since the trend of 5G technology in towards the use of higher frequency ranges, it would be of great importance to carry out studies aimed at characterizing the effects of mmWave exposures, for which the information from scientific literature is not so complete and exhaustive as for the sub 6 GHz frequencies. This is a sort of knowledge gap that must be filled up to permit a specific and targeted surveillance held by the authorized health agencies and possibly an update of the guidelines/standards currently in use.

The proposed simulation methodology can be a useful and suitable technique to satisfactorily assess and verify

in advance environmental RF-EMF exposure recommendations and limits to implement safe, efficient and reliable current and future wireless deployments for complex high-node density heterogeneous environments.

Open access paper: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9382976

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Hematobiochemical and histopathological alterations of kidney and testis due to exposure of 4G cell phone radiation in mice

Imam Hasan, Tanjina Amin, Md. Rafiqul Alam, Mohammad Rafiqul Islam. Hematobiochemical and histopathological alterations of kidney and testis due to exposure of 4G cell phone radiation in mice. Saudi Journal of Biological Sciences. Available online 17 February 2021. https://doi.org/10.1016/j.sjbs.2021.02.028.

Abstract

The radiofrequency electromagnetic radiation emitted by smart phones on biological systems has wide media coverage and public concern in recent years. The aim of this study was to explore the effects of fourth-generation cell phone radiation exposure on hematological (Total leukocyte count, Total erythrocyte count, and hemoglobin %), biochemical (Serum creatinine) parameters, and histopathological changes in the kidney and testis of Swiss albino mice. A total of 30 male Swiss albino mice weighing 45–65 g was randomly divided into three groups (n = 10). The first group A was the control group, the second group B, was exposed to 40 minutes of mobile phone radiation daily, the third group C was exposed to 60 minutes of radiation daily from two 2400 Megahertz fourth-generation connected mobile phones for 60 days, respectively. The electromagnetic radiation frequency radiometer measured the frequency of electromagnetic radiation emitted from cell phones. The specific absorption rate was calculated as 0.087 W/kg. The control group was kept under similar conditions, but the electromagnetic field was not given for the same period. All the mice were sacrificed at the end of the experiment. The blood samples were collected for hematobiochemical study, and then kidney and testis tissues were collected for histopathological study. Results of the study showed that the body weight and total erythrocyte count values were significantly ($p < 0.05$) decreased while total leukocyte count, hemoglobin %, and serum creatinine values were significantly ($p < 0.05$) increased in both the radiation exposure groups relative to the control group. Histopathological observation showed the kidney of 60 minutes exposed mice interstitial inflammation that causes marked mononuclear cellular infiltration compared to the 40 minutes and control mice. Compared to control mice, histopathological examinations of testicular tissue from the exposed mice, showed irregular in shapes and non-uniform sizes and fewer spermatogenic cells layer that leads to the larger lumen in the seminiferous tubules. It is concluded that fourth-generation cell phone radiation exposure may affect blood hemostasis and inflammation of mice's kidney and testis tissue. Based on these studies, it is important to increase public consciousness of potential adverse effects of mobile phone radiofrequency electromagnetic radiation exposure.

Open access paper: https://www.sciencedirect.com/science/article/pii/S1319562X21001017

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The effect of 4.5 G (LTE Advanced-Pro network) mobile phone radiation on the optic nerve

Erkin Özdemir, Ülkü Çömelekoglu, Evren Degirmenci, Gülsen Bayrak, Metin Yildirim, Tolgay Ergenoglu, Banu Coşkun Yılmaz, Begüm Korunur Engiz, Serap Yalin, Dilan Deniz Koyuncu, Erkan Ozbay. The effect of 4.5 G (LTE Advanced-Pro network) mobile phone radiation on the optic nerve. Cutan Ocul Toxicol. 2021 Mar 3;1-27. doi: 10.1080/15569527.2021.1895825.

Abstract

Purpose: Rapid development in mobile phone technologies increase the average mobile phone usage duration. This increase also triggers exposure to radiofrequency radiation (RF), which is a risk factor for the health. In this study, it was aimed to investigate the effect of mobile phone working with LTE-Advanced Pro (4.5G) mobile network on the optic nerve, which is responsible for the transmission of visual information.

Material and methods: Thirty-two rats divided into two groups as control (no RF, sham exposure) and experimental (RF exposure using a mobile phone with LTE-Advanced Pro network; 2 hours/day, 6 weeks). The visual evoked potential (VEP) was recorded and determined amplitudes and latencies of VEP waves. Optic nerve malondialdehyde level, catalase and superoxide dismutase activities were determined. Furthermore, ultrastructural and morphometric changes of optic nerve were evaluated.

Results: In VEP recordings, the mean VEP amplitudes of experimental group were significantly lower than control group. In ultrastructural evaluation, myelinated nerve fibers and glial cells were observed in normal histologic appearance both in sham and experimental group. However, by performing morphometric analysis, in the experimental group, axonal diameter and myelin thickness were shown to be lower and the G-ratio was higher than in the sham group. In the experimental group, malondialdehyde level was significantly higher and superoxide dismutase and catalase activities were significantly lower than sham group. There was a high correlation between VEP wave amplitudes and oxidative stress markers.

Conclusion: Findings obtained in this study support optic nerve damage. These results point out an important risk that may decrease the quality of life.

https://pubmed.ncbi.nlm.nih.gov/33653184/

Excerpts

In recent years, everyone, from child to old, has a smartphone, and everyday a long time is passed looking at the screen of this phone. Comfort and efficiency achieved thanks to the high data transfer rate provided by LTE-Advanced Pro technology increase this time day by day. Eyes are the most affected body parts from this condition. In addition to the effects such as strabismus and eye impairment arising from looking at a small screen, it is also important to examine the hidden risks that the RF magnetic field created by the phone will cause on the eye. In this study, the effects of RF emission created by a LTE-Advanced Pro technology phone on the optic nerve were examined in all aspects and the findings were given in the previous section. Briefly it can be said that, for the first time in scientific literature, the findings of the present study indicate that the LTE-

Advanced Pro mobile phone radiation causes significant damage by triggering oxidative stress in the optic nerve. LTE-Advanced Pro technology uses a wider RF band between 800 MHz and 2600 MHz and the network system selects the most appropriate band itself according to the user's requirements. It is known that penetration depth of RF increases with decreasing frequency [39]. Since effects of RF radiation were observed on the optic nerve which is behind the eye, it can be said that low frequency bands such as 800 MHz were mostly active during the experiments. Maybe this inference cannot be generalized for all communication purposes, but usage probability of low frequency bands during LTE-Advanced Pro smart phone usage will always keep the damage risk on optic nerve alive.

Fig. 3A and 3B show the distribution of electric field and SAR, respectively. As seen, maximum E field was 5.0 V/m (Fig. 3A) and maximum SAR (10 g) was 0.01 W/kg (Fig. 3B). The SAR value in the area of eyes was about 0.0035 W/kg (Fig. 3B).

Before and after exposure, body surface temperatures were 28.08 ± 0.19 and 28.07 ± 0.26 °C, respectively in the sham group. These values were 28.37 ± 0.29 and 28.39 ± 0.22 °C, respectively for the RF groups. There was no significant difference within sham ($p = 0.275$) and RF ($p = 0.120$) groups before and after exposure. Also, there was no significant differences in surface body temperature between sham and RF exposed groups before ($p = 0.142$) and after ($p = 0.321$) exposure.

In the present study, for the first time, it was shown that exposition to 4.5 G mobile phone radiation for 2 hours/day for 6 weeks causes optic nerve damage. The optic nerve transmits all visual information to the visual cortex, and any damage in this nerve can cause permanent and serious vision loss. This study demonstrated that RF exposure may be an environmental risk factor for eye toxicity and potential eye disorders. Further studies are needed to reveal the potentiality of the risk in this area.

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Potential influence of prenatal 2.45 GHz radiofrequency electromagnetic field exposure on Wistar albino rat testis

Viera Almášiová, Katarína Holovská, Sandra Andrašková, Viera Cigánková, Zuzana Ševčíková, Adam Raček, Zuzana Andrejčáková, Katarína Beňová, Štefan Tóth, Eva Tvrdá, Ján Molnár, Enikö Račeková. Potential influence of prenatal 2.45 GHz radiofrequency electromagnetic field exposure on Wistar albino rat testis. Histol Histopathol. 2021 Mar 25;18331. doi: 10.14670/HH-18-331.

Abstract

An ever-increasing use of wireless devices over the last decades has forced scientists to clarify their impact on living systems. Since prenatal development is highly sensitive to numerous noxious agents, including radiation, we focused on the assessment of potential adverse effects of microwave radiation (MR) on testicular development. Pregnant Wistar albino rats (3 months old, weighing 282±8 g) were exposed to pulsed MR at a frequency of 2.45 GHz, mean power density of 2.8 mW/cm², and a specific absorption rate of 1.82 W/kg for 2 hours/day throughout pregnancy. Male offspring were no longer exposed to MR following birth. Samples of

biological material were collected after reaching adulthood (75 days). In utero MR exposure caused degenerative changes in the testicular parenchyma of adult rats. The shape of the seminiferous tubules was irregular, germ cells were degenerated and often desquamated. The diameters of the seminiferous tubules and the height of the germinal epithelium were significantly decreased (both at $**p<0.01$), while the interstitial space was significantly increased ($**p<0.01$) when compared to the controls. In the group of rats prenatally exposed to MR, the somatic and germ cells were rich in vacuoles and their organelles were often altered. Necrotizing cells were more frequent and empty spaces between Sertoli cells and germ cells were observed. The Leydig cells contained more lipid droplets. An increased Fluoro Jade - C and superoxide dismutase 2 positivity was detected in the rats exposed to MR. Our results confirmed adverse effects of MR on testicular development.

Open access paper: https://www.hh.um.es/Articles-Proofs/18-331-manuscript.pdf

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Response to Melnick (2020)

No authors listed. Response to Melnick (2020). Health Phys. 2020 Jun;118(6):683-685. doi: 10.1097/HP.0000000000001269.

No abstract

DOI: 10.1097/HP.0000000000001269

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Personal Exposure Assessment to Wi-Fi Radiofrequency Electromagnetic Fields in Mexican Microenvironments

Raquel Ramirez-Vazquez, Jesus Gonzalez-Rubio, Isabel Escobar, Carmen Del Pilar Suarez Rodriguez, Enrique Arribas. Personal Exposure Assessment to Wi-Fi Radiofrequency Electromagnetic Fields in Mexican Microenvironments. Int J Environ Res Public Health. 2021 Feb 14;18(4):1857. doi: 10.3390/ijerph18041857

Abstract

In recent years, personal exposure to Radiofrequency Electromagnetic Fields (RF-EMF) has substantially increased, and most studies about RF-EMF with volunteers have been developed in Europe. To the best of our knowledge, this is the first study carried out in Mexico with personal exposimeters. The main objective was to measure personal exposure to RF-EMF from Wireless Fidelity or wireless Internet connection (Wi-Fi) frequency bands in Tamazunchale, San Luis Potosi, Mexico, to compare results with maximum levels permitted by international recommendations and to find if there are differences in the microenvironments subject to measurements. The study was conducted with 63 volunteers in different microenvironments: home, workplace, outside, schools, travel, and shopping. The mean minimum values registered were 146.5 μW/m2 in travel from the Wi-Fi 2G band and 116.8 μW/m2 at home from the Wi-Fi 5G band, and the maximum values registered were 499.7 μW/m2 and 264.9 μW/m2 at the workplace for the Wi-Fi 2G band and the Wi-Fi 5G band, respectively. In

addition, by time period and type of day, minimum values were registered at nighttime, these values being 129.4 µW/m2 and 93.9 µW/m2, and maximum values were registered in the daytime, these values being 303.1 µW/m2 and 168.3 µW/m2 for the Wi-Fi 2G and Wi-Fi 5G bands, respectively. In no case, values exceeded limits established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). Of the study participants (n = 63), a subgroup (n = 35) answered a survey on risk perception. According to these results, the Tamazunchale (Mexico) population is worried about this situation in comparison with several European cities; however, the risk perception changes when they are informed about the results for the study.

Open access paper: https://pubmed.ncbi.nlm.nih.gov/33673014/

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Radio-frequency electromagnetic field exposure and contribution of sources in the general population: an organ-specific integrative exposure assessment

Luuk van Wel, Ilaria Liorni, Anke Huss, Arno Thielens, Joe Wiart, Wout Joseph, Martin Röösli, Milena Foerster, Amelie Massardier-Pilonchery, Myles Capstick, Elisabeth Cardis, Roel Vermeulen. Radio-frequency electromagnetic field exposure and contribution of sources in the general population: an organ-specific integrative exposure assessment. J Expo Sci Environ Epidemiol. 2021 Mar 2. doi: 10.1038/s41370-021-00287-8.

Abstract

In order to achieve an integrated radio-frequency electromagnetic fields (RF-EMF) dose assessment, detailed information about source-specific exposure duration and output power is needed. We developed an Integrated Exposure Model (IEM) to combine energy absorbed due to use of and exposure to RF-EMF sources and applied it to a sample of the general population to derive population RF-EMF estimates. The IEM used specific absorption rate transfer algorithms to provide RF-EMF daily dose estimates (mJ/kg/day) using source-specific attributes (e.g. output power, distance), personal characteristics and usage patterns. Information was obtained from an international survey performed in four European countries with 1755 participants. We obtained median whole-body and whole-brain doses of 183.7 and 204.4 mJ/kg/day. Main contributors to whole-brain dose were mobile phone near the head for calling (2G networks) and far-field sources, whereas the latter together with multiple other RF-EMF sources were main contributors for whole-body dose. For other anatomical sites, 2G phone calls, mobile data and far-field exposure were important contributors. The IEM provides insight into main contributors to total RF-EMF dose and, applied to an international survey, provides an estimate of population RF-dose. The IEM can be used in future epidemiological studies, risk assessments and exposure reduction strategies.

https://pubmed.ncbi.nlm.nih.gov/33654268/

Excerpts

Relative contributions per source

For the whole-brain the use of mobile phones near the head remains by far the main contributor to total dose. Phone calls performed on a 2G network, which generally uses a higher output power, provide a high

contribution followed at a distance by nearby Wi-Fi-routers. Regarding whole-body dose, the contribution of other sources becomes more important. Far-field exposure, Wi-Fi-routers, laptops, tablets and even other functions than calling on a mobile phone provide a higher contribution to the whole-body dose. This indicates that while just looking at mobile phone calls may include most RF-EMF exposure for health outcomes focused on the brain, this is not the case for the whole-body. In addition, adaptive output power control depending on the mobile phones' function may further influence exposure levels, as explained below. When looking at potential health endpoints at anatomical sites other than the brain (e.g. heart, liver), multiple devices should be included.

RF-EMF dose reduction

With the relative contributions found in this study, various non-technical interventions may be considered to reduce overall RF-EMF dose. The avoidance of using a mobile phone near the head when using 2G networks may be an efficient way to reduce overall exposure by half for the whole-brain and up to 25% for the whole-body. This can be achieved on modern smartphones by disabling the use of 2G networks altogether or by using a wired hands-free kit instead. In the latter case, the exposure will shift from the head to other parts of the body when the device is held in a hand or pocket. In general, we observed a higher RF-EMF dose with device functions that require higher amounts of data, such as video streaming. Placing the device on a nearby surface or stand with data intensive uses can be considered to reduce dose. For far-field exposure, it is generally difficult to achieve individual reduction as these are continuous exposures generally not controlled by the subject, such as FM radio broadcast and mobile phone antennas.

Conclusion

In conclusion, we developed the most comprehensive RF-EMF dose estimation tool to date. Realistic population exposure scenarios were obtained by using data on mobile phone use from an international survey in the model. Overall RF-EMF dose for the whole-body and whole-brain was found to be higher in younger age groups in comparison with older groups. Mobile phone calls on 2G networks were found to be the main contributor to whole-brain RF-EMF dose. For whole-body dose, far-field of telecommunications and multiple other RF-EMF sources played a prominent role as well. These findings can be used in the creation of non-technical interventions aimed at lowering RF-EMF exposure from current technologies, with the modular structure of the model allowing inclusion of new technologies such as 5th generation networks. Future epidemiological studies involving RF-EMF exposure should take multiple RF-EMF sources into account by adding detailed questions on exposure duration when investigating other anatomical sites than the brain.

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Evidence of bystander effect induced by radiofrequency radiation in a human neuroblastoma cell line

Olga Zeni, Stefania Romeo, Anna Sannino, Rosanna Palumbo, Maria Rosaria Scarfì. Evidence of bystander effect induced by radiofrequency radiation in a human neuroblastoma cell line. Environ Res. 2021 Feb 26;110935. doi: 10.1016/j.envres.2021.110935.

Abstract

In previous studies we demonstrated that radiofrequency (RF) electromagnetic fields (EMF) is able to reduce DNA damage induced by a subsequent treatment with genotoxic agents, resembling the adaptive response, a phenomenon well known in radiobiology. In this study we report on the capability of the culture medium from SH-SY5Y neuroblastoma cells exposed to 1950 MHz to elicit, in recipient non-exposed cells, a reduction of menadione-induced DNA damage ($P<0.05$; comet assay), indicating the capability of non-ionizing radiation to elicit a bystander effect. A comparable reduction was also detected in cultures directly exposed to the same EMF conditions ($P<0.05$), confirming the adaptive response. In the same exposure conditions, we also evidenced an increase of heat shock protein 70 (hsp70) in culture medium of cells exposed to RF with respect to sham exposed ones (western blot analysis; $P<0.05$), while no differences were detected in the intracellular content of hsp70. On the whole, our results evidence a protective effect of RF against menadione-induced DNA damage in directly and non-directly exposed cells, and suggest hsp70 pathway to be investigated as one of the potential candidate underpinning the interaction between RF exposure and biological systems.

https://pubmed.ncbi.nlm.nih.gov/33647301/

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The Effect of Pulsed Electromagnetic Fields on Angiogenesis

Lihong Peng, Chenying Fu, Lu Wang, Qing Zhang, Zejun Liang, Chengqi He, Quan Wei. The Effect of Pulsed Electromagnetic Fields on Angiogenesis. Bioelectromagnetics. 2021 Mar 6. doi: 10.1002/bem.22330.

Abstract

A pulsed electromagnetic field (PEMF) has been used to treat inflammation-based diseases such as osteoporosis, neurological injury, and osteoarthritis. Numerous animal experiments and in vitro studies have shown that PEMF may affect angiogenesis. For ischemic diseases, in theory, blood flow may be richer by increasing the number of blood vessels which supply blood to ischemic tissue. PEMF plays a role in enhancing angiogenesis, and their clinical application may go far beyond the current scope. In this review, we analyzed and summarized the effects and possible mechanisms of PEMF on angiogenesis. Most studies have shown that PEMF with specific parameters can promote angiogenesis, which is manifested by an increased vascular growth rate and increased capillary density. The potential mechanisms consist of promoting vascular endothelial cell proliferation, migration, and tube formation, and increasing the expression level of vascular endothelial growth factor (VEGF), fibroblast growth factor 2 (FGF2), angiopoietin-2 (Ang-2), and other angiogenic growth factors. Additionally, PEMF has an impact on the activation of voltage-gated calcium channels (VGCC).

https://pubmed.ncbi.nlm.nih.gov/33675261/

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Effects of radiofrequency electromagnetic radiation emitted from a mobile phone base station on the redox homeostasis in different organs of Swiss albino mice

Mary Zosangzuali, Marina Lalremruati, C Lalmuansangi, F Nghakliana, Lalrinthara Pachuau, Priyanka Bandara, Zothan Siama. Effects of radiofrequency electromagnetic radiation emitted from a mobile phone base station on the redox homeostasis in different organs of Swiss albino mice. Electromagn Biol Med. 2021 Mar 9;1-15. doi: 10.1080/15368378.2021.1895207.

Abstract

This study was designed to investigate the possible effects of exposure to mobile phone base station (MPBS) emits 1800-MHz RF-EMR on some oxidative stress parameters in the brain, heart, kidney and liver of Swiss albino mice under exposures below thermal levels. Mice were randomly assigned to three experimental groups which were exposed to RF-EMR for 6 hr/day, 12 hr/day and 24 hr/day for 45 consecutive days, respectively, and a control group. The glutathione (GSH) levels and activities of glutathione-s-transferase (GST) and superoxide dismutase (SOD) were significantly reduced in mice brain after exposure to RF-EMR for 12 hr and 24 hr per day. Exposure of mice to RF-EMR for 12 hr and 24 hr per day also led to a significant increase in malondialdehyde (an index of lipid peroxidation) levels in mice brain. On the contrary, exposures used in this study did not induce any significant change in various oxidative stress-related parameters in the heart, kidney and liver of mice. Our findings showed no significant variations in the activities of aspartate amino-transferase (AST), alanine amino-transferase (ALT), and on the level of creatinine (CRE) in the exposed mice. This study also revealed a decrease in RBC count with an increase in WBC count in mice subjected to 12 hr/day and 24 hr/day exposures. Exposure to RF-EMR from MPBS may cause adverse effects in mice brain by inducing oxidative stress arising from the generation of reactive oxygen species (ROS) as indicated by enhanced lipid peroxidation, and reduced levels and activities of antioxidants.

https://pubmed.ncbi.nlm.nih.gov/33687298/

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Effects of 1.5-GHz high-power microwave exposure on the reproductive systems of male mice

Guofu Dong, Hongmei Zhou, Yan Gao, Xuelong Zhao, Qi Liu, Zhihui Li, Xi Zhao, Jiye Yin, Changzhen Wang. Effects of 1.5-GHz high-power microwave exposure on the reproductive systems of male mice. Electromagn Biol Med. 2021 Mar 10;1-10. doi: 10.1080/15368378.2021.1891091.

Abstract

High-power microwaves (HPMs) have been reported to have hazardous effects on multiple human and animal organs. However, the biological effects of 1.5-GHz HPMs on the reproductive system are not clear. Here, we studied the effects of 1.5 -GHz HPM whole-body exposure on the pathological structure of the testicles and changes in spermatozoa mobility. C57BL/6 mice of groups L, M, and H were exposed to 1.5-GHz HPM fields for two 15-min intervals at the average specific absorption rates of 3, 6, and 12 W/Kg, respectively. The pathological structure of the testicles and spermatozoa, as well as serum testosterone and sperm motility parameters, were evaluated at 6 h, 1 d, 3 d, and 7 d after exposure. As a result, there were no significant pathological or ultrastructural changes in the testicles or spermatozoa and serum testosterone levels. The number of

progressively motile spermatozoa, curvilinear velocity, linear velocity, and average path velocity of the exposure group increased at 6 h, decreased at 1 d, and recovered at 3 d. The opposite results were considered a stress response to the thermal effect of the microwaves. Our results indicated that 1.5-GHz HPM whole-body exposure in mice at SARs of 3, 6, and 12 W/Kg for 30 min did not cause obvious damage to the reproductive system.

https://pubmed.ncbi.nlm.nih.gov/33688776/

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Directional Migration of Breast Cancer Cells Hindered by Induced Electric Fields May Be Due to Accompanying Alteration of Metabolic Activity

Travis H. Jones, Kirti Kaul, Ayush A. Garg, Jonathan W. Song, Ramesh K. Ganju, Vish V. Subramaniam. Directional Migration of Breast Cancer Cells Hindered by Induced Electric Fields May Be Due to Accompanying Alteration of Metabolic Activity. Bioelectricity. 20 Jan 2021. https://doi.org/10.1089/bioe.2020.0048

Abstract

Background: Induced electric fields (iEFs) control directional breast cancer cell migration. While the connection between migration and metabolism is appreciated in the context of cancer and metastasis, effects of iEFs on metabolic pathways especially as they relate to migration, remain unexplored.

Materials and Methods: Quantitative cell migration data in the presence and absence of an epidermal growth factor (EGF) gradient in the microfluidic bidirectional microtrack assay was retrospectively analyzed for additional effects of iEFs on cell motility and directionality. Surrogate markers of oxidative phosphorylation (succinate dehydrogenase [SDH] activity) and glycolysis (lactate dehydrogenase activity) were assessed in MDA-MB-231 breast cancer cells and normal MCF10A mammary epithelial cells exposed to iEFs and EGF.

Results: Retrospective analysis of migration results suggests that iEFs increase forward cell migration speeds while extending the time cells spend migrating slowly in the reverse direction or remaining stationary. Furthermore, in the presence of EGF, iEFs differentially altered flux through oxidative phosphorylation in MDA-MB-231 cells and glycolysis in MCF10A cells.

Conclusions: iEFs interfere with MDA-MB-231 cell migration, potentially, by altering mitochondrial metabolism, observed as an inhibition of SDH activity in the presence of EGF. The energy intensive process of migration in these highly metastatic breast cancer cells may be hindered by iEFs, thus, through hampering of oxidative phosphorylation.

Conclusion

A retrospective analysis of the momentary speeds and velocities (forward and reverse directions) reported in Garg et al.,9 revealed that cancer cell migration is hindered by iEFs because migrating cells slow down or are immobile some of the time in the 700 μm long microchannel over the duration of the experiment. Thus, iEFs not

only reduce the number of cancer cells migrated but, on average, also slow them down. We have separately shown that SDH activity is hindered in MDA-MB-231 cells and LDH activity is enhanced in MCF10A cells by iEFs in the presence of EGF. This additional data on the effects of iEF on cellular metabolism may explain the previously reported changes in migration characteristics in microtrack microchannels. This work has paved the way for better understanding of how iEFs interact with MDA-MB-231 cells and points to possible new therapeutic options for treating metastasis that involve targeting specific metabolic pathways.

https://www.liebertpub.com/doi/10.1089/bioe.2020.0048

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Heart Rate Variability and Magnetic Field Exposure Among Train Engine Drivers-A Pilot Study

Kjell Hansson Mild, Roland Bergling, Rolf Hörnsten. Heart Rate Variability and Magnetic Field Exposure Among Train Engine Drivers-A Pilot Study. Bioelectromagnetics. 2021 Mar 1. doi: 10.1002/bem.22329.

No abstract.

https://pubmed.ncbi.nlm.nih.gov/33644873/

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Effects Induced by a Weak Static Magnetic Field of Different Intensities on HT-1080 Fibrosarcoma Cells

Hakki Gurhan, Rodolfo Bruzon, Sahithi Kandala, Ben Greenebaum, Frank Barnes. Effects Induced by a Weak Static Magnetic Field of Different Intensities on HT-1080 Fibrosarcoma Cells. Bioelectromagnetics. 2021 Mar 18. doi: 10.1002/bem.22332.

Abstract

In this study, we investigated the effects of weak static magnetic fields (SMFs) on HT-1080 human fibrosarcoma cells. Exposures to SMFs for four consecutive days were varied from 0.5 to 600 μT for treated units, while exposures to control units were held at 45 μT. Growth rates were measured by comparing cell counts, whereas membrane potentials, mitochondrial calcium, mitochondrial superoxide (O2 -), nitric oxide (NO), hydrogen peroxide (H2 O2), intercellular pH, and oxidative stress were measured by using fluorescent dyes. The relative cell growth rates vary with the angle of the SMFs. Increases in the magnitude of the SMFs increased concentrations of mitochondrial calcium and membrane potential and decreased intracellular pH. H2 O2 , an important reactive oxygen species (ROS), increases at 100 and 200 μT, decreases at 300 and 400 μT and increases again at 500 and 600 μT. Overall, oxidative stress increases slightly with increasing SMFs, while superoxide and NO concentrations decrease. These results indicate that weak SMFs can accelerate and inhibit cell growth rates and induce alterations in ROS. Changes in ROS and oxidative stress are important for various cell functions. Calcium influx into mitochondria was one of the initial steps into the corresponding changes.

https://pubmed.ncbi.nlm.nih.gov/33735454/

Excerpts

In the present study, we looked at mitochondrial ROS generation as an important source for ROS signaling and concentrated our attention on the initial parts of the mitochondrial signaling pathways. Mitochondrial superoxide, H2O2, and NO are considered important intra-mitochondrial signaling molecules. In our experiments, ROS responses to the SMF were more complex. Changes in H2O2 are not linearly correlated with cell growth. This might be due to increases in antioxidant concentrations [Rosenspire et al., 2005]. Decreases in H2O2 correspond to where we observed the highest increase in cell growth rates. There are various studies showing that low levels of H2O2 can initiate cell proliferation [Antunes and Brito, 2017; Sies, 2017]. The mitochondrial superoxide and the NO tend to decrease with the increase in MF. The mitochondrial superoxide decreased with respect to the control for all SMF values, being highly significant for 200 and 400 μT, and the NO decreased with respect to the control for 0.5, 100, 400, and 600 μT. H2O2 and oxidative stress tend to increase with the increase in SMF. In both parameters, a highly significant increase was observed for 100 and 200 μT.

The importance of these results is that variations of background MFs can both increase and decrease cell growth rates and corresponding concentrations of ROS and other signaling molecules. These observed changes are significant as different concentration levels of ROS could have beneficial or adverse effects on biology. In conclusion, the basic effect observed here is that changes in SMFs create a change in the growth rate of the cells and changes in some important molecular concentrations on both sides of the cell and mitochondrial membrane. Though the growth rate is one of the parameters that we have studied, the changes in the signaling molecules and other cell parameters might cause long-term effects in biological systems. An example of this is long-term changes in oxidative stress related to cancer and aging-related diseases. Canceling out the earth's MF substantially, down to 0.5 μT by Mu metal cages, not only gave us the capability to eliminate background noise but also allowed us to observe effects at a level much lower than the earth's MF. Thus, in this study, we believe that measuring and controlling the SMFs and eliminating the effects of temperature and background noise in experiments are important for attempting to understand the effects of electromagnetic fields on biological systems. Additionally, we believe that the amplitude, angle of incidence, and length of the exposure can lead to variable results and need to be included in the description of experimental protocols [Barnes and Greenebaum, 2015].

Future work will include time-varying MFs, where we expect to see both electric and MF effects. Time-varying MFs induce electric fields; other data indicate that both electric and MFs can induce changes in cell growth rates and other biological parameters [Bingham, 1996]. More research work will be required to determine the mechanisms by which these two different fields modify the behavior of cells.

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No evidence for genotoxicity in mice due to exposure to intermediate-frequency magnetic fields used for wireless power-transfer systems

Shin Ohtani, Akira Ushiyama, Keiji Wada, Yukihisa Suzuki, Kazuyuki Ishii, Kenji Hattori. No evidence for

genotoxicity in mice due to exposure to intermediate-frequency magnetic fields used for wireless power-transfer systems. Mutat Res. Mar-Apr 2021;863-864:503310. doi: 10.1016/j.mrgentox.2021.503310.

Abstract

Time varying magnetic fields (MFs) are used for the wireless power-transfer (WPT) technology. Especially, 85 kHz band MFs, which are included in the intermediate frequency (IF) band (300 Hz - 10 MHz), are commonly used WPT system for charging electric vehicles. Those applications of WPT technology have elicited public concern about health effects of IF-MF. However, existing data from health risk assessments are insufficient and additional data are needed. We assessed the genotoxic effects of IF-MF exposure on erythroid differentiation in mice. A high-intensity IF-MF mouse exposure system was constructed to induce an average whole-body electric field of 54.1 V/m. Blood samples were obtained from male mice before and after a 2-week IF-MF exposure (1 h/day, total: 10 h); X-irradiated mice were used as positive controls. We analyzed the blood samples with the micronucleus (MN) test and the Pig-a mutation assay. No significant differences were seen between IF-MF-exposed and sham-exposed mice in the frequencies of either MN or Pig-a mutations in mature erythrocytes and reticulocytes. IF-MF exposure did not induce genotoxicity in vivo under the study conditions (2.36× the basic restriction for occupational exposure, 22.9 V/m, in the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines). The absence of significant biological effects due to IF-MF exposure supports the practical application of this technology.

Highlights

- We examined the genotoxicity of IF-MF exposure >2× the ICNIRP guideline.
- IF-MF had no genotoxic effects in an *in vivo* micronucleus test and *Pig-a* assay.
- These observations are useful for assessing the safety of a WPT system.

https://pubmed.ncbi.nlm.nih.gov/33678242/

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Occupational Exposure to Extremely Low-Frequency Magnetic Fields and Risk of Amyotrophic Lateral Sclerosis: Results of a Feasibility Study for a Pooled Analysis of Original Data

Dan Baaken, Dagmar Dechent, Maria Blettner, Sarah Drießen, Hiltrud Merzenich. Occupational Exposure to Extremely Low-Frequency Magnetic Fields and Risk of Amyotrophic Lateral Sclerosis: Results of a Feasibility Study for a Pooled Analysis of Original Data. Bioelectromagnetics. 2021 Mar 25. doi: 10.1002/bem.22335.

Abstract

Previous meta-analyses have suggested an increased risk of amyotrophic lateral sclerosis (ALS) associated with occupational exposure to extremely low-frequency magnetic fields (ELF-MF). However, results should be interpreted with caution since studies were methodologically heterogeneous. Here, we assessed the feasibility of a pooling study to harmonize and re-analyze available original data. A systematic literature search was conducted. Published epidemiological studies were identified in PubMed and EMF-Portal from literature

databases' inception dates until January 2019. The characteristics of all studies were described, including exposure metrics, exposure categories, and confounders. A survey among the principal investigators (PI) was carried out to assess their willingness to provide their original data. The statistical power of a pooling study was evaluated. We identified 15 articles published between 1997 and 2019. Studies differed in terms of outcome, study population, exposure assessment, and exposure metrics. Most studies assessed ELF-MF as average magnetic flux density per working day; however, exposure categories varied widely. The pattern of adjustment for confounders was heterogeneous between studies, with age, sex, and socioeconomic status being most frequent. Eight PI expressed their willingness to provide original data. A relative risk of ≥1.14 for ALS and occupational exposure to ELF-MF can be detected with a power of more than 80% in a pooled study. The pooling of original data is recommended and could contribute to a better understanding of ELF-MF in the etiology of ALS based on a large database and reduced heterogeneity due to a standardized analysis protocol with harmonized exposure metrics and exposure categories.

Open access paper: https://onlinelibrary.wiley.com/doi/10.1002/bem.22335

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The Influence of the Extremely Low Frequency Electromagnetic Field on Clear Cell Renal Carcinoma

Cios A, Ciepielak M, Stankiewicz W, Szymański Ł. The Influence of the Extremely Low Frequency Electromagnetic Field on Clear Cell Renal Carcinoma. *International Journal of Molecular Sciences*. 2021; 22(3):1342. https://doi.org/10.3390/ijms22031342.

Abstract

The development of new technologies and industry is conducive to the increase in the number and variety of electromagnetic field (EMF) sources in our environment. The main sources of EMF are high-voltage lines, household appliances, audio/video devices, mobile phones, radio stations, and radar devices. In the growing use of electronic devices, scientists are increasingly interested in the effects of EMF on human health. Even though many studies on the effects of EMF have already been carried out, none of them has shown a significant effect on mammals, including humans. Moreover, it is not entirely clear how EMF influences cell behavior. The International Agency for Research on Cancer on 31 May 2011, classified PEM as a possible carcinogenic factor. This study aimed to investigate the effect of the electromagnetic field on morphological and functional changes in clear cell renal carcinoma. The research was carried out on in vitro cultures of four cell lines: HEK293, 786-O 769-P, and Caki1. The results of the research showed that the EMF of low frequency had a slight effect on the viability of cells. EMF, which induced cell arrest in the G1 phase, increased the number of early apoptotic cells and decreased the number of viable cells in the 786-O line. EMF did not affect the proliferation and viability of HEK293 cells. Extreme low-frequency EMF (ELF-EMF) also showed an inhibitory effect on the migration and metastatic properties of clear cell kidney cancer cells. Moreover, shortly after the end of ELF-EMF exposure, significant increases in ROS levels were observed in all tested cell lines. As part of the work, it was shown that low-frequency EMF shows an inhibitory effect on the proliferation of primary cancer cells, diminishing their migratory, invasive, and metastatic abilities. It also increases the apoptosis of cancer cells and the amount of reactive oxygen species. Based on the results of our research, we want to point up that the effect of ELF-EMF depends on a specific metabolic state or at a specific stage in the cell cycle of the cells under study

Open access paper: https://www.mdpi.com/1422-0067/22/3/1342/htm

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Interference of Cardiovascular Implantable Electronic Devices by Static Electric and Magnetic Fields

Kai Jagielski, Thomas Kraus, Dominik Stunder. Interference of Cardiovascular Implantable Electronic Devices by Static Electric and Magnetic Fields. Expert Rev Med Devices. 2021 Mar 12. doi: 10.1080/17434440.2021.1902802.

Abstract

Introduction: Electromagnetic interference (EMI) of cardiovascular implantable electronic devices (CIED) can lead to malfunctions and pose a danger for implant carriers. The increased use of DC technologies, e.g., in electric mobility, creates more static fields representing an increasing hazard for implant carriers.

Areas covered: A combination of approaches was used to determine thresholds for EMI by static fields. A literature search was conducted to identify relevant EMI mechanisms and to extract possible thresholds. The literature search revealed four interference mechanisms caused by static magnetic fields and none for static electric fields. Due to the scarce information on motion-induced EMI, numerical simulations were performed to obtain a threshold. The simulation results were evaluated using medical product standards and benchmark tests on commercially available CIEDs. The results show that motion-induced interference should not occur below the activation of the magnetic safety switch (reed switch or Hall-effect sensor, MSS).

Expert opinion: The determined threshold for motion-induced EMI at 24.8 mT shows that the MSS activation is still the most relevant mechanism that can occur at 0.8 mT. Limit values for the general population do not protect implant carriers from EMI.

https://pubmed.ncbi.nlm.nih.gov/33710950/

Conclusion

The aim of this study was the assessment of risks for CIED patients by SEF and SMF. Regarding SEF, no indication was found that CIED can be interfered with when implant wearers are exposed to SEF. This does not include potential EMI from contact currents as they may occur from charged objects in the vicinity of SEF. Contact currents were not the focus of this study due to the significantly different scenario between field exposure and contact current, in which skin resistance and voltage level play a decisive role. Under the influence of SEF exposure, the shielding of the human body as a Faraday cage is sufficient to prevent electric induction into CIED that are located entirely under the human skin.

Regarding SMF, four interference mechanisms have been identified. As a reed switch or Hall effect sensor, the unintended activation of the MSS is the most investigated effect and can occur at SMF greater than 0.8 mT. Magnetic forces on CIED may be relevant for strong magnetic fields in the magnitude of teslas as they arise from MRI devices. A parameter reset or reprogramming of the CIED by SMF seems to be relatively uncommon, and

only one publication reported a reproducible case with a PM by earphones. Rather few publications treat motion-induced EMI with the iEGM of the CIED, which has been investigated with numerical simulations and benchmark tests in this study.

In this study, activation thresholds for motion-induced EMI were determined and published for the first time. However, an estimated occurrence starting at 24.8 mT shows that motion-induced EMIs are less relevant than the activation of MSS that can already occur at 0.8 mT. However, motion-induced EMIs still pose a potential risk to implant wearers because the CIED may not provide the necessary therapy.

Other DC technologies and SMF sources will likely emerge in the future, both in professional and private environments. As a result, EMI from static fields will continue to be significant. The question arises whether the triggering of MSS around 1 mT is still practical, where even today, many technical applications already generate static magnetic fields of more than 1 mT, or whether there is a need for innovation on the part of the manufacturers.

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Swimming direction of the glass catfish is responsive to magnetic stimulation

Ryan D Hunt, Ryan C Ashbaugh, Mark Reimers, Lalita Udpa, Gabriela Saldana De Jimenez, Michael Moore, Assaf A Gilad, Galit Pelled. Swimming direction of the glass catfish is responsive to magnetic stimulation. PLoS One. 2021 Mar 5;16(3):e0248141. doi: 10.1371/journal.pone.0248141.

Abstract

Several marine species have developed a magnetic perception that is essential for navigation and detection of prey and predators. One of these species is the transparent glass catfish that contains an ampullary organ dedicated to sense magnetic fields. Here we examine the behavior of the glass catfish in response to static magnetic fields which will provide valuable insight on function of this magnetic response. By utilizing state of the art animal tracking software and artificial intelligence approaches, we quantified the effects of magnetic fields on the swimming direction of glass catfish. The results demonstrate that glass catfish placed in a radial arm maze, consistently swim away from magnetic fields over 20 μT and show adaptability to changing magnetic field direction and location.

Open access paper: https://pubmed.ncbi.nlm.nih.gov/33667278/

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Lost opportunities for cancer prevention: historical evidence on early warnings with emphasis on radiofrequency radiation

Lennart Hardell and Michael Carlberg. Lost opportunities for cancer prevention: historical evidence on early warnings with emphasis on radiofrequency radiation. Reviews on Environmental Health. 2021. doi: https://doi.org/10.1515/reveh-2020-0168.

Abstract

Some historical aspects on late lessons from early warnings on cancer risks with lost time for prevention are discussed. One current example is the cancer-causing effect from radiofrequency (RF) radiation. Studies since decades have shown increased human cancer risk. The fifth generation, 5G, for wireless communication is about to be implemented world-wide despite no comprehensive investigations of potential risks to human health and the environment. This has created debate on this technology among concerned people in many countries. In an appeal to EU in September 2017, currently endorsed by more than 400 scientists and medical doctors, a moratorium on the 5G deployment was required until proper scientific evaluation of negative consequences has been made (www.5Gappeal.eu). That request has not been taken seriously by EU. Lack of proper unbiased risk evaluation of the 5G technology makes adverse effects impossible to be foreseen. This disregard is exemplified by the recent report from the International Commission on non-ionizing radiation protection (ICNIRP) whereby only thermal (heating) effects from RF radiation are acknowledged despite a large number of reported non-thermal effects. Thus, no health effects are acknowledged by ICNIRP for non-thermal RF electromagnetic fields in the range of 100 kHz–300 GHz. Based on results in three case-control studies on use of wireless phones we present preventable fraction for brain tumors. Numbers of brain tumors of not defined type were found to increase in Sweden, especially in the age group 20–39 years in both genders, based on the Swedish Inpatient Register. This may be caused by the high prevalence of wireless phone use among children and in adolescence taking a reasonable latency period and the higher vulnerability to RF radiation among young persons.

Radiofrequency radiation (Excerpts)

In 2011 radiofrequency electromagnetic fields (RF-EMF) in the frequency range 30 kHz–300 GHz were evaluated by IARC at WHO to be possibly carcinogenic to humans, Group 2B [62], [, 63]. This was based on evidence of increased risk for glioma and acoustic neuroma in human epidemiology studies on use of mobile and/or cordless phone (DECT) [64], [65], [66], [67], [68], [69]. The increased cancer risk was supported by laboratory studies [70], [, 71].

Extremely low frequency (ELF)-EMF was in 2001 evaluated by IARC to be a possible human carcinogen, Group 2B [72]. This was the first time that non-ionizing radiation at low intensity levels can be a possible cause of cancer. It predated the IARC finding for RF-EMF by a decade.

Since then the evidence on RF-EMF carcinogenesis has strengthened based on further human studies on use of wireless phones, as reviewed [73], [, 74]. Also animal studies show increased cancer risk, both near field RF-EMF exposure [75], [76], [77] and far field exposure [78], [, 79]. Mechanistic studies show increase of reactive oxygen species (ROS) [80] as well as DNA damage [81]. These results give support to the increased cancer risk in humans and laboratory tested animals for RF radiation. In fact, RF-EMF may now be classified as a human carcinogen, Group 1 [82], [, 83]. However, such classification can only be made by IARC.

Of course, these well documented health hazards from RF-EMF are not well accepted by the telecom industry and its allied experts. Several methods are used to create doubt. Studies are discredited, only partly cited, or even not cited at all [84], [85], [86]. Thereby the uniformed reader gets the wrong information on actual risks. This includes also regulatory agencies and policy makers. Even agencies aimed at setting exposure guidelines may include pro-industry and biased scientists that obscure the true risks [87], [, 88].

ICNIRP

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) is a private non-governmental (NGO) organization registered in Munich, Germany. ICNIRP appoints its own members and is closed to transparency. It was started in 1992 with the biophysicist Michael Repacholi as the first chairman, now emeritus member. ICNIRP has published three articles with guidelines on RF-EMF exposure [86], [89], [90]. Only thermal (heating) effects from RF radiation are recognized, thereby excluding all studies showing harmful effects at lower non-thermal intensities. In contrast to ICNIRP, some other expert panels such as European Academy of Environmental Medicine [91], the Bioinitiative group [92], and the Russian Commission for Protection from Non-Ionizing Radiation [93], take into account non-thermal RF effects and suggest much lower guidelines for RF exposure.

ICNIRP has managed to get collaborative status with WHO, as discussed previously [88]. The aim is to harmonize the RF-radiation guidelines all over the world. For that purpose ICNIRP has been successful. The guidelines are set to allow very high exposure levels so that the deployment of this technology is not hampered, in favor of industry but at disadvantage to human health and environment. In fact, the ICNIRP guidelines have never been challenged by industry in peer-reviewed articles, which must be taken as a green card for acceptance by industry.

Attributable fraction

The attributable fraction (AF), sometimes also called the etiologic fraction, is the number of cases in which exposure played an etiologic role. This is the preventable fraction if exposure would not be present. In Belpomme et al. [73] we published meta-analyses for longest cumulative use of mobile phones with odds ratio (OR) and 95 % confidence interval (CI), both for total and for ipsilateral wireless phone use. Note that only the Hardell group assessed also use of cordless phones (DECT). We present here AF based on statistically significant increased risks in the meta-analyses. AF is the proportion of cases that can be attributed to the particular exposure. This is calculated as the exposed case fraction multiplied by [(OR-1)/OR].

As displayed in Table 1 the AF for glioma was calculated to 4.88%, 95% CI = 2.44–6.57%, corresponding to 211 preventable cases, 95% CI = 105–284 cases in the longest time for all cumulative use of wireless phones. Regarding ipsilateral use of the wireless phone AF was 6.03%, 95% CI = 4.51–7.12%, yielding 150 cases; 95% CI 112–177 to be preventable.

Rates of brain tumors in the Swedish National Inpatient Register ICD-code D43

Rates of brain tumors of unknown type, D43, were studied using the Swedish Inpatient Register (IPR) without any personal identification information [94]. It was established in 1964 and has complete national coverage since 1987 [95]. Register data on D43 are available from 1998. Currently more than 99% of hospital discharges are registered. For outpatients the data are less reliable due to missing information. The reporting of outpatients has increased during more recent years so these time trends may give spurious results, thus we omitted outpatients from the analysis.

Data were analyzed for the time period 1998–2019. Age-standardized rates are not available in the register. Instead numbers of patients per 100,000 inhabitants are reported. The Joinpoint Regression Analysis program version 4.1.1.1 was used to examine numbers of patients per 100,000 in inpatient care and incidence per 100,000 person-years in the Swedish Inpatient Register, by fitting a model of 0–3 joinpoints using permutation tests with Bonferroni correction for multiple testing to calculate the number of joinpoints that best fits the material [96]. When joinpoints were detected annual percentage changes (APC) and 95% CIs were calculated for each linear segment. Average annual percentage changes (AAPC) were also calculated for the whole time period using the average of the APCs weighted by the length of the segment. To be able to calculate APC and AAPC the data was log-transformed prior to analysis. Thus, it was not possible to perform joinpoint regression analysis when there were years with no cases during that time period. Since the data do not include any personal identification no ethical approval was needed.

In men AAPC increased during 1998–2019 with +1.77%, 95% confidence interval (CI) −0.02, +3.58%, Table 2; Figure 1. The increase was highest in the age group 20–39 years, +2.90%, 95% CI +1.66, +4.16 %, Figure 2. AAPC increased statistically significant in all age groups, except 0–19 years.

Similar results were found in women with AAPC +1.70%, 95% CI +0.38, +3.05% during 1998–2019, Table 3; Figure 3. Also in women the highest increase of AAPC was found in the age group 20–39 years, +2.89%, 95% CI + 1.54, +4.27%, Figure 4. AAPC increased statistically significant in all age groups except 0–19 years and 80+ years. Especially high increase of APC was seen in women aged 60–79 years during 2005–2019, and women aged 80+ years during 2010–2019.

Discussion

RF radiation is a current controversy regarding cancer risks. The 2011 IARC evaluation on carcinogenesis [62], [, 63] has been downplayed and detracted by industry and captured agencies from the very beginning in spite of increasing evidence on harmful effects. However, IARC has decided that a new evaluation of cancer risks is top priority within a few years [100].

In this article we give some further data on the RF carcinogenesis. The attributable fraction gives the number of cases that could have been prevented if no risk exists for a specific exposure. Based on results in case-control studies from three study groups that have shown statistically significant increased risk for glioma and acoustic neuroma 211 glioma cases (all exposure) and 42 acoustic neuroma cases (ipsilateral exposure) would have been preventable in the longest cumulative exposure group. The preventable fraction was 4.88 and 4.63%, respectively. Highest preventable fraction was found for glioma with ipsilateral wireless phone use, 6.03% corresponding to 150 cases. Lower AF was calculated for meningioma, 1.75%, yielding 39 preventable cases (ipsilateral exposure). As displayed in Belpomme et al. [73] these results were based on Interphone [67], Coureau et al. [101], and Carlberg, Hardell [102], each without statistically significant increased risk. However, meta-analysis of these studies yielded, OR = 1.49, 95% CI = 1.08–2.06.

We have previously published results on increasing rates of tumors of unknown type in the brain or CNS both in the Swedish Inpatient Register and Causes of Death Register during 1998–2013 [103]. There was a clear

increasing trend in both genders during that time period, especially during more recent years with AAPC +1.78 %, 95% CI + 0.76, 2.81% for both genders combined. A joinpoint was found in men in 2007; time period 2007–2013 APC +4.95%, 95% CI +1.59, +8.42%. Similarly, in women a joinpoint was detected in 2008; time period 2008–2013 APC +4.08%, 95% CI +1.80, +6.41%.

We have now extended the time period up to 2019. Thus, we report increasing AAPC in both genders during 1998–2019 of similar magnitude as previously. In men the result was of borderline significance although the AAPC overlapped previous findings. Lower APC was found during more recent years in both men and women, see Figures 1 and 3. This may reflect a better diagnostic procedure and thus decreasing numbers of unknown brain tumor type. A delay in reporting to the register during recent years may also have an impact on the results.

It is noteworthy that we found highest AAPC in the age group 20–39 years in both men and women, Tables 2 and 3. We found in our case-control study on glioma a median latency period for use of mobile phone of 9.0 years (mean 10.1 years). The corresponding results for cordless phones (DECT) were 7.0 and 8.0 years, respectively [104]. In a population-based study during 2005–2006 on use of mobile and cordless phones among Swedish children aged 7–14 years 79.1% reported access to mobile phone and use of cordless phone was reported by 83.8% [105]. Thus, our current findings with increasing numbers of brain tumors in the age group 20–39 years may be consistent with use of wireless phones taking a reasonable latency period. Moreover, our previous results showed highest risk for subjects that started the use of mobile or cordless phone before 20 years of age [104]. That age groups would also be more vulnerable to RF radiation [106]. In legends to Figures 1 and 3 we report the history for wireless phone use in Sweden. Figure 5 displays the number of out-going mobile phone minutes in millions during 2000–2019 in Sweden. The major increase is since early 21st century and may be associated with our findings of increasing numbers of brain tumors of unknown type considering a reasonable latency time.

As we have discussed elsewhere the Swedish Cancer Register is not reliable to study the incidence of brain tumors [103], [, 107]. The register is mainly based on reporting of cases with histopathological diagnosis. Now diagnosis may be based on CT and/or MRI without further investigations especially of patients with poor outcome. Biopsy or operation may be difficult to perform due to tumor location, age and co-morbidity. In the Swedish Cancer Register about 90% of the cases are diagnosed with cytology or histology, a number that has increased somewhat during recent years [107]. This fact indicates that brain tumors of unknown type are under-reported to the Cancer Register.

This review gives insight into missed opportunities for cancer prevention exemplified by asbestos, tobacco, certain pesticides and now RF radiation. No doubt economic considerations are favored instead of cancer prevention. The cancer victim is the loser in terms of suffering, life quality and shorter life expectancy. Also the life for the next-of-kin is affected. A strategy to sow doubt on cancer risks was established decades ago and is now adopted and implemented in a more sophisticated way by the telecom industry regarding RF-EMF risks to human beings and the environment. Industry has the economic power, access to politicians and media whereas concerned people are unheard.

Open access paper: https://www.degruyter.com/document/doi/10.1515/reveh-2020-0168/html or https://www.degruyter.com/document/doi/10.1515/reveh-2020-0168/pdf

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Review: Genetic effects of non-ionizing electromagnetic fields

Henry Lai. Genetic effects of non-ionizing electromagnetic fields. Electromagnetic Biology and Medicine. Published online: 04 Feb 2021. doi: 10.1080/15368378.2021.1881866

Abstract

This is a review of the research on the genetic effects of non-ionizing electromagnetic field (EMF), mainly on radiofrequency radiation (RFR) and static and extremely low frequency EMF (ELF-EMF). The majority of the studies are on genotoxicity (e.g., DNA damage, chromatin conformation changes, etc.) and gene expression. Genetic effects of EMF depend on various factors, including field parameters and characteristics (frequency, intensity, wave-shape), cell type, and exposure duration. The types of gene expression affected (e.g., genes involved in cell cycle arrest, apoptosis and stress responses, heat-shock proteins) are consistent with the findings that EMF causes genetic damages. Many studies reported effects in cells and animals after exposure to EMF at intensities similar to those in the public and occupational environments. The mechanisms by which effects are induced by EMF are basically unknown. Involvement of free radicals is a likely possibility. EMF also interacts synergistically with different entities on genetic functions. Interactions, particularly with chemotherapeutic compounds, raise the possibility of using EMF as an adjuvant for cancer treatment to increase the efficacy and decrease side effects of traditional chemotherapeutic drugs. Other data, such as adaptive effects and mitotic spindle aberrations after EMF exposure, further support the notion that EMF causes genetic effects in living organisms.

https://www.tandfonline.com/doi/abs/10.1080/15368378.2021.1881866

For excerpts from this paper see: https://www.saferemr.com/2021/02/genetic-effects-of-non-ionizing.html

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The Association Between Smartphone Use and Breast Cancer Risk Among Taiwanese Women: A Case-Control Study

Ya-Wen Shih, Chin-Sheng Hung, Cheng-Chiao Huang, Kuei-Ru Chou, Shu-Fen Niu, Sally Chan, and Hsiu-Ting Tsai. The Association Between Smartphone Use and Breast Cancer Risk Among Taiwanese Women: A Case-Control Study. Cancer Manag Res. 2020; 12: 10799–10807. 2020 Oct 29. doi: 10.2147/CMAR.S267415

Abstract

Introduction Breast cancer is a common malignancy worldwide. Smartphones have gradually become indispensable to our modern lives and have already changed lifestyles of human beings. To our best knowledge,

no study has investigated the relationship between smartphone use and breast cancer. This case-control study purposely investigated the relationship between smartphone use and breast cancer risk.

Materials and Methods This was a case-control study comprising 894 healthy controls and 211 patients with breast cancer. All participants were asked to respond to standard questionnaires to collect information on sleep quality, smartphone addiction, and smartphone use.

Results Participants with smartphone addiction had a significantly higher 1.43-fold risk of breast cancer. Individuals with the habitual behavior of smartphone use >4.5 minutes before bedtime had a significantly increased 5.27-fold risk of breast cancer compared to those who used a smartphone for ≤4.5 minutes before bedtime. Additionally, a closer distance between the smartphone and the breasts when using the smartphone exhibited a significantly increased 1.59-fold risk. Participants who carried their smartphone near their chest or waist-abdomen area had significantly increased 5.03-fold and 4.06-fold risks of breast cancer, respectively, compared to those who carried the smartphone below the waist. Moreover, there was a synergistic effect of smartphone addiction and smartphone use of >4.5 minutes before bedtime which increased the breast cancer risk.

Conclusion Excessive smartphone use significantly increased the risk of breast cancer, particularly for participants with smartphone addiction, a close distance between the breasts and smartphone, and the habit of smartphone use before bedtime.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7605549/

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Chemical polarization effects of electromagnetic field radiation from the novel 5G network deployment at ultra high frequency

Ugochukwu O. Matthew, Jazuli S. Kazaure. Chemical polarization effects of electromagnetic field radiation from the novel 5G network deployment at ultra high frequency. Health and Technology. Published online Jan. 27, 2021.

Abstract

The wide-spectrum of non-ionizing, non-visible radiation emitted from the novel 5G network deployment was investigated and found liable to produce effects capable of heating up and altering human body nomenclature. The Ultra-high frequency magnetic fields, induced circulation of currents in the surrounding human body when potentially exposed. The quantum of these electromagnetic charges is influenced by the magnitude of the external magnetic field. The Magnetic fields warming is the major organic consequence of the electromagnetic fields radiofrequency radiation emitted from 5G network installation especially at a very high frequencies. From the current research, the levels of electromagnetic fields to which individuals are naturally unmasked under 4G network and 5G network technology in SCENARIO1, SCENARIO 2 and SCENARIO 3 are very negligible to alter human body dipolar chemistry. On the several findings of the research, deploying 5G network technology under the ultra-high frequency above 20 GHz will produce effect that will heat up the human body tissues due to

electromagnetic field inducement since human body is dipolar in nature. The research established that while the current digital society will continue investment into 5G network technology, caution must be applied not to deploy 5G network under ultra-high frequency above 20 GHz due to its adverse health effects.

Conclusions

From the knowledge and principle of electromagnetism, human beings are constituted of substantial amount of oriented cells with diverse electromagnetic field attributes. The Biological attributes of the human tissue under diverse electromagnetic radiative emission are studied and that had provided the basis upon which the current research on the effects of electromagnetic fields on the human body. The heating consequences of the radio electromagnetic waves from 5G network technology deployment had formed the fundamental basis for current research. On the several findings of the research, deploying 5G network technology under the ultra-high baseband above 20 GHz will produce effects such as heating up of the body tissues due to electromagnetic field inducement on the account that human body is dipolar in nature. The effects will extend to produce dielectric polarization, ionic polarization, interfacial polarization and orientational polarization. This is generally on the account that variations on dielectric properties of biological tissues with the frequency of the electromagnetic field inducement are very dissimilar. While it is very imperative to determine the frequency distribution in deploying the novel 5G network to avoid adverse dielectric dispersion that may flow into the human body.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7839940/

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Age-dependence of electromagnetic power and heat deposition in near-surface tissues in emerging 5G bands

Giulia Sacco, Stefano Pisa, Maxim Zhadobov. Age-dependence of electromagnetic power and heat deposition in near-surface tissues in emerging 5G bands. Sci Rep. 2021 Feb 17;11(1):3983. doi: 10.1038/s41598-021-82458-z.

Abstract

With the development of 5th generation (5G) mobile networks people of different ages will be exposed in the upper part of the microwave spectrum. From the perspective of non-ionizing radiation dosimetry, an accurate analysis of age-dependent electromagnetic power deposition and resulting heating is required. In this study, we evaluate the effect of age on exposure at 26 GHz and 60 GHz. A near-surface tissue model illuminated by a plane wave is used to asses the exposure considering both frequency-independent and frequency-dependent limits. The age-related variation of the skin thickness and tissue electromagnetic properties has been considered. Moreover, the blood flow decrease rate has been taken into account to assess the age-dependent heating. Our results demonstrate that the overall variations of the power density, specific absorption rate (SAR) and heating in the near-surface tissues are limited to about 10-15%. These variations are mainly due to the tissue permittivity and blood flow change with age. In contrast to the transmitted power density that increases with age, the peak SAR decreases at both frequencies. The peak steady-state heating increases from 5 to 70 years old by roughly 11% at 26 GHz and 13% at 60 GHz.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7889919/

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Reduction of 5G cellular network radiation in wireless mobile phone using an asymmetric square shaped passive metamaterial design

Tayaallen Ramachandran, Mohammad Rashed Iqbal Faruque, Air Mohammad Siddiky, Mohammad Tariqul Islam. Reduction of 5G cellular network radiation in wireless mobile phone using an asymmetric square shaped passive metamaterial design. Sci Rep. 2021 Jan 29;11(1):2619. doi: 10.1038/s41598-021-82105-7.

Abstract

This study aims to demonstrate the feasibility of metamaterial application in absorption reduction of 5G electromagnetic (EM) energy in the human head tissue. In a general sense, the radio frequency (RF) energy that received by wireless mobile phone from the base station, will emit to surrounding when the devices are in active mode. Since the latest fifth generation technology standard for cellular networks is upon us, the emission of radiation from any wireless devices needs to be taken into consideration. This motivation helps to prepare this paper that focuses on construction of novel and compact square-shaped metamaterial (SM) design to reduce electromagnetic exposure to humans. The commercially available substrate material known as FR-4 with thickness of 1.6 mm was selected to place the metamaterial design on it. The electromagnetic properties and Specific Absorption Rate (SAR) analyses were carried out numerically by utilising high-performance 3D EM analysis, Computer Simulation Technology Studio (CST) software. Meanwhile, for the validation purpose, the metamaterial designs for both unit and array cells were fabricated to measure the electromagnetic properties of the material. From the numerical simulation, the introduced SM design manifested quadruple resonance frequencies in multi bands precisely at 1.246 (at L-band), 3.052, 3.794 (at S-band), and 4.858 (C-band) GHz. However, the comparison of numerically simulated and measured data reveals a slight difference between them where only the second resonance frequency was decreased by 0.009 GHz while other frequencies were increased by 0.002, 0.045, and 0.117 GHz in sequential order. Moreover, the SAR analysis recorded high values at 3.794 GHz with 61.16% and 70.33% for 1 g and 10 g of tissue volumes, respectively. Overall, our results demonstrate strong SAR reduction effects, and the proposed SM design may be considered a promising aspect in the telecommunication field.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7846749/ or https://www.nature.com/articles/s41598-021-82105-7

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Radiofrequency radiation: A possible threat to male fertility

Himanshi, Umesh Rai, Rajeev Singh. Radiofrequency Radiation: A possible threat to male fertility. Reprod Toxicol. 2021 Jan 23;S0890-6238(21)00021-6. doi: 10.1016/j.reprotox.2021.01.007.

Abstract

Radiofrequency exposure from man-made sources has increased drastically with the era of advanced technology. People could not escape from such RF radiations as they have become the essential part of our routine life such as Wi-Fi, microwave ovens, TV, mobile phones, etc. Although non-ionizing radiations are less damaging than ionizing radiations but its long term exposure effect cannot be avoided. For fertility to be affected, either there is an alteration in germ cell, or its nourishing environment, and RF affects both the parameters subsequently, leading to infertility. This review with the help of in vitro and in vivo studies shows that RF could change the morphology and physiology of germ cells with affected spermatogenesis, motility and reduced concentration of male gametes. RF also results in genetic and hormonal changes. In addition, the contribution of oxidative stress and protein kinase complex after RFR exposure is also summarized which could also be the possible mechanism for reduction in sperm parameters. Further, some preventative measures are described which could help in reverting the radiofrequency effects on germ cells.

https://pubmed.ncbi.nlm.nih.gov/33497741/

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Male cellular telephone exposure, fecundability, and semen quality: results from two preconception cohort studies

E E Hatch, S K Willis, A K Wesselink, E M Mikkelsen, M L Eisenberg, G J Sommer, H T Sorensen, K J Rothman, L A Wise. Male cellular telephone exposure, fecundability, and semen quality: results from two preconception cohort studies. *Human Reproduction*, deab001, 10 February 2021. https://doi.org/10.1093/humrep/deab001

Abstract

STUDY QUESTION To what extent is exposure to cellular telephones associated with male fertility?

SUMMARY ANSWER Overall, we found little association between carrying a cell phone in the front pants pocket and male fertility, although among leaner men (BMI <25 kg/m^2), carrying a cell phone in the front pants pocket was associated with lower fecundability.

WHAT IS KNOWN ALREADY Some studies have indicated that cell phone use is associated with poor semen quality, but the results are conflicting

STUDY DESIGN, SIZE, DURATION Two prospective preconception cohort studies were conducted with men in Denmark (n = 751) and in North America (n = 2349), enrolled and followed via the internet from 2012 to 2020.

PARTICIPANTS/MATERIALS, SETTING, METHODS On the baseline questionnaire, males reported their hours/day of carrying a cell phone in different body locations. We ascertained time to pregnancy via bi-monthly follow-up questionnaires completed by the female partner for up to 12 months or until reported conception. We used proportional probabilities regression models to estimate fecundability ratios (FRs) and 95% confidence intervals (CIs) for the association between male cell phone habits and fecundability, focusing on front pants pocket exposure, within each cohort separately and pooling across the cohorts using a fixed-effect meta-analysis. In a subset of participants, we examined selected semen parameters (semen volume, sperm concentration and sperm motility) using a home-based semen testing kit.

MAIN RESULTS AND THE ROLE OF CHANCE There was little overall association between carrying a cell phone in a front pants pocket and fecundability: the FR for any front pants pocket exposure versus none was 0.94 (95% CI: 0.0.83–1.05). We observed an inverse association between any front pants pocket exposure and fecundability among men whose BMI was <25 kg/m^2 (FR = 0.72, 95% CI: 0.59–0.88) but little association among men whose BMI was ≥25 kg/m^2 (FR = 1.05, 95% CI: 0.90–1.22). There were few consistent associations between cell phone exposure and semen volume, sperm concentration, or sperm motility.

LIMITATIONS, REASONS FOR CAUTION Exposure to radiofrequency radiation from cell phones is subject to considerable non-differential misclassification, which would tend to attenuate the estimates for dichotomous comparisons and extreme exposure categories (e.g. exposure 8 vs. 0 h/day). Residual confounding by occupation or other unknown or poorly measured factors may also have affected the results.

WIDER IMPLICATIONS OF THE FINDINGS Overall, there was little association between carrying one's phone in the front pants pocket and fecundability. There was a moderate inverse association between front pants pocket cell phone exposure and fecundability among men with BMI <25 kg/m^2, but not among men with BMI ≥25 kg/m^2. Although several previous studies have indicated associations between cell phone exposure and lower sperm motility, we found few consistent associations with any semen quality parameters.

STUDY FUNDING/COMPETING INTEREST(S) The study was funded by the National Institutes of Health, grant number R03HD090315. In the last 3 years, PRESTO has received in-kind donations from Sandstone Diagnostics (for semen kits), Swiss Precision Diagnostics (home pregnancy tests), Kindara.com (fertility app), and FertilityFriend.com (fertility app). Dr. L.A.W. is a fibroid consultant for AbbVie, Inc. Dr. H.T.S. reports that the Department of Clinical Epidemiology is involved in studies with funding from various companies as research grants to and administered by Aarhus University. None of these studies are related to the current study. Dr. M.L.E. is an advisor to Sandstone Diagnostics, Ro, Dadi, Hannah, and Underdog. Dr. G.J.S. holds ownership in Sandstone Diagnostics Inc., developers of the Trak Male Fertility Testing System. In addition, Dr. G.J.S. has a patent pending related to Trak Male Fertility Testing System issued.

https://academic.oup.com/humrep/advance-article-abstract/doi/10.1093/humrep/deab001/6132077

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What is the radiation before 5G? A correlation study between measurements in situ and in real time and epidemiological indicators in Vallecas, Madrid

Isabel López, Nazario Félix, Marco Rivera, Adrián Alonso, Ceferino Maestú. What is the radiation before 5G? A correlation study between measurements in situ and in real time and epidemiological indicators in Vallecas, Madrid. Environmental Research. Volume 194, March 2021, 110734.
https://doi.org/10.1016/j.envres.2021.110734.

Highlights

• People who are exposed to higher radiation values present more severe headaches, dizziness and nightmares.

• The methodology for obtaining electromagnetic radiation measurements should be reviewed.
• The population continues to receive radiation peaks in distances greater than 200 m, no one is free from exposure.

Abstract

Background Exposure of the general population to electromagnetic radiation emitted by mobile phone base stations is one of the greater concerns of residents affected by the proximity of these structures due to the possible relationship between radiated levels and health indicators.

Objectives This study aimed to find a possible relationship between some health indicators and electromagnetic radiation measurements.

Methods A total of 268 surveys, own design, were completed by residents of a Madrid neighborhood surrounded by nine telephone antennas, and 105 measurements of electromagnetic radiation were taken with a spectrum analyzer and an isotropic antenna, in situ and in real – time, both outside and inside the houses.

Results It was shown statistically significant p - values in headaches presence ($p = 0.010$), nightmares ($p = 0.001$), headache intensity ($p < 0.001$), dizziness frequency ($p = 0.011$), instability episodes frequency ($p = 0.026$), number of hours that one person sleeps per day ($p < 0.001$) and three of nine parameters studied from tiredness. Concerning cancer, there are 5.6% of cancer cases in the study population, a percentage 10 times higher than that of the total Spanish population.
Discussion: People who are exposed to higher radiation values present more severe headaches, dizziness and nightmares. Moreover, they sleep fewer hours.

https://www.sciencedirect.com/science/article/abs/pii/S0013935121000281

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Association between the pattern of mobile phone use and sleep quality in Northeast China college students

Jia Meng, Fang Wang, Rentong Chen, Hui Hua, Qian Yang, Dan Yang, Nan Wang, Xin Li, Fangfang Ma, Liting Huang, Zhenzhen Zou, Menglin Li, Tieting Wang, Yannan Luo, Yunda Li, Yang Liu. Association between the pattern of mobile phone use and sleep quality in Northeast China college students. Sleep Breath. 2021 Feb 2. doi: 10.1007/s11325-021-02295-2.

Abstract

Objectives: Currently, mobile penetration is high amongst college students. The aims of this study were to investigate the characteristics of mobile phone use and to explore the influence of mobile phone use characteristics on sleep quality amongst college students.

Methods: From December 2016 to January 2017, we collected mobile phone use characteristics and sleep quality data using the Pittsburgh Sleep Quality Index (PSQI) and standardised questionnaires that were

answered by 4500 medical university students in Liaoning Province (actual response rate of 94%, n = 4234 college students). This study used the SPSS 21.0 software to establish the database and perform the statistical analysis.

Results: One hundred percent of the college students had mobile phones and used mobile phones for entertainment (91%), work (51%), obtaining information (61%), and other purposes (23%). Additionally, there was a statistically significant difference in the PSQI score between students who held the phone at a distance of more than 10 cm from their eyes and those who held it a distance of less than 10 cm (P = 0.002). Multiple logistic regression analysis showed that the risk of poor sleep quality was 1.21-1.53 times higher for those who spent more than 5 h a day using their phones and 1.41-1.59 times higher for those who used their phones for more than half an hour before going to bed when the lights were off.

Conclusions: Daily cumulative mobile phone use and use with the lights off before sleep are associated with poorer sleep quality.

https://pubmed.ncbi.nlm.nih.gov/33532989/

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The Effect of Continuous Low-Intensity Exposure to Electromagnetic Fields from Radio Base Stations to Cancer Mortality in Brazil

Nádia Cristina Pinheiro Rodrigues, Adilza Condessa Dode, Mônica Kramer de Noronha Andrade, Gisele O'Dwyer, Denise Leite Maia Monteiro, Inês Nascimento Carvalho Reis, Roberto Pinheiro Rodrigues, Vera Cecília Frossard, Valéria Teresa Saraiva Lino. The Effect of Continuous Low-Intensity Exposure to Electromagnetic Fields from Radio Base Stations to Cancer Mortality in Brazil. Int J Environ Res Public Health. 2021 Jan 29;18(3):1229. doi: 10.3390/ijerph18031229.

Abstract

Background: this study aims to estimate the rate of death by cancer as a result of Radio Base Station (RBS) radiofrequency exposure, especially for breast, cervix, lung, and esophagus cancers.

Methods: we collected information on the number of deaths by cancer, gender, age group, gross domestic product per capita, death year, and the amount of exposure over a lifetime. We investigated all cancer types and some specific types (breast, cervix, lung, and esophagus cancers).

Results: in capitals where RBS radiofrequency exposure was higher than 2000/antennas-year, the average mortality rate was 112/100,000 for all cancers. The adjusted analysis showed that, the higher the exposure to RBS radiofrequency, the higher cancer mortality was. The highest adjusted risk was observed for cervix cancer (rate ratio = 2.18). The spatial analysis showed that the highest RBS radiofrequency exposure was observed in a city in southern Brazil that also showed the highest mortality rate for all types of cancer and specifically for lung and breast cancer.

Conclusion: the balance of our results indicates that exposure to radiofrequency electromagnetic fields from RBS increases the rate of death for all types of cancer.

Open access paper: https://www.mdpi.com/1660-4601/18/3/1229

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Sonic Health Attacks by Pulsed Microwaves in Havana Revisited [Health Matters]

James C. Lin. Sonic Health Attacks by Pulsed Microwaves in Havana Revisited [Health Matters]. IEEE Microwave Magazine. 22(3):71-73, March 2021. doi: 10.1109/MMM.2020.3044125.

Abstract

Presents the results of the U.S. National Academies of Sciences, Engineering, and Medicine (NASEM) report, “An Assessment of Illness in U.S. Government Employees and Their Families at Overseas Embassies." it is almost exactly three years since the publication of my article “Strange Reports of Weaponized Sound in Cuba” [2]. There, it was first hypothesized that “[a]ssuming that the reported events are reliable, there is actually a scientific explanation for the source of sonic energy. It could well be from a targeted beam of high-power microwave pulse radiation” [2]. In examining plausible causes of the described illnesses, the NASEM report makes that point that, among the mechanisms the study committee considered, the most plausible mechanism to explain these cases, especially in individuals with distinct early symptoms, appears to be directed, pulsed RF (microwave) energy.

https://ieeexplore.ieee.org/document/9343783

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Notice of Retraction and Replacement. Li et al. Association Between Maternal Exposure to Magnetic Field Nonionizing Radiation During Pregnancy and Risk of Attention-Deficit/Hyperactivity Disorder in Offspring in a Longitudinal Birth Cohort

De-Kun Li. Notice of Retraction and Replacement. Li et al. Association Between Maternal Exposure to Magnetic Field Nonionizing Radiation During Pregnancy and Risk of Attention-Deficit/Hyperactivity Disorder in Offspring in a Longitudinal Birth Cohort. Letter: February 18, 2021. JAMA Netw Open. 2020;3(3):e201417

To the Editor On behalf of my coauthors, I write to report a concern raised about the methods and analyses for the Original Investigation, “Association Between Maternal Exposure to Magnetic Field Nonionizing Radiation During Pregnancy and Risk of Attention-Deficit/Hyperactivity Disorder in Offspring in a Longitudinal Birth Cohort,”1 that was published in JAMA Network Open on March 24, 2020. The concern was brought to the attention of the journal editors by a reader and the editors forwarded this concern to us. After discussion and assessment, we have determined that there were errors in the statistical analyses, which required use of different analyses and which result in changes to some of the original findings and limitations to the interpretations of this study. As a result, the editors have asked us to retract and replace this article.

This study was conducted to determine whether maternal exposure to high levels of magnetic field (MF) nonionizing radiation was associated with an increased risk of attention-deficit/hyperactivity disorder (ADHD) in offspring by using measurements of MF nonionizing radiation levels and physician-diagnosed ADHD. We included a longitudinal birth cohort of 1482 mother-child pairs whose mothers were participants of an existing birth cohort and whose level of exposure to MF nonionizing radiation was captured by wearing a monitor for 24 hours during pregnancy in 2 previous studies conducted from October 1, 1996, to October 31, 1998, and from May 1, 2006, to February 29, 2012.

To examine the association of high levels of MF nonionizing radiation with risk of ADHD, we used the 90th percentile of the 24-hour measurements as the MF index, which reflects the MF nonionizing radiation level at or above which a participant was exposed for 10% of the time during the day. We had originally classified participating mother-child dyads into low or high MF nonionizing radiation exposure groups based on the experience of previous studies. 2-4 However, we erroneously reported using a 1.3-mG cut point based on the 25th percentile of the MF index's distribution. And we then conducted analyses with participants dichotomized to a low exposure level (those whose MF nonionizing radiation level was <1.3 mG) or a high exposure level (those whose MF nonionizing radiation level was ≥1.3 mG). These analyses led to the conclusions that "in utero exposure to high levels of MF nonionizing radiation was associated with an increased risk of ADHD, especially ADHD with immune-related comorbidity." 1

At the request of the editors, we have conducted new analyses based on continuous MF exposure levels as well as analyses based on categorical MF exposure levels, without using a cut point level. We have also conducted a dose-response analysis based on the categorical exposure levels with increased MF exposure levels being compared with the same reference group because a dose-response association is commonly examined in epidemiological studies.

With these new analyses, we continue to find in utero exposures to some, but not all, high levels of MF nonionizing radiation were associated with a higher risk of ADHD. However, the associations observed were inconsistent and nonlinear, limiting interpretations. Thus, changes are needed to the original article, including the following:

We removed the cut point–based results in the original Table 1 and replaced the data using mean (SD) based on continuous MF exposure levels. Tables 2 through 4, which previously reported findings based on dichotomous low and high MF exposure levels, have been replaced with findings from the analysis using continuous measure and categorical levels of MF exposure. We also replaced the eTable in Supplement 1 with similar analyses.

We have added an eFigure in Supplement 2 showing the findings of the dose-response analysis between MF exposure in quintiles of mother-child dyads and the risk of ADHD. In addition, we have replaced the original dichotomized Kaplan-Meier survival curve with multicategorical Kaplan-Meier survival curves for multiple maternal exposure levels.

Finally, we have added to the Discussion section the following limitations: "no corrections were made for

multiple comparisons and for many of the significant associations observed among children with ADHD and concurrent immune-related comorbidities, the CIs were wide, indicating that these findings should be interpreted with caution."

On behalf of my coauthors, I apologize for any confusion this has caused readers and have requested that the original article be retracted and replaced with a corrected version. The corrections affect the Abstract, text, Tables, Figure, and Supplement 1. The replacement article includes new supplements with a copy of the original article with the errors highlighted and another copy with the corrections highlighted.

Open access paper: https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2776553

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Associations between artificial light at night and risk for thyroid cancer: A large US cohort study

Dong Zhang, Rena R Jones, Peter James, Cari M Kitahara, Qian Xiao. Associations between artificial light at night and risk for thyroid cancer: A large US cohort study. Cancer. 2021 Feb 8. doi: 10.1002/cncr.33392.

Abstract

Background: Light at night (LAN) inhibits nighttime secretion of melatonin and may cause circadian disruption, which may be a risk factor for cancer. Recent studies have linked high LAN exposure with elevated breast cancer risk. Given that breast cancer may share a common hormone-dependent etiology with thyroid cancer and that circadian rhythms play a role in regulating thyroid function, the authors hypothesized that exposure to LAN is positively associated with thyroid cancer incidence.

Methods: This study examined the association between LAN and thyroid cancer incidence in the National Institutes of Health-American Association of Retired Persons Diet and Health Study. LAN exposure was estimated from satellite data and was linked to residential addresses at the baseline. Incident thyroid cancer cases were ascertained via linkage to state cancer registries. Cox regression was used to determine the relationship between LAN and thyroid cancer risk, with adjustments made for sociodemographic, lifestyle, and other environmental factors.

Results: Among 464,371 participants, a positive association was found between LAN and thyroid cancer risk. Specifically, in comparison with the lowest quintile of LAN, the highest quintile was associated with a 55% increase in risk (hazard ratio [HR], 1.55; 95% confidence interval [CI], 1.18-2.02). The association was primarily driven by papillary thyroid cancer and was stronger in women (HR, 1.81; 95% CI, 1.26-2.60) than men (HR, 1.29; 95% CI, 0.86-1.94). In women, the association was stronger for localized cancer, whereas in men, the association was stronger for a more advanced stage. Results were consistent across different tumor sizes.

Conclusions: LAN was positively associated with thyroid cancer risk. Future studies are needed to confirm this association and identify underlying biological mechanisms.

https://pubmed.ncbi.nlm.nih.gov/33554351/

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Effects of selective outcome reporting on risk perception

F Freudenstein, R J Croft, S P Loughran, B M Zeleke, P M Wiedemann. Effects of selective outcome reporting on risk perception. Environ Res. 2021 Feb 3;110821. doi: 10.1016/j.envres.2021.110821.

Highlights

• An experimental study investigated how selective reporting of study results - indicating increased health effects - influenced its receiver's risk perception.
• Selective reporting of risk information increased risk perception when compared to receiving the full information.
• Selectively informed subjects revealed a stronger tendency towards overgeneralization of health risks.
• The results indicate that reporting of full study results is an important factor in effective risk communication.

Abstract

The current study aimed to investigate how selective reporting of study results indicating increased health effects will influence its receiver's risk perception. Using the example of the Interphone Study from 2010 on mobile phone usage and cancer, an online experiment was conducted separating respondents into two groups. One group of subjects was informed selectively about a relationship between heavy mobile phone use and an elevated risk of glioma (brain cancer) only. The other group of subjects was informed about the full results of the analyses of glioma risk by cumulative call time, which suggests that other than for the heavy users, there were no statistically significant elevated risks related to mobile phone use. The results showed that selective reporting of risk information increased risk perception when compared to receiving the full information. Additionally, the selectively informed subjects revealed a stronger tendency towards overgeneralization of the 'elevated brain cancer risk' to all mobile phone users, although this did not extend to an overgeneralization to other electromagnetic field sources or differences in the perception of a usage time dependency for possible health risks. These results indicate that reporting of full results is an important factor in effective risk communication.

https://pubmed.ncbi.nlm.nih.gov/33548295/https://pubmed.ncbi.nlm.nih.gov/33548295/

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Electromagnetic radiation as an emerging driver factor for the decline of insects

Alfonso Balmori. Electromagnetic radiation as an emerging driver factor for the decline of insects. Sci Total Environ. Available online 28 January 2021, 144913. https://doi.org/10.1016/j.scitotenv.2020.

Highlights

• Biodiversity of insects is threatened worldwide
• This reductions is mainly attributed to agricultural practice and pesticide use
• There is sufficient evidence on the damage caused by electromagnetic radiation
• Electromagnetic radiation may be a complementary driver in this decline
• The precautionary principle should be applied before any new deployment (e.g. 5G)

Abstract

The biodiversity of insects is threatened worldwide. Numerous studies have reported the serious decline in insects that has occurred in recent decades. The same is happening with the important group of pollinators, with an essential utility for pollination of crops. Loss of insect diversity and abundance is expected to provoke cascading effects on food webs and ecosystem services. Many authors point out that reductions in insect abundance must be attributed mainly to agricultural practices and pesticide use. On the other hand, evidence for the effects of non-thermal microwave radiation on insects has been known for at least 50 years. The review carried out in this study shows that electromagnetic radiation should be considered seriously as a complementary driver for the dramatic decline in insects, acting in synergy with agricultural intensification, pesticides, invasive species and climate change. The extent that anthropogenic electromagnetic radiation represents a significant threat to insect pollinators is unresolved and plausible. For these reasons, and taking into account the benefits they provide to nature and humankind, the precautionary principle should be applied before any new deployment (such 5G) is considered.

Excerpt

The precautionary principle and the importance of seriously considering EMR as a factor of insect decline.

Despite the strong scientific evidence of the negative impacts of electromagnetic radiation on insects, a recent study funded by the European Union's Horizon 2020 Research and Innovation Programme (EKLIPSE) stated that our current knowledge concerning the impact of anthropogenic RF-EMR on pollinators (and other invertebrates) is inconclusive (Vanbergen et al., 2019). Thus, the extent to which anthropogenic EMR represents a significant threat to insect pollinators is unresolved. For these reasons, and taking into account the benefits they provide to nature and humankind, the precautionary principle of the European Union (Communication from the Commission on the Precautionary Principle, 2000) should be applied.

The potential effects of RF-EMFs on most taxonomic groups, including migratory birds, bats and insects, are largely unknown, and the potential effects on wildlife could become more relevant with the expected adoption of new mobile network technology (5G), raising the possibility of unintended biological consequences (Sutherland et al., 2018). Thus, before any new deployment (such 5G) is considered, its effects should be clearly assessed, at least while conclusions are drawn and these existing uncertainties are overcome, according to the official document ‘Late Lessons of EarlyWarnings’ (European Environment Agency, 2013).

A letter by the United States Department of the Interior sent to the National Telecommunications and Information Administration in the Department of Commerce warns about the scarcity of studies carried out on the impacts from non-ionising EMR emitted by communication towers (United States Department of the

Interior, 2014). The precise potential effects of increases in EMR on wildlife, which are not yet well recognised by the global conservation community, have been identified as an important emerging issue for global conservation and biological diversity (Sutherland et al., 2018). Thus, aswe have explained in this review, EMR should be seriously considered as a complementary driver for the dramatic decline in insects in recent studies, acting in synergy with agricultural intensification, pesticides, invasive species and climate change.

https://www.sciencedirect.com/science/article/abs/pii/S0048969720384461

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Biological Effects of Exposure to a Radiofrequency Electromagnetic Field on the Placental Barrier in Pregnant Rats

Hye Sun Kim, Hyung-Do Choi, Jeong-Ki Pack, Nam Kim, Young Hwan Ahn. Biological Effects of Exposure to a Radiofrequency Electromagnetic Field on the Placental Barrier in Pregnant Rats. Bioelectromagnetics. 2021 Feb 1. doi: 10.1002/bem.22322.

Abstract

The placenta protects the fetus against excessive stress-associated maternal cortisol during pregnancy. We studied whether exposure to radiofrequency electromagnetic field (RF-EMF) radiation during pregnancy can cause changes in dams and their placentas. Pregnant Sprague-Dawley rats were divided into cage-control, sham-exposed, and RF-exposed groups. They were exposed to RF-EMF signals at a whole-body specific absorption rate of 4 W/kg for 8 h/day from gestational Day 1 to 19. Levels of cortisol in the blood, adrenal gland, and placenta were measured by enzyme-linked immunosorbent assay. Levels of adrenocorticotropic hormone and corticotropin-releasing hormone were monitored in maternal blood. Expression levels of placental 11β-hydroxysteroid dehydrogenase type 2 (11β-HSD2) messenger RNA (mRNA) were measured by reverse transcription polymerase chain reaction. Morphological changes in the placenta were analyzed using hematoxylin and eosin staining. Fetal parts of the placenta were measured using Zen 2.3 blue edition software. Maternal cortisol in circulating blood (RF: 230 ± 24.6 ng/ml and Sham: 156 ± 8.3 ng/ml) and the adrenal gland (RF: 58.3 ± 4.5 ng/ml and Sham: 30 ± 3.8 ng/ml) was significantly increased in the RF-exposed group ($P < 0.05$). Placental cortisol was stably maintained, and the level of placental 11β-HSD2 mRNA expression was not changed in the RF-exposed group. RF-EMF exposure during pregnancy caused a significant elevation of cortisol levels in circulating blood; however, no changes in the placental barrier were observed in pregnant rats.

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Analyzing the impact of 900 MHz EMF short-term exposure to the expression of 667 miRNAs in human peripheral blood cells

Andreas Lamkowski, Matthias Kreitlow, Jörg Radunz, Martin Willenbockel, Marcus Stiemer, Lars Ole Fichte, Carl Friedrich Rädel, Matthäus Majewski, Patrick Ostheim, Matthias Port, Michael Abend. Analyzing the impact of

900 MHz EMF short-term exposure to the expression of 667 miRNAs in human peripheral blood cells. Sci Rep. 2021 Feb 24;11(1):4444. doi: 10.1038/s41598-021-82278-1.

Abstract

More than ever before, people around the world are frequently exposed to different sections of the electromagnetic spectrum, mainly emitted from wireless modern communication technologies. Especially, the level of knowledge on non-thermal biological EMF effects remains controversial. New technologies allow for a more detailed detection of non-coding RNAs which affect the post-transcriptional control. Such method shall be applied in this work to investigate the response of human blood cells to electromagnetic irradiation. In this ex vivo in vitro study, we exposed peripheral blood cells from 5 male donors to a continuous wave of 900 MHz EMF for 0, 30, 60 and 90 min. Significant micro RNA (miRNA) expression changes ($p \leq 0.05$) above or below the SHAM exposed samples were evaluated using a quantitative real time PCR platform for simultaneous detection of 667 miRNAs called low density array. Only significant miRNA expression changes which were detectable in at least 60% of the samples per exposure group were analyzed. The results were compared with data from room temperature + 2 °C (RT + 2 °C) samples (here referred to as hyperthermia) to exclude miRNA expression altered by hyperthermia. The validation study by using the same donors and study design was performed after an interval of 2 years. When analyzing a total of 667 miRNAs during the screening study, 2 promising candidate miRNAs were identified, which were down regulated almost twice and showed a complete separation from the unexposed control group (miR-194 at 30 min and miR-939 at 60 min). The p-values even survived the Bonferroni correction for multiple comparisons ($p = 0.0007$ and $p = 0.004$, respectively). None of these miRNAs were expressed at a second time point after EMF exposure. Following an alternative analysis approach, we examined for miRNAs revealing an expected significant association of differential miRNA expression with the dose-time EMF exposure product, separately for each donor. Donors 2 and 3 revealed 11 and 10 miRNA species being significantly associated with EMF exposure which differed significantly from the other donors showing a minor number of differentially expressed miRNAs and could identify donors 2 and 3 as particularly EMF-responsive. The measurements were repeated after 2 years. The number of expressed/non-expressed miRNAs was almost similar (97.4%), but neither the number nor the previously differentially expressed miRNAs could be reproduced. Our data neither support evidence of early changes at miRNA expression level in human whole blood cells after 900 MHz EMF exposure nor the identification of EMF-responsive individuals.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7904780/

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Chronic exposure to 2.45 GHz microwave radiation improves cognition and synaptic plasticity impairment in vascular dementia model

Mahnaz Bayat, Narges Karimi, Mohammad Karami, Afshin Borhani Haghighi, Kamjoo Bayat, Somayeh Akbari, Masoud Haghani. Chronic exposure to 2.45 GHz microwave radiation improves cognition and synaptic plasticity impairment in vascular dementia model. Int J Neurosci. 2021 Feb 26;1-13. doi: 10.1080/00207454.2021.1896502.

Abstract

In this study, we evaluated the effects of 2.45 GHz microwave radiation on cognitive dysfunction induced by vascular dementia (VaD). The VaD was induced by bilateral-common carotid occlusion (2-VO). The rats were divided into 4 groups including: control (n = 6), sham (n = 6), 2-VO (n = 8), and 2-VO + Wi-Fi (n = 10) groups. Wi-Fi modem centrally located at the distance of 25 cm from the animal's cages and the animals were continuously exposed to Wi-Fi signal while they freely moved in the cage (2 h/day for forty-five days). Therefore, the power density (PD) and specific absorption rate value (SAR) decreased at a distance of 25 to 60 cm (PD =0.018 to 0.0032 mW/cm2, SAR =0.0346 to 0.0060 W/Kg). The learning, memory, and hippocampal synaptic-plasticity were evaluated by radial arm maze (RAM), passive avoidance (PA), and field-potential recording respectively. The number of hippocampal CA1 cells was also assessed by giemsa-staining.Our results showed that VaD model led to impairment in the spatial learning and memory performance in RAM and PA that were associated with long-term potentiation (LTP) impairment, decrease of basal-synaptic transmission (BST), increase of GABA transmission, and decline of neurotransmitter release-probability as well as hippocampal cell loss. Notably, chronic Wi-Fi exposure significantly recovered the learning-memory performance, LTP induction, and cell loss without any effect on BST. The LTP recovery by Wi-Fi in the 2-VO rats was probably related to significant increases in the hippocampal CA1 neuronal density, partial recovery of neurotransmitter release probability, and reduction of GABA transmission as evident by rescue of paired-pulse ratio 10ms.

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Histopathological and epigenetic alterations in the spinal cord due to prenatal electromagnetic field exposure: An H3K27me3-related mechanism

Ayşe İkinci Keleş, Burcu Biterge Süt. Histopathological and epigenetic alterations in the spinal cord due to prenatal electromagnetic field exposure: An H3K27me3-related mechanism. Toxicol Ind Health. 2021 Feb 23. doi: 10.1177/0748233721996947.

Abstract

Neural system development is one of the most important stages of embryogenesis. Perturbations in this crucial process due to genetic and environmental risk factors cause neural tube defects and other central nervous system diseases. We investigated the effects of prenatal exposure to 900-MHz electromagnetic field (EMF) on the spinal cord. Pregnant rats were exposed to 900-MHz EMF for 1 h/day from E13.5 until birth. Six pups from the control and EMF groups were sacrificed at postnatal day 32, and the upper thoracic region of the spine was removed and processed for histological procedures. For histopathological analyses, hematoxylin&eosin staining and, for stereological analyses and the quantitation of motor neurons, cresyl violet staining was performed. H3K27me3 levels were determined via immunofluorescence staining. Histopathological analysis identified structural alterations of ependymal cells, enlarged central canals, as well as degenerated and shrunken motor neurons in the EMF group, while the control group tissues had normal appearances. We also observed enrichment of H3K27me3 in the ependymal cells and the motor neurons in the spinal cord of the control group

rats, while the EMF group had low levels of H3K27me3 staining. Our results suggest that the loss of H3K27me3 signals might correlate with reduced neuronal stem cell potential in the EMF group and result in anatomical and structural differences in the spinal cord. This study provided a comprehensive histopathological analysis of the spinal cord after prenatal EMF exposure and offered an H3K27me3-dependent molecular explanation for the detrimental effects of EMF exposure on the spine.

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An Evaluation of the Genotoxic Effects of Electromagnetic Radiation at 900 MHz, 1800 MHz, and 2100 MHz Frequencies with a SMART Assay in Drosophila melanogaster

Merve Gunes, Kayhan Ates, Burcin Yalcin, Sibel Akkurt, Sukru Ozen, Bulent Kaya. An Evaluation of the Genotoxic Effects of Electromagnetic Radiation at 900 MHz, 1800 MHz, and 2100 MHz Frequencies with a SMART Assay in Drosophila melanogaster. Electromagn Biol Med. 2021 Feb 24;1-10. doi: 10.1080/15368378.2021.1878210.

Abstract

With the development of today's technology, the electromagnetic radiation spread by mobile phones and base stations is also rapidly increasing, and this causes serious concerns about the environment and human health. The Drosophila model organism is widely used in genetic toxicology studies because its genome is highly similar to the genes identified in human diseases. In this study, the genotoxic effects of radiofrequency electromagnetic radiation were evaluated by the wing Somatic Mutation and Recombination Test (SMART) in Drosophila melanogaster at 900 MHz, 1800 MHz, and 2100 MHz. The SMART method is based on the observation of genetic changes occurring in the trichomes of the Drosophila wings appearing as mutant clones under the microscope. Throughout the study, total clone parameters were evaluated by exposing the Drosophila larvae to electromagnetic fields for two, four, and six hours per day for two days. As a result of the study, it was observed that the number of mutant clones was statistically increased according to the negative control group in all applications except for the six-hour application at 1800 MHz.

https://pubmed.ncbi.nlm.nih.gov/33622140/

Conclusion

... To summarise, this article includes data on Drosophila larvae exposure to RF-EMR at 900 MHz, 1800 MHz, and 2100 MHz for evaluating genotoxicity by virtue of the SMART test. Even if the six-hour experiment’s results at 1800 MHz showed no statistical significance, the rest of the obtained results showed that the number of mutant clones was increased as compared with the negative control group. Also, experimental results showed that the effects of RF-EMR depend on the exposed electrical field, the frequency, and the span between *D. melanogaster* and the antenna.

Studies have shown that EMR can induce various types of cancer and can cause DNA damage (Brainard et al. 1999; Hardell and Sage 2008; Phillips et al. 2009). In addition, there are experimental studies in the production

of ROS which have shown no significant results in apoptosis (Hou et al. 2015). Although studies have shown that EMR has a genotoxic effect, the opposite results have also been observed (Liu et al. There are contradictions in the studies on the biological effects of EMR (Lonn et al. 2005; Cao et al. 2009). This suggests that various cell lines or different systems may have different results. To our knowledge, this is the first study in which the genotoxic effects of the 900 MHz, 1800 MHz, and 2100 MHz radiofrequencies have been studied in *D. melanogaster*. Today, extensive studies are needed to demonstrate the toxicity of RF-EMF (Vila et al. 2018).

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Genotoxicity of radiofrequency electromagnetic fields: Protocol for a systematic review of in vitro studies

Stefania Romeo, Olga Zeni, Anna Sannino, Susanna Lagorio, Mauro Biffoni, Maria Rosaria Scarfì. Genotoxicity of radiofrequency electromagnetic fields: Protocol for a systematic review of in vitro studies. Environ Int. 2021 Jan 21;148:106386. doi: 10.1016/j.envint.2021.106386.

Abstract

Background: Exposure to radiofrequency electromagnetic fields (RF-EMF, 100 kHz - 300 GHz) emitted by wireless communication technologies is pervasive and ubiquitous. Concern has been raised about possible adverse effects to human health. In 2011 the International Agency for Research on Cancer has classified RF-EMF as possibly carcinogenic to humans, highlighting that the evidence is weak and far from conclusive. Updated systematic reviews of the scientific literature on this topic are lacking, especially for mechanistic studies.

Objectives: To develop a protocol for a systematic review of experimental studies investigating genotoxic effects induced by RF-EMF in in vitro cellular models. Genotoxicity is one of the key-biological indicators of carcinogenicity, and the most common characteristics of established carcinogens. The predefined procedures for conducting the systematic review are outlined below.

Methods: We will follow the guidelines developed by the National Toxicology Program-Office of Health Assessment and Translation (NTP-OHAT), adapted to the evaluation of in vitro studies.

Eligibility criteria: We will include experimental in vitro studies addressing the relationship between controlled exposures to RF-EMF and genotoxicity in mammalian cells only. Eligibility for inclusion will be further restricted to peer reviewed articles reporting findings from primary studies.

Information sources: We will search the scientific literature databases NCBI PubMed, Web of Science, and EMF-Portal. No filter on publication date will be applied. Only studies published in English will be considered. The reference lists of the included papers and available reviews will be screened for unidentified relevant papers. References will be managed through Endnote X9 software.

Data extraction and synthesis of results: Data from included papers will be extracted according to predefined forms. Heterogeneity within the available evidence will determine the type of evidence synthesis that is appropriate. Findings will be summarized in tables, graphical displays and in a narrative synthesis of the available evidences. A meta-analysis will be carried out if subgroups of studies homogeneous in terms of

exposure characteristics, endpoint, and cell types will be identified.

Risk of bias: The internal validity of included studies will be assessed using the NTP-OHAT Risk of Bias Rating Tool for animal studies, adapted to in vitro studies. This stage of the process will be managed through the Health Assessment Workspace Collaborative (HAWC).

Evidence appraisal: To rate confidence in the body of evidence, we will use the OHAT GRADE-based approach for animal studies.

Framework and funding: This protocol concerns one of the evidence streams considered in a larger systematic review of the scientific literature on the potential carcinogenicity of RF-EMF, performed by scientists from several Italian public research agencies. The project is supported by the Italian Workers' Compensation Authority (INAIL) in the framework of the CRA with the Istituto Superiore di Sanità "BRiC 2018/06 - Scientific evidence on the carcinogenicity of radiofrequency electromagnetic fields".

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Effects of Non-Ionizing Electromagnetic Pollution on Invertebrates, Including Pollinators Such as Honey Bees: What We Know, What We Don't Know, and What We Need to Know

Friesen M, Havas M. 2020. Effects of Non-Ionizing Electromagnetic Pollution on Invertebrates, Including Pollinators Such as Honey Bees: What We Know, What We Don't Know, and What We Need to Know." Pages 127-138 In Working Landscapes. Proceedings of the 12th Prairie Conservation and Endangered Species Conference, February 2019, Winnipeg, Manitoba. Edited by D. Danyluk. Critical Wildlife Habitat Program, Winnipeg, Manitoba. http://pcesc.ca/media/45404/final-2019-pcesc-proceedings.pdf.

Abstract

Invertebrates, including pollinators such as honey bees, can be adversely affected by non-ionizing electromagnetic radiation (EMR). Sources contributing to common environmental EMR exposures include antennae (cell phone, broadcast, and radar), communications satellites, and power lines. Adverse biochemical changes and disorientation have been reported for honey bees and other invertebrates. Field studies have reported changes in abundance and composition of "key pollinator groups" (wild bees, hoverflies, bee flies, beetles, and wasps) that have been attributed to emissions from telecommunications towers. We take a close look at the biological effects on invertebrates of EMR reported in the scientific literature and a general look at evidence from studies on plants, birds, humans, and other animals (domestic, laboratory, wild). We discuss possible implications of excessive electromagnetic pollution on ecosystems and identify knowledge gaps and what we need to know before more electromagnetic pollution is added to the environment, especially in the form of 5G.

Introduction

Invertebrates (animals without backbones) are major components of most ecosystems. Insects are key to the integrity of many ecosystems in many roles including as pollinators. Honey bees play a role in pollination of domestic as well as wild plants and are often used as bio-indicator species and as a “model” to examine environmental problems. The global decline of pollinators is of grave concern and efforts are being made to identify the reasons (Potts et al. 2010; Sánchez-Bayo and Wyckhuys 2019). One factor not widely considered is the possible role of anthropogenic electromagnetic radiation (EMR).

Electromagnetic fields (EMFs) are invisible electric and magnetic fields of force. All living organisms have evolved in Earth’s natural EMFs and depend on them to live. Natural sources include Earth’s static magnetic field, and static electricity, including differences in charges among clouds and the earth that can lead to lightning. Electromagnetic radiation (EMR) originates when fields change.

Anthropogenic (human-made, artificial) EMR sources are sometimes referred to as electromagnetic pollution or electrosmog. The main frequency ranges of interest in this article are: 1) extremely low frequencies (ELF) of 50/60 to 90 Hz that emanate from sources such as power lines and building wiring; and 2) radiofrequency radiation (RFR) of 700 MHz to 6 GHz, commonly used for devices such as cell phones, radio and television, and their supporting infrastructure, e.g., cell towers, antennae on buildings, and orbiting communications satellites. Also discussed are frequencies currently being developed and deployed above 6 GHz for 5G (5th Generation) for faster and more pervasive connectivity, including the “Internet of Things”.

http://pcesc.ca/media/45404/final-2019-pcesc-proceedings.pdf

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Effects of electromagnetic field (EMF) radiation on androgen synthesis and release from the pig endometrium during the fetal peri-implantation period

Wiktoria Kozlowska, Ewa Monika Drzewiecka, Agata Zmijewska, Anna Koziorowska, Anita Franczak. Effects of electromagnetic field (EMF) radiation on androgen synthesis and release from the pig endometrium during the fetal peri-implantation period. Anim Reprod Sci. 2021 Jan 21;226:106694. doi: 10.1016/j.anireprosci.2021.106694.

Abstract

An electromagnetic field (EMF) may have effects on female reproduction. This study was conducted to determine whether EMF [50 and 120 Hz, 2 and 4 h of incubation in the presence or absence of progesterone (P4, 10-5 M)] affects androgen synthesis and release from the pig endometrium. Endometrial slices were collected from pigs (n = 5) during the fetal peri-implantation period (i.e., days 15-16 of gestation) and treated in vitro with EMF. The selected endometrial slices were treated with P4 to determine whether this hormone has effects on protection of the tissue from EMF radiation. The CYP17A1 and HSD3B1 mRNA transcript abundance, steroid 17αhydroxylase/17, 20-lyase (cytochrome P450c17) and hydroxyΔ5steroid dehydrogenase/3β and steroidΔisomerase (3βHSD) protein abundance were examined using Real-Time PCR and Western Blot procedures, respectively. In media collected after incubation, the concentrations of androstenedione (A4) and

testosterone (T) were quantified used a RIA. When P4 was added to the culture medium, EMF radiation had suppressive effects on endometrial T release after 2 and 4 h of incubation when the EMF treatment was occurring and increased A4 release after 4 h of incubation with EMF at 120 Hz. When there was no inclusion of P4, release of A4 was decreased after 2 h of EMF treatment at 120 Hz and after 4 h of EMF treatment at 50 and 120 Hz. Progesterone did not have functions that protected the pig endometrium against EMF radiation during the fetal peri-implantation period.

https://pubmed.ncbi.nlm.nih.gov/33486154/

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Changes in Honeybee Behavior Parameters under the Influence of the E-Field at 50 Hz and Variable Intensity

Paweł Migdał, Agnieszka Murawska, Paweł Bieńkowski, Ewelina Berbeć, Adam Roman. Changes in Honeybee Behavior Parameters under the Influence of the E-Field at 50 Hz and Variable Intensity. Animals (Basel). 2021 Jan 20;11(2):E247. doi: 10.3390/ani11020247.

Abstract

EM-fields come from both natural and anthropogenic sources. This study aimed to investigate changes in honeybee behavior parameters under the influence of an electric field at 50 Hz and variable intensity. Bees were exposed for 1 h, 3 h, or 6 h to the following artificial E-field intensities: 5.0 kV/m, 11.5 kV/m, 23.0 kV/m, or 34.5 kV/m. Bees in the control group were under the influence of an E-field <2.0 kV/m. Six basic behaviors were selected for bee observation (walking, grooming, flight, stillness, contact between individuals, and wing movement). Our research shows the impact of bee exposure time on behavioral change within groups. Exposure for 3 h caused a decrease in the time that bees spent on behaviors and in the number of occurrences. After 6 h, the parameters increased within the groups, as was the case with 1 h exposure. This may indicate that there is a behavioral barrier that allows the pattern to normalize for some time.

Open access paper: https://www.mdpi.com/2076-2615/11/2/247

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The Effect of an Anthropogenic Magnetic Field on the Early Developmental Stages of Fishes-A Review

Krzysztof Formicki, Agata Korzelecka-Orkisz, Adam Tański. The Effect of an Anthropogenic Magnetic Field on the Early Developmental Stages of Fishes-A Review. Int J Mol Sci. 2021 Jan 26;22(3):1210. doi: 10.3390/ijms22031210.

Abstract

The number of sources of anthropogenic magnetic and electromagnetic fields generated by various underwater

facilities, industrial equipment, and transferring devices in aquatic environment is increasing. These have an effect on an array of fish life processes, but especially the early developmental stages. The magnitude of these effects depends on field strength and time of exposure and is species-specific. We review studies on the effect of magnetic fields on the course of embryogenesis, with special reference to survival, the size of the embryos, embryonic motor function, changes in pigment cells, respiration hatching, and directional reactions. We also describe the effect of magnetic fields on sperm motility and egg activation. Magnetic fields can exert positive effects, as in the case of the considerable extension of sperm capability of activation, or have a negative influence in the form of a disturbance in heart rate or developmental instability in inner ear organs.

https://pubmed.ncbi.nlm.nih.gov/33530555/

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Exposure to 50 Hz Extremely-Low-Frequency Magnetic Fields Induces No DNA Damage in Cells by Gamma H2AX Technology

Ye Lv, Shuchang Chen, Bing Zhu, Hong Xu, Shanshan Xu, Weiyan Liu, Yunyun Shen, Qunli Zeng. Exposure to 50 Hz Extremely-Low-Frequency Magnetic Fields Induces No DNA Damage in Cells by Gamma H2AX Technology. Biomed Res Int. 2021 Feb 15;2021:8510315. doi: 10.1155/2021/8510315.

Abstract

The current results for extremely-low-frequency magnetic fields (ELF-MF) on DNA damage are still debated. A sensitive indicator and systematic research are needed to assess the effects of ELF-MF. In this study, we used γH2AX as an early and sensitive molecular marker to evaluate the DNA damage effects of ELF-MF in vitro. Human amnion epithelial cells (FLs), human skin fibroblast cells (HSFs), and human umbilical vein endothelial cells (HUVECs) were exposed to 50 Hz ELF-MF at 0.4, 1, and 2 mT for 15 min, 1 h, and 24 h, respectively. After exposure, cells were subjected to γH2AX immunofluorescence and western blot. The results showed no significant difference in the average number of foci per cell, the percentage of γH2AX foci-positive cells, or the expression of γH2AX between the sham and 50 Hz ELF-MF exposure groups ($P > 0.05$). In conclusion, 50 Hz ELF-MF did not induce DNA damage in FLs, HSFs, or HUVECs, which was independent of the intensity or duration of the exposure.

Open access paper: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7899753/

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Static Magnetic Field Induces Abnormality of Glucose Metabolism in rats' brain and results in anxiety-like behavior

Tang Shuo, Ye Yumeng, Yang Leilei, Hao Yanhui, Yu Chao, Yan Hua, Xing Yuan, Jia Zhaoqian, Hu Cuicui, Zuo Hongyan, Li Yang. Static Magnetic Field Induces Abnormality of Glucose Metabolism in rats' brain and results in anxiety-like behavior. J Chem Neuroanat. 2021 Feb 4;101923. doi: 10.1016/j.jchemneu.2021.101923.

Abstract

In this study, fifty-four male Wistar rats were randomly divided into four groups according to the static magnetic field (SMF) intensity, namely, control, low-intensity, moderate-intensity, and high-intensity groups. The rats' whole body was exposed to a superconducting magnet exposure source. The exposure SMF intensity for the low-intensity, moderate-intensity, and high-intensity groups was 50 m T, 100 m T, and 200 m T, respectively, and the exposure time was 1 h/day for consecutive 15 days. After different exposure times, glucose metabolism in rats' brain was evaluated by micro-positron emission tomography (micro-PET), and the expression of hexokinase 1(HK1) and 6-phosphate fructokinase-1(PFK1) was detected by western blot. The exploration and locomotion abilities of the rats were evaluated by conducting open field test (OFT). Furthermore, pathological changes of rats' brain were observed under a microscope by using hematoxylin-eosin staining. PET results showed that moderate-intensity SMFs could cause fluctuant changes in glucose metabolism in rats' brain and the abnormalities were SMF intensity dependent. The expression of the two rate-limiting enzymes HK1 and PFK1 in glucose metabolism in brain significantly decreased after SMF exposure. The OFT showed that the total distance, surrounding distance, activity time, and climbing and standing times significantly decreased after SMF exposure. The main pathological changes in the brain were pyknosis, edema of neurons, and slight widening of the perivascular space, which occurred after 15 times of exposure. This study indicated that SMF exposure could lead to abnormal glucose metabolism in the brain and might result in anxiety-like behaviors.

https://pubmed.ncbi.nlm.nih.gov/33549700/

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Turning preference in dogs: North attracts while south repels

Jana Adámková, Kateřina Benediktová, Jan Svoboda, Luděk Bartoš, Lucie Vynikalová, Petra Nováková, Vlastimil Hart, Michael S Painter, Hynek Burda. Turning preference in dogs: North attracts while south repels. PLoS One. 2021 Jan 28;16(1):e0245940. doi: 10.1371/journal.pone.0245940.

Abstract

It was shown earlier that dogs, when selecting between two dishes with snacks placed in front of them, left and right, prefer to turn either clockwise or counterclockwise or randomly in either direction. This preference (or non-preference) is individually consistent in all trials but it is biased in favor of north if they choose between dishes positioned north and east or north and west, a phenomenon denoted as "pull of the north". Here, we replicated these experiments indoors, in magnetic coils, under natural magnetic field and under magnetic field shifted 90° clockwise. We demonstrate that "pull of the north" was present also in an environment without any outdoor cues and that the magnetic (and not topographic) north exerted the effect. The detailed analysis shows that the phenomenon involves also "repulsion of the south". The clockwise turning preference in the right-preferring dogs is more pronounced in the S-W combination, while the counterclockwise turning preference in the left-preferring dogs is pronounced in the S-E combination. In this way, south-placed dishes are less frequently chosen than would be expected, while the north-placed dishes are apparently more preferred.

Turning preference did not correlate with the motoric paw laterality (Kong test). Given that the choice of a dish is visually guided, we postulate that the turning preference was determined by the dominant eye, so that a dominant right eye resulted in clockwise, and a dominant left eye in counterclockwise turning. Assuming further that magnetoreception in canines is based on the radical-pair mechanism, a "conflict of interests" may be expected, if the dominant eye guides turning away from north, yet the contralateral eye "sees the north", which generally acts attractive, provoking body alignment along the north-south axis.

Open access paper: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0245940

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Electromagnetic fields, 5G and health: what about the precautionary principle?

John William Frank. Electromagnetic fields, 5G and health: what about the precautionary principle? J Epidemiol Community Health. Published Online First: 19 January 2021. doi: 10.1136/jech-2019-213595.

Abstract

New fifth generation (5G) telecommunications systems, now being rolled out globally, have become the subject of a fierce controversy. Some health protection agencies and their scientific advisory committees have concluded that there is no conclusive scientific evidence of harm. Several recent reviews by independent scientists, however, suggest that there is significant uncertainty on this question, with rapidly emerging evidence of potentially harmful biological effects from radio frequency electromagnetic field (RF-EMF) exposures, at the levels 5G roll-out will entail. This essay identifies four relevant sources of scientific uncertainty and concern: (1) lack of clarity about precisely what technology is included in 5G; (2) a rapidly accumulating body of laboratory studies documenting disruptive in vitro and in vivo effects of RF-EMFs—but one with many gaps in it; (3) an almost total lack (as yet) of high-quality epidemiological studies of adverse human health effects from 5G EMF exposure specifically, but rapidly emerging epidemiological evidence of such effects from past generations of RF-EMF exposure; (4) persistent allegations that some national telecommunications regulatory authorities do not base their RF-EMF safety policies on the latest science, related to unmanaged conflicts of interest. The author, an experienced epidemiologist, concludes that one cannot dismiss the growing health concerns about RF-EMFs, especially in an era when higher population levels of exposure are occurring widely, due to the spatially dense transmitters which 5G systems require. Based on the precautionary principle, the author echoes the calls of others for a moratorium on the further roll-out of 5G systems globally, pending more conclusive research on their safety.

Conclusions and recommendation

In assessing causal evidence in environmental epidemiology, Bradford Hill himself pointed out that ‘the whole picture matters;’ he argued against prioritising any subset of his famous nine criteria for causation. One’s overall assessment of the likelihood that an exposure causes a health condition should take into account a wide variety of evidence, including ‘biological plausibility’. 34 35 After reviewing the evidence cited above, the writer, an experienced physician-epidemiologist, is convinced that RF-EMFs may well have serious human health effects. While there is also increasing scientific evidence for RF-EMF effects of ecological concern in other species, 6–8 16–18 23 both plant and animal, these have not been reviewed here, for reasons of space and the author’s disciplinary limitations. In addition, there is convincing evidence, cited above, that several nations’ regulatory

apparatus, for telecommunications innovations such as the 5G roll-out, is not fit for purpose. Indeed, significant elements in that apparatus appear to have been captured by vested interests. Every society's public health—and especially the health of those most likely to be susceptible to the hazard in question (in the case of EMFs, children and pregnant women)—needs to be protected by evidence-based regulations, free from significant bias.

Finally, this commentary would be remiss if it did not mention a widely circulating conspiracy theory, suggesting that 5G and related EMF exposures somehow contributed to the creation or spread of the current COVID-19 pandemic. There are knowledgeable commentators' reports on the web debunking this theory, and no respectable scientist or publication has backed it. 40 41 Indeed, combatting it is widely viewed by the scientific community as critical to dealing with the pandemic, as conspiracy theorists holding this view have already carried out violent attacks on mobile phone transmission facilities and other symbolic targets, distracting the public and authorities at a time when pandemic control actions are paramount. 42 This writer completely supports that view of the broader scientific community: the theory that 5G and related EMFs have contributed to the pandemic is baseless.

It follows that, for the current 5G roll-out, there is a sound basis for invoking 'the precautionary principle'. 43 This is the environmental and occupational health principle by which significant doubt about the safety of a new and potentially widespread human exposure should be a reason to call a moratorium on that exposure, pending adequate scientific investigation of its suspected adverse health effects. In short, one should 'err on the side of caution'. In the case of 5G transmission systems, there is no compelling public health or safety rationale for their rapid deployment. The main gains being promised are either economic (for some parties only, not necessarily with widely distributed financial benefits across the population) or related to increased consumer convenience. Until we know more about what we are getting into, from a health and ecological point of view, those putative gains need to wait.

Open access paper: https://jech.bmj.com/content/early/2021/01/04/jech-2019-213595 or https://jech.bmj.com/content/jech/early/2021/01/04/jech-2019-213595.full.pdf

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Effects of Electromagnetic Waves with LTE and 5G Bandwidth on the Skin Pigmentation In Vitro

Kyuri Kim, Young Seung Lee, Nam Kim, Hyung-Do Choi, Dong-Jun Kang, Hak Rim Kim, Kyung-Min Lim. Effects of Electromagnetic Waves with LTE and 5G Bandwidth on the Skin Pigmentation In Vitro. Int J Mol Sci. 2020 Dec 26;22(1):E170. doi: 10.3390/ijms22010170.

Abstract

With the rapid growth of wireless communication devices, the influences of electromagnetic fields (EMF) on human health are gathering increasing attention. Since the skin is the largest organ of the body and is located at the outermost layer, it is considered a major target for the health effects of EMF. Skin pigmentation represents one of the most frequent symptoms caused by various non-ionizing radiations, including ultraviolet radiation, blue light, infrared, and extremely low frequency (ELF). Here, we investigated the effects of EMFs with long-term evolution (LTE, 1.762 GHz) and 5G (28 GHz) bandwidth on skin pigmentation in vitro. Murine and Human melanoma cells (B16F10 and MNT-1) were exposed to either LTE or 5G for 4 h per day, which is considered the

upper bound of average smartphone use time. It was shown that neither LTE nor 5G exposure induced significant effects on cell viability or pigmentation. The dendrites of MNT-1 were neither lengthened nor regressed after EMF exposure. Skin pigmentation effects of EMFs were further examined in the human keratinocyte cell line (MNT-1-HaCaT) co-culture system, which confirmed the absence of significant hyper-pigmentation effects of LTE and 5G EMFs. Lastly, MelanoDerm™, a 3D pigmented human epidermis model, was irradiated with LTE (1.762 GHz) or 5G (28 GHz), and image analysis and special staining were performed. No changes in the brightness of MelanoDerm™ tissues were observed in LTE- or 5G-exposed tissues, except for only minimal changes in the size of melanocytes. Collectively, these results imply that exposure to LTE and 5G EMFs may not affect melanin synthesis or skin pigmentation under normal smartphone use condition.

Open access paper: https://www.mdpi.com/1422-0067/22/1/170

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Association between reproductive health and nonionizing radiation exposure

Pooja Negi, Rajeev Singh. Association between reproductive health and nonionizing radiation exposure. Electromagnetic Biology and Medicine. Published online: 20 Jan 2021. DOI: 10.1080/15368378.2021.1874973.

Abstract

Recently, a decreasing rate of fertility has to be credited to an array of factors such as environmental, health and lifestyle. Male infertility is likely to be affected by the strong exposure to heat and radiations. The most common sources of nonionizing radiations are cell phones, laptops, Wi-Fi and microwave ovens, which may participate to the cause of male infertility. One of the major sources of daily exposure to non-ionizing radiation is mobile phones. A mobile phone is now basically dominating our daily life through better services such as connectivity, smartphone devices. However, the health consequences are linked with their usage are frequently ignored. Constant exposure to non-ionizing radiations produced from a cell phone is one of the possible reasons for growing male infertility. Recently, several studies have shown that cell phone users have altered sperm parameters causing declining reproductive health. Cell phone radiation harms male fertility by affecting the different parameters like sperm motility, sperm count, sperm morphology, semen concentration, morphometric abnormalities, increased oxidative stress along with some hormonal changes. This review is focusing on the prevailing literature from in vitro and in vivo studies suggesting that non-ionizing exposure negatively affects human male infertility.

https://pubmed.ncbi.nlm.nih.gov/33471575/

Conclusion

Generally, the outcome of the studies has indicated that mobile phone usage changes different sperm parameters in both ways in-vitro (human) and in-vivo (animals). Several studies disclose that the exposure to cell phones produces harmful effects on the testes, which may affect sperm motility, sperm number, sperm concentration, and morphology and an increased DNA damage, causing micronuclei formation and reactive oxygen species within the cell. So many evidences showed that exposure from cell phones results in elevated oxidative stress with disintegrated DNA and it is directly and indirectly dependent on the time of cell phone use.

Further researches are required to provide strong evidence that the use of mobile phones may disturb sperm and testicular activity. Several evidences suggest that the irregularities reported due to RF-EMF-exposure depend on physical parameters such as utilized RF wavelength, penetration range into the object, and transmission length of the radiation. Unfortunately, existing studies are not able to suggest a true mechanism between the harmful effects of RF-EMF radiation and the male reproductive system. To conclude all of the above, government bodies and agencies should form strong guidelines against cell phone exposure and take preventive actions such as in the usage of mobile phones, preventing chatting, reducing the overall contact time, and holding the gadget away from the groin may be of significant help to people pursuing fertility. Moreover, very limited studies are available on protective actions so far so a large-scale analysis is also required to determine the reproductive parameters.

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Implications of mmWave Radiation on Human Health: State of the Art Threshold Levels

Ravilla Dilli. Implications of mmWave Radiation on Human Health: State of the Art Threshold Levels. IEEE Access. 18 January 2021. DOI: 10.1109/ACCESS.2021.3052387.

Abstract

millimeter (mmWave) frequencies are covering from 30GHz to 300GHz in the electromagnetic spectrum and their uses in various applications like next-generation wireless communication systems (massive 5G telecommunications network), medical devices, airport security and automatic collision avoidance systems are growing vastly in the near future. Therefore, it is important to study the effects of mmWave radiation (non-ionization radiation) on biological systems and biophysical mechanisms. This paper focus on thorough review of nascent literature about current understandings of biological effects and epidemiological studies due to mmWave radiation in human beings. It presents latest guidelines with quantitative electromagnetic field thresholds by considering the realistic exposure scenarios of “general public” and “occupational” who undergo through wireless communication sources in their daily life. It also gives necessary safety measures to be taken while using the emerging mmWave technologies for future generation wireless communication networks. https://ieeexplore.ieee.org/document/9328127

Conclusions and Futurescope

This paper has investigated mainly on the latest and current research work on various adverse health effects in human beings due to continuous and discontinuous, short-term and long-term RF EMFs exposures at mmWave frequency bands. It has mentioned the state-of-art threshold levels for exposures to RF EMFs at mmWave frequency bands.However, there are few exposure scenarios like RF EMFs interfering with electrical equipment (also called EMC), potential harms to volunteer research participants, EMFs due to metallic implants which are part of medical treatment are out of scope to the threshold levels mentioned in this paper. The future scope of this work is to establish guidelines and safety measures at THz frequency bands, also consider the EMC influences in defining threshold values. Currently, the EHS health disorders are greatly increasing day by day in people who use smart phones for a long time in a day. Future continuations of this research work include

deriving scientific basis which gives relation between the usage of mmWave communication devices and EHS health disorders in humans.

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Redefining electrosensitivity: A new literature-supported model

Mary Redmayne, Siobhan Reddel. Redefining electrosensitivity: A new literature-supported model. Electromagnetic Biology and Medicine. Jan 2021. DOI: 10.1080/15368378.2021.1874971.

Abstract

In critically examining literature on electrohypersensitivity and the reported somatic responses to anthropogenic modulated radiofrequency radiation (RFR) exposure, it becomes apparent that electrohypersensitivity is one part of a range of consequences. Current evidence on the necessity of considering patients' overall health status leads us to propose a new model in which electrohypersensitivity is but part of the electrosensitive status inherent in being human. We propose the likelihood and type of response to environmental RFR include i) a linear somatic awareness continuum, ii) a non-linear somatic response continuum, and iii) the extent of each individual's capacity to repair damage (linked to homeostatic response). We anticipate this last, dynamic, aspect is inextricably linked to the others through the autonomic nervous system. The whole is dependent upon the status of the interconnected immune and inflammatory systems. This holistic approach leads us to propose various outcomes. For most, their body maintains homeostasis by routine repair. However, some develop electrohypersensitivity either due to RFR exposure or as an ANS-mediated, unconscious response (aka nocebo effect), or both. We suggest RFR exposure may be one factor in the others developing an auto-immune disease or allergy. A few develop delayed catastrophic disease such as glioma. This model gives the blanket term ElectroMagnetic Illness (EMI) to all RFR-related conditions. Thus, EHS appears to be one part of a range of responses to a novel and rapidly changing evolutionary situation.

Conclusion and consequences of the model

Overall, there is compelling evidence in the broader literature indicating that EHS is but one part of a more complex range of responses related to humans being intrinsically electrosensitive.

In fact, "Many of the general malaise symptoms associated with IEI (Idiopathic Environmental Intolerance) 7 are common in the general population" p.42 (World Health Organisation 2004). This is not a sign of a healthy general population even by the WHO's definition of health, 8 and causes must be identified. Life is dependent upon, and arguably defined by the electrical activity, of the brain, the broader nervous system and indeed the body's ongoing efforts to maintain homeostasis. As we said earlier, internal electrical impulses are inherent to life; when they stop, we die. There are also natural, static and low-frequency, non-modulated, electromagnetic fields with which we have evolved and most of which we use and even rely upon. Our bodies and cells have their own resonant frequencies, and research has shown cell sensitivity to RFR exposure at ultra-low intensities (Kositsky, 2001). It is almost to be expected that exposures never encountered during the course of evolution would affect us. Indeed, "Since the low-level environmental exposures associated with IEI are commonly found in everyone's daily living environment, the exposed population is indistinguishable from the general population.

Everyone is exposed" p.44 (World Health Organisation 2004).

Our current model of electrosensitivity includes the "general population" and expresses that differing responses are a normal part of being alive. For some of those who do not appear to respond (no symptoms), there will mostly likely be cellular impacts. For most, these will be promptly repaired or otherwise dealt with (e.g., apoptosis); for some, damage will gradually or eventually accumulate and may lead, in time, to a catastrophic response in the form of a disease that began as oxidative stress that the body has fought but finally to which it has catastrophically succumbed. For others, effects will be felt and cause early symptoms. Among these people, some will respond by avoiding the exposure either subconsciously or consciously, while others will ignore them and eventually pay the price. Others will develop EHS. At this stage, it will often go undiagnosed due to lack of training in recognising this possible diagnosis.

Importantly, this model implies that there is a need to acknowledge that EHS (with all its variety) is one part of a range of symptomless pre-cursor and EMI responses to a novel and rapidly changing evolutionary situation. There should be no stigma to EHS, and those affected deserve the same level of concern and extent of assistance as those with allergies or auto-immune diseases, the principal actions being minimisation of the harmful stimulant until personal repair capacity has improved, then slowly re-introducing exposure, to the extent manageable on an individual basis. Assistance with this would be necessary at several stages so the body is not pushed into the hypo-responsive state, but rather assisted to reach the best possible health with the best practicable repair capacity.

We propose that to work towards avoiding, ameliorating, or attempting to overcome EHS it is necessary not only to observe the positive actions recommended, but also to build capacity. And capacity provides the energy necessary to build resilience (Gerritsen and Band 2018).

https://www.tandfonline.com/doi/full/10.1080/15368378.2021.1874971

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The Impact of Mobile Phone Use on Tinnitus: A Systematic Review and Meta-Analysis

Artur Kacprzyk, Tomasz Stefura, Marta Krzysztofik, Tomasz Rok, Eugeniusz Rokita, Grzegorz Tatoń. The Impact of Mobile Phone Use on Tinnitus: A Systematic Review and Meta-Analysis. Bioelectromagnetics. 2021 Jan 13. doi: 10.1002/bem.22316.

Abstract

Tinnitus is a perception of sound in the absence of an external source. The aim of our study was to investigate with a meta-analytical approach, whether mobile phone (MP) use increases the risk of tinnitus. Eight studies reporting the risk of tinnitus in relation to MP use were identified, and six high-quality studies (two cohort studies, one case-control study, and three cross-sectional ones) were included in the meta-analysis. The quality assessment was performed using the Newcastle-Ottawa scale. The risk of tinnitus was analyzed depending on the exposure to MPs in subgroups according to the study design and method of exposure assessment. Two

cohort studies, which assessed the exposure to MPs using network operator data, indicated no significantly increased risk of tinnitus among highly exposed MP users in comparison to lightly exposed individuals (odds ratio [OR]: 1.03 [95% confidence interval [CI]: 0.93-1.15]). Likewise, the self-reported exposure data from two cohorts/case-control and four cross-sectional studies did not find an association between exposure to MPs and tinnitus (OR: 1.20 [95% CI: 0.40-3.61] and OR: 1.73 [95% CI: 0.67-4.49], respectively). Current scientific knowledge, including high-quality studies with a reliable exposure assessment based on network operator data, does not support the hypothesis that MP use is associated with tinnitus.

https://pubmed.ncbi.nlm.nih.gov/33440459/

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Is there evidence for oxidative stress caused by electromagnetic fields? A summary of relevant observations in experimental animal and cell experiments related to health effects in the last ten years

Prof Meike Mevissen, David Schürmann. Is there evidence for oxidative stress caused by electromagnetic fields? A summary of relevant observations in experimental animal and cell experiments related to health effects in the last ten years. BERENIS – The Swiss expert group on electromagnetic fields and non-ionising radiation Newsletter – Special Issue January 2021.

Introduction

This special issue of the BERENIS newsletter contains an up-to-date assessment of a possible correlation between oxidative stress and exposure to magnetic and electromagnetic fields and their putative effects on health. For this purpose, relevant animal and cell studies published between 2010 and 2020 were identified and summarized. An extended report presenting these recent studies in more detail will be published soon by the FOEN1. This special issue contains a short version of the report.

Conclusions

In summary, the majority of the animal and more than half of the cell studies provided evidence of increased oxidative stress caused by RF-EMF or ELF-MF. This notion is based on observations in a large number of cell types, applying different exposure times and dosages (SAR or field strengths), also in the range of the regulatory limits. Certainly, some studies are burdened with methodological uncertainties and weaknesses or are not very comprehensive in terms of exposure time, dose, number and quantitative analysis of the biomarkers used, to name a few. Taking these methodological weaknesses into account, nonetheless, a tendency becomes apparent, namely that EMF exposure, even in the low dose range, can lead to changes in oxidative balance. Organisms and cells are generally able to react to oxidative stress, and many studies showed adaptation to EMF exposure after a recovery phase. Pre-existing conditions, such as immune deficiencies or diseases (diabetes, neurodegenerative diseases), compromise the body's defence mechanisms, including antioxidative protection, and it is therefore possible that individuals with these conditions experience more severe health effects. In addition, the studies show that very young and elderly individuals can react less efficiently to oxidative stress induced by EMF, which of course also applies to other stressors that cause oxidative stress. More extensive studies under standardised conditions are necessary, to better understand and confirm these phenomena and observations.

Open access report: https://t.co/ubvIFOnyXd?amp=1

BERENIS - Swiss expert group on electromagnetic fields and non-ionising radiation

The FOEN has nominated a consultative group of Swiss experts from various disciplines with scientific competence regarding electromagnetic fields and NIR, which has commenced its work in July 2014. The group is called “BERENIS”, based on the acronym of the respective German term. The BERENIS experts regularly screen the scientific literature, and assess the publications which they consider relevant for the protection of humans from potentially adverse effects.

The Swiss expert group on electromagnetic fields and non-ionising radiation (BERENIS)

In Switzerland, the Federal Office for the Environment (FOEN) is the **responsible government body for monitoring and assessing research on health effects of non-ionising radiation (NIR)** from stationary sources in the environment. This includes informing and updating the public about the current state of research, which is the basis for the ambient regulatory limits stated in the Swiss "ordinance relating to protection from non-ionising radiation". In the case of reliable new scientific knowledge and experiences, the FOEN would advise the Federal Council of Switzerland to adapt these ambient regulatory limits.

Assessing the results and conclusions of scientific studies enables **early detection of potential health risks of NIR**. The FOEN places particular emphasis to not overlook any evidence of harmfulness for public health demanding for corrective regulatory interventions. Furthermore, critical assessment of available scientific data is required to make firm statements about the validity of the presented evidence for biological effects, their relevance for public health, and if so, to estimate the number of potentially affected people.

NIR includes a broad spectrum of frequencies with varying intensities and radiation characteristics, which is becoming more complex and multifaceted as the development and application of technologies emitting them is very dynamic and rapidly increasing. In the context of the work of BERENIS, NIR at frequencies below 10 GHz is addressed. Potential biological effects and the underlying mechanisms of NIR are manifold, and research activities range from the molecular to the population level. As a consequence, specific expertise in various disciplines is needed to assess the related scientific studies rooted in **many different biological, medical and technical scientific realms**.

The FOEN has therefore nominated a **consultative group of Swiss experts from various disciplines with scientific competence regarding electromagnetic fields and NIR**, which has commenced its work in July 2014. The group is called "BERENIS", based on the acronym of the respective German term. The BERENIS experts regularly screen the scientific literature, and assess the publications which they consider relevant for the protection of humans from potentially adverse effects. The results of this evaluation are published in quarterly newsletters, which can be downloaded from this webpage.

Members of BERENIS

- Prof. Dr. Martin Röösli, Swiss Tropical and Public Health Institute, Basel (in charge)
- Prof. Dr. Peter Achermann, The KEY Institute for Brain-Mind Research, Zurich
- Dr. Jürg Fröhlich, Fields at Work GmbH, Zurich
- Prof. Dr. med. Jürg Kesselring, previous head of the Department of Neurorehabilitation, Rehabilitation Centre, Clinics of Valens
- Prof. Dr. Meike Mevissen, Vet-Pharmacology & Toxicology, University of Bern
- Dr. David Schürmann, Molecular Genetics Group, Department of Biomedicine, University of Basel

- Dr. med. Edith Steiner, Ärztinnen und Ärzte für Umweltschutz, Basel

Secretariat:

- Dr. Stefan Dongus, Swiss Tropical and Public Health Institute, Basel

Federal Office for the Environment:

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Observers:

- Dr. Evelyn Stempfel (Federal Office of Public Health)
- Dr. Roland Krischek (Swiss National Accident Insurance Fund)
- Dr. Christian Monn (State Secretariat for Economic Affairs)
- Dr. Samuel Iff (State Secretariat for Economic Affairs)

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Empirical study on specific absorption rate of head tissues due to induced heating of 4G cell phone radiation

Christopher B, Mary S, Khandaker MU, Jojo PJ. Empirical study on specific absorption rate of head tissues due to induced heating of 4G cell phone radiation. Radiation Physics and Chemistry. 178(Special Issue): 108910. Jan 2021. DOI:10.1016/j.radphyschem.2020.108910.

Abstract

Exposures to electromagnetic radiation mainly from the extended use of mobile phones may initiate biological damages in the human body at the macromolecular level. Several studies on human and animal models have shown significant changes in the functions of neural cells. Present empirical study analyses the thermal changes and the specific absorption rates (SAR) of brain, eye and skin tissues due to prolonged exposure to mobile phone radiation. A phantom, simulating human head with skin, skull and brain was used for the study. The Phantom was exposed to radiation for longer durations (600 s and more) and the temperature variations at different specific points were studied with sensitive thermocouple probes. SAR (1 g of contiguous tissue) values were determined using the variations of temperature and other parameters. The average rise in brain temperature was found to be 0.10 +/- 0.05 degrees C at 30 mm deep in the brain and the estimated SAR was 0.66 +/- 0.35 Wkg(-1). The increase in temperature for the eye socket was 0.03 +/- 0.02 degrees C with SAR 0.15 +/- 0.08 Wkg(-1). The average rise in temperature for skin was 0.14 +/- 0.05 degrees C and the SAR was 0.66 +/- 0.42 Wkg(-1). Although the measured SAR lie within the safe limit of 2 Wkg(-1) recommended by the international regulatory body, considering the tremendous growth in the number of mobile phone users and prolonged use of mobile phone in communication purposes, the cumulative effects could be a real concern for human health.

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Association between estimated whole-brain radiofrequency electromagnetic fields dose and cognitive function in preadolescents and adolescents

Cabre-Riera A, van Wel, L, Liorni, I, Thielens A, Birks LE, Pierotti L, Joseph W, Gonzalez-Safont L, Ibarluzea J, Ferrero A, et al. Association between estimated whole-brain radiofrequency electromagnetic fields dose and cognitive function in preadolescents and adolescents. Int J Hygiene Envir Health. 231:113659. Jan 2021. DOI: 10.1016/j.ijheh.2020.113659.

Abstract

Objective: To investigate the association between estimated whole-brain radiofrequency electromagnetic fields (RF-EMF) dose, using an improved integrated RF-EMF exposure model, and cognitive function in preadolescents and adolescents.

Methods: Cross-sectional analysis in preadolescents aged 9-11 years and adolescents aged 17-18 years from the Dutch Amsterdam Born Children and their Development Study (n = 1664 preadolescents) and the Spanish INfancia y Medio Ambiente Project (n = 1288 preadolescents and n = 261 adolescents), two population-based birth cohort studies. Overall whole-brain RF-EMF doses (mJ/kg/day) were estimated for several RF-EMF sources together including mobile and Digital Enhanced Cordless Telecommunications phone calls (named phone calls), other mobile phone uses than calling, tablet use, laptop use (named screen activities), and far-field sources. We also estimated whole-brain RF-EMF doses in these three groups separately (i.e. phone calls, screen activities, and far-field) that lead to different patterns of RF-EMF exposure. We assessed non-verbal intelligence in the Dutch and Spanish preadolescents, information processing speed, attentional function, and cognitive flexibility in the Spanish preadolescents, and working memory and semantic fluency in the Spanish preadolescents and adolescents using validated neurocognitive tests.

Results: Estimated overall whole-brain RF-EMF dose was 90.1 mJ/kg/day (interquartile range (IQR) 42.7; 164.0) in the Dutch and Spanish preadolescents and 105.1 mJ/kg/day (IQR 51.0; 295.7) in the Spanish adolescents. Higher overall estimated whole-brain RF-EMF doses from all RF-EMF sources together and from phone calls were associated with lower non-verbal intelligence score in the Dutch and Spanish preadolescents (-0.10 points, 95% CI-0.19; -0.02 per 100 mJ/kg/day increase in each exposure). However, none of the whole-brain RF-EMF doses was related to any other cognitive function outcome in the Spanish preadolescents or adolescents.

Conclusions: Our results suggest that higher brain exposure to RF-EMF is related to lower non-verbal intelligence but not to other cognitive function outcomes. Given the cross-sectional nature of the study, the small effect sizes, and the unknown biological mechanisms, we cannot discard that our results are due to chance finding or reverse causality. Longitudinal studies on RF-EMF brain exposure and cognitive function are needed.

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The effect of mobile phone waves on salivary secretion in dental students of Rafsanjan University of Medical Sciences

N. Kamyab, Z. Mordouei, M. Hosseini, M. Sheikh Fathollahi. The effect of mobile phone waves on salivary secretion in dental students of Rafsanjan University of Medical Sciences.
Int J Radiat Res 2021, 19(1): 81-87.

Abstract

Background: Excessive use of mobile phones is addictive and causes many complications. The severity of these complications depends on the duration of the call and the frequency of using mobile phones. Therefore, this study aimed to determine the effect of mobile phone waves on salivary secretion.

Materials and Methods: This descriptive study was conducted on 120 dental students in Rafsanjan, Iran, in 2015. Using the call history of the mobile phones, the number and duration of each person's daily calls were obtained. The spitting method was used to collect unstimulated saliva, and stimulated saliva was collected with the help of natural chewing gums without sugar and additive flavors. After sampling, the falcon tubes containing saliva were centrifuged at 2500 rpm for 10 minutes. Then the saliva volume was read from the tube and recorded. Independent two-sample t test, one-way ANOVA, and multiple linear regression model were used for data analysis.

Results: Students who talked for more than 40 minutes or 20-40 minutes a day on their mobile phones had a mean unstimulated salivary secretion of 0.885 and 0.331 ml/min, respectively and mean stimulated salivary secretion of 0.702 and 0.708 ml/min, respectively more than students who talked less than 20 minutes a day on their cell phones ($P<0.05$).

Conclusion: The results showed that increased duration of cell phone calls was associated with increasing the amount of stimulated and unstimulated salivary secretion, which could decrease the risk of developing oral infections and tooth decay.

http://ijrr.com/article-1-3459-en.html

Conclusion

The results of the present study indicated that increased duration of cell phone calls was correlated to increasing the amount of salivary secretion. It is suggested future studies be conducted on all age groups and in addition to quantity, the quality of saliva is examined. Measuring the amount of saliva secreted on the dominant side of cell phone use and compare it with the recessive side is also recommended.

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Measuring the impact of ICNIRP vs. stricter-than-ICNIRP exposure limits on QoS and EMF from cellular networks

Jaime Galán-Jiménez, Luca Chiaraviglio. Measuring the impact of ICNIRP vs. stricter-than-ICNIRP exposure limits on QoS and EMF from cellular networks. Computer Networks. 6 January 2021. 107824. https://doi.org/10.1016/j.comnet.2021.107824.

Abstract

The installation of new equipment (Base Stations, BSs) during the planning phase of a cellular network (including 5G BSs) is governed by exposure limits in terms of allowable ElectroMagnetic Field (EMF) levels. The exposure limits can be either defined by i) international bodies (e.g., ICNIRP) or ii) national regulations imposing limits stricter than i). In this work, we compare the impact of ICNIRP vs. stricter-than-ICNIRP exposure regulations on the Quality of Service (QoS) and EMF. To this aim, we perform a large-scale measurement campaign in one scenario in Spain subject to ICNIRP regulations and another one in Italy subject to EMF limits stricter than ICNIRP ones. Both the scenarios are characterized by similar exposure conditions, comparable user density, and common 4G performance targets by the operators. Results, obtained by measuring QoS and EMF at selected locations, reveal that the QoS in the scenario subject to strict EMF limits is heavily worsened compared to the one in which ICNIRP-based limits are enforced. Clearly, the scenario with strict EMF limits presents a lower level exposure over the territory compared to the one imposing ICNIRP limits.

https://www.sciencedirect.com/science/article/abs/pii/S1389128621000128

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Effects of 2600 MHz Radiofrequency Radiation in Brain Tissue of Male Wistar Rats and Neuroprotective Effects of Melatonin

Kevser Delen, Bahriye Sırav, Sinem Oruç, Cemile M Seymen, Dilek Kuzay, Korkut Yeğin, Gülnur Take Kaplanoğlu. Effects of 2600 MHz Radiofrequency Radiation in Brain Tissue of Male Wistar Rats and Neuroprotective Effects of Melatonin. Bioelectromagnetics. 2021 Jan 13. doi: 10.1002/bem.22318.

Abstract

The debate on the biological effects of radiofrequency radiation (RFR) still continues due to differences in the design of studies (frequency, power density, specific absorption rate [SAR], exposure duration, cell, tissue, or animal type). The current study aimed to investigate the effects of 2,600 MHz RFR and melatonin on brain tissue biochemistry and histology of male rats. Thirty-six rats were divided into six groups randomly: cage-control, sham, RFR, melatonin, sham melatonin, and RFR melatonin. In RFR groups, animals were exposed to 2,600 MHz RFR for 30 days (30 min/day, 5 days/week) and the melatonin group animals were subcutaneously injected with melatonin (7 days/week, 10 mg/kg/day) for 30 days. SAR in brain gray matter was calculated as 0.44 and 0.295 W/kg for 1 and 10 g averaging, respectively. RFR exposure decreased the GSH, GSH-Px, and SOD levels and increased the MPO, MDA, and NOx levels ($P < 0.005$) significantly. RFR exposure also led to an increase in structural deformation and apoptosis in the brain tissue. This study revealed that exogenous high-dose

melatonin could reduce these adverse effects of RFR. Limiting RFR exposure as much as possible is recommended, and taking daily melatonin supplements may be beneficial.

https://pubmed.ncbi.nlm.nih.gov/33440456/

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The effect of 900-MHz radiofrequency electromagnetic fields during the adolescence on the histological structure of rat testis and its androgen and estrogen receptors localization

Gur FM, Keles AI, Erol HS, Guven C, Taskin E, Kaya H, Gur HE, Odaci E, Halici MB, Timurkaan S. The effect of 900-MHz radiofrequency electromagnetic fields during the adolescence on the histological structure of rat testis and its androgen and estrogen receptors localization. Int J Radiation Research. 19(1):135-144. Jan 2021. DOI: 10.18869/acadpub.ijrr.19.1.135

Abstract

Background: Mobile phones as an electronic device which are emitting radiofrequency-electromagnetic field (RF-EMF). In this study was intend to determine the contingent effects of cell phone induced RF-EMF on testicular tissue in adolescence.

Materials and Methods: Rats in the RF-EMF group were exposed to 900 MHz RF-EMF, while sham and control rats were not. After the completion of the test steps, the testicular tissues which were rapidly removed from the body of sacrificed rats were examined by using histopathological and biochemical methods. Testicular tissues cut to 5 mu m thickness undergo routine histological procedures. Thus, histopathological evaluation will be completed. Malondialdehyde (MDA), glutathione (GSH), catalase (CAT) and superoxide dismutase (SOD) levels in testicular tissues were measured by biochemical methods to determine whether oxidative stress occurred or not.

Results: Histopathologic findings were not observed in any of the studied groups. There was also no difference between the groups in terms of localization of androgen and estrogen receptors. The incidence of apoptotic index and TUNEL-positive cells was similar in all three groups. In the RF-EMF group, although the levels of MDA and CAT were significantly higher, GSH levels were lower than the other groups. There was no essential difference between the groups in terms of SOD level.

Conclusions: The obtained results of this study showed that exposed to 900 MHz RF-EMF in adolescents caused oxidative stress in the testes, but testicular damage which is caused by oxidative stress remained too low to be detected by histopathological methods in this study.

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Sensitivity of plants to high frequency electromagnetic radiation: cellular mechanisms and morphological changes

Shalinder Kaur, Alain Vian, Shikha Chandel, Harminder PalSingh, Daizy Rani Batish, Ravinder Kumar Kohli. Sensitivity of plants to high frequency electromagnetic radiation: cellular mechanisms and morphological

changes. Rev Environ Sci Biotechnol (2021). https://doi.org/10.1007/s11157-020-09563-9.

Abstract

The technological advancement and increased usage of wireless and other communication devices have greatly enhanced the level of radiofrequency electromagnetic field radiation (EMF-r) in the environment. It has resulted in unprecedented increased exposure of living organisms to these radiations. Most of the studies in past have, however, focused on animal systems and comparatively less attention has been paid to plants with studies reporting various, sometimes contradictory effects. This review is an attempt to provide a critical appraisal of the available reports regarding the impacts of these radiations on plant development and the underlying physiological, biochemical, and molecular mechanisms involved. Here, we propose that the main entry point for the biological effects of EMF-r corresponds to an increase in ROS metabolism and cytosolic calcium that leads to various cellular responses including changes in gene expression and/or enzymatic activities, which could ultimately result in immediate cellular alterations or delayed plant growth. This may constitute a new perspective in the interpretation of plant responses to EMF-r exposure. Understanding the impacts of EMF-r and the inherent abilities of plants to cope up with such changes should lead to EMF-r being considered as full-fledged environmental signals that are perceived by the plants and integrated into their development patterns.

Conclusion and perspectives

Over the course of past decades, the extensive applications of EMF-r producing devices, and their potential to induce biological effects, have encouraged scientists to investigate the possible mechanisms of their action. Few studies have documented the progressive impacts of EMF-r on biota; however, studies with appropriate methodology suggested biological effects that require additional experimentation to understand their integration into plant development (rather than describing them in terms of positive or negative effects, as often found in the literature). The contradictory outcomes of studies suggest that the effects of EMF-r may be highly dependent upon exposure conditions (power density, frequency, and duration) and are species specific. A standardization of the procedure in use to expose plant to EMF-r, at least for model plants (arabidopsis, tomato, wheat, maize…) and for common frequencies (900, 1800 and MHz) would be highly valuable to allow a better comparison of the measured biological effects. However, the initial interaction and mechanism of EMF-r with plant tissue (the ‘‘primo-interaction’’) is not yet understood, even if several putative mechanisms have been proposed. These include dipole transition of polar structures (Amat et al. 2006), forced vibration of free ions (Panagopoulos et al. 2000, 2002) or modification of ligand binding capacity (Chiabrera et al. 2000). These uncertainties make difficult the elaboration of efficient strategies to characterize the complexity of the plant response. The literature emphasizes that EMF-r interfere with the growth and development of plants at the molecular or whole plant level, clearly involving some factors (calcium, ROS, secondary metabolites, ATP) of plant responses to environmental cues. There are convincing evidences to consider EMF-r as real environmental signals’ that plants possibly integrate into their development. Nevertheless, in the real environment, EMF-r induced stress is certainly of secondary importance in comparison with other more serious stresses for plants (drought, pathogen attack, wind, etc.). However, an unintended consequence is that a constant level of exposure to electromagnetic fields may condition plants to respond secondarily more efficiently to a severe stress, installing a kind of memory in the plant (Thellier et al. 2000; Hilker et al. 2016). This hypothesis would be

worth testing experimentally and may have valuable application in agriculture. In this perspective, global approaches to plant responses to EMF-r exposure (RNA sequencing, proteomics, metabolomics, DNA methylation, etc.) are still too few in the present literature for a more exhaustive knowledge of the metabolic pathways affected by exposure to EMF-r and should be investigated/deciphered in experimental designs.

https://link.springer.com/article/10.1007/s11157-020-09563-9

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Environmental Risk Factors and Health: An Umbrella Review of Meta-Analyses

Rojas-Rueda D, Morales-Zamora E, Alsufyani WA, Herbst CH, AlBalawi SM, Alsukait R, Alomran M. Environmental Risk Factors and Health: An Umbrella Review of Meta-Analyses. *International Journal of Environmental Research and Public Health*. 2021; 18(2):704.

Abstract

Background: Environmental health is a growing area of knowledge, continually increasing and updating the body of evidence linking the environment to human health.

Aim: This study summarizes the epidemiological evidence on environmental risk factors from meta-analyses through an umbrella review.

Methods: An umbrella review was conducted on meta-analyses of cohort, case-control, case-crossover, and time-series studies that evaluated the associations between environmental risk factors and health outcomes defined as incidence, prevalence, and mortality. The specific search strategy was designed in PubMed using free text and Medical Subject Headings (MeSH) terms related to risk factors, environment, health outcomes, observational studies, and meta-analysis. The search was limited to English, Spanish, and French published articles and studies on humans. The search was conducted on September 20, 2020. Risk factors were defined as any attribute, characteristic, or exposure of an individual that increases the likelihood of developing a disease or death. The environment was defined as the external elements and conditions that surround, influence, and affect a human organism or population's life and development. The environment definition included the physical environment such as nature, built environment, or pollution, but not the social environment. We excluded occupational exposures, microorganisms, water, sanitation and hygiene (WASH), behavioral risk factors, and no-natural disasters.

Results: This umbrella review found 197 associations among 69 environmental exposures and 83 diseases and death causes reported in 103 publications. The environmental factors found in this review were air pollution, environmental tobacco smoke, heavy metals, chemicals, ambient temperature, noise, radiation, and urban residential surroundings. Among these, we identified 65 environmental exposures defined as risk factors and 4 environmental protective factors. In terms of study design, 57 included cohort and/or case-control studies, and 46 included time-series and/or case-crossover studies. In terms of the study population, 21 included children, and the rest included adult population and both sexes. In this review, the largest body of evidence was found in air pollution (91 associations among 14 air pollution definitions and 34 diseases and mortality diagnoses),

followed by environmental tobacco smoke with 24 associations. Chemicals (including pesticides) were the third larger group of environmental exposures found among the meta-analyses included, with 19 associations.

Conclusion: Environmental exposures are an important health determinant. This review provides an overview of an evolving research area and should be used as a complementary tool to understand the connections between the environment and human health. The evidence presented by this review should help to design public health interventions and the implementation of health in all policies approach aiming to improve population health.

Excerpts

Table 13: https://www.mdpi.com/1660-4601/18/2/704/htm

Radon, a radioactive natural, was found in a recent meta-analysis as a risk factor for lung cancer [100] at indoor radon exposure levels above 100 Bq/m^3 (Table 13). In another meta-analysis, indoor radon exposure was also associated as a risk factor for childhood leukemia [101]. Finally, long-term exposures to extremely low-frequency electromagnetic fields were also found associated as a risk factor for amyotrophic lateral sclerosis [67] and childhood leukemia [99] (Table 13). Extremely low-frequency (ELF) magnetic fields are alternating fields generated by the distribution and supply of electricity.

Although this umbrella review found several publications and associations among environmental exposures and health outcomes, we also identified several evidence gaps. Most of the studies focus on identifying environmental risk factors, and only a few studies have been focusing on identifying environmental protective factors. Furthermore, few studies have focused on vulnerable and disadvantaged populations (children, elders, social disadvantaged, ethnic minorities, etc.). Furthermore, most studies do not provide a clear definition of the health outcomes using the international classification of diseases (ICD), nor a comparable exposure definition when the same pollutant is used. In terms of the meta-analysis, we exclude several studies from this review because, in the analyses, cross-sectional studies were mixed with other observational studies (i.e., cohorts). Additionally, several studies did not report heterogeneity values (i.e., I2) or do not provide dose-response functions essential for population risk assessment, health impact assessments and policy translation. We have summarized a list of recommendations for future research in environmental health studies based on these gaps, and we have listed those recommendations in Table 16.

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Repeated electromagnetic field stimulation lowers amyloid-β peptide levels in primary human mixed brain tissue cultures

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Abstract

Late Onset Alzheimer's Disease is the most common cause of dementia, characterized by extracellular deposition of plaques primarily of amyloid-β (Aβ) peptide and tangles primarily of hyperphosphorylated tau protein. We present data to suggest a noninvasive strategy to decrease potentially toxic Aβ levels, using repeated electromagnetic field stimulation (REMFS) in primary human brain (PHB) cultures. We examined effects of REMFS on Aβ levels (Aβ40 and Aβ42, that are 40 or 42 amino acid residues in length, respectively) in PHB cultures at different frequencies, powers, and specific absorption rates (SAR). PHB cultures at day in vitro 7 (DIV7) treated with 64 MHz, and 1 hour daily for 14 days (DIV 21) had significantly reduced levels of secreted Aβ40 ($p = 001$) and Aβ42 ($p = 0.029$) peptides, compared to untreated cultures. PHB cultures (DIV7) treated at 64 MHz, for 1 or 2 hour during 14 days also produced significantly lower Aβ levels. PHB cultures (DIV28) treated with 64 MHz 1 hour/day during 4 or 8 days produced a similar significant reduction in Aβ40 levels. 0.4 W/kg was the minimum SAR required to produce a biological effect. Exposure did not result in cellular toxicity nor significant changes in secreted Aβ precursor protein-α (sAPPα) levels, suggesting the decrease in Aβ did not likely result from redirection toward the α-secretase pathway. EMF frequency and power used in our work is utilized in human magnetic resonance imaging (MRI, thus suggesting REMFS can be further developed in clinical settings to modulate Aβ deposition.

https://pubmed.ncbi.nlm.nih.gov/33436686/