

SCIENTIFIC STUDIES 2023

RF HEALTH SAFETY LIMITS AND RECOMMENDATIONS

Lin JC. RF Health Safety Limits and Recommendations [Health Matters], IEEE Microwave Magazine, 24(6):18-77, June 2023, doi: 10.1109/MMM.2023.3255659.

Abstract

The rapid proliferation of cellular mobile telecommunication devices and systems is raising public health concerns about the biological effects and safety of RF radiation exposure. There is also concern about the efficacy of promulgated health safety limits, rules, and recommendations for the RF radiation used by these devices and systems. This article reviews and discusses the U.S. Federal Communications Commission (FCC) notices and rules, International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines, and International Committee on Electromagnetic Safety (ICES) standard for safety levels with respect to human exposure to electric, magnetic, and electromagnetic fields (EMFs). The recently revised RF exposure limits are adjusted only for heating with RF radiation. These limits are largely intended to restrict short-term heating by RF radiation that raises tissue temperatures. They are narrow in scope and are not applicable to long-term exposure at low levels. This review discusses the assumptions underlying the standards and the outdated exposure metrics employed, and concludes that the revised guidelines do not adequately protect children, workers, or the public from exposure to RF radiation or people with sensitivity to electromagnetic radiation from wireless devices and systems. Furthermore, the review discusses important animal data that the standards do not appear to take into account. Moreover, for millimeter-wave radiation from 5G mobile communications, there are no adequate human health effects studies in the published literature. The conclusions by scientific organizations, such as the International Agency for Research on Cancer (IARC), that diverge from these standards are also discussed. The review concludes that many of the recommended limits are debatable and require more scientific justification from the standpoint of safety and public health protection.

Excerpts

A recent article challenged the health safety afforded by the current exposure limits to RF radiation and called for an independent evaluation of the scientific evidence [14]. It shows that the current exposure limits ignore hundreds of scientific studies that document adverse health effects at exposures below the threshold level claimed by these safety limits. It further contends that the scientific evidence invalidates the health assumptions underlying the promulgated RF exposure limits. Specifically, for frequencies below 6 GHz, a SAR value of 4 W/kg, spatially and temporally averaged over the whole-body mass, was assumed as the effective threshold for adverse biological effects in humans. The level was predicated on disruption of operant-conditioned work schedules in a few trained rodents and primates. Also, it assumed that a heat-production rate of 4 W/kg was within the normal range of human thermoregulatory capacity. The ANSI/IEEE C95.1-1992 standards, and thus the FCC rules, ICES limits, and ICNIRP guidelines, are introduced to prevent only adverse thermal effects on the functioning of the human body. So, the SAR of 4 W/kg remains as the basis for the revised ICNIRP and ICES RF exposure limits.

The International Commission on the Biological Effects of Electromagnetic Fields article argued that the exposure limits, based on science from the 1980s, before cellular mobile phones were ubiquitous, do not adequately protect children, people with electromagnetic hypersensitivity, industrial workers, and the public from unsafe exposure to the RF radiation from cell phone and wireless devices and systems. Furthermore, while the revised ICNIRP safety guideline and ICES standard make recommendations to protect against adverse health effects from exposure to RF radiation, in fact, the guidelines and standards are based on controlling whole-body temperatures from increasing above 1 °C or local tissue temperatures to 5 °C for short-term exposures of 6 or 30 min (Table 1).

Contrary to persistent and recent concerns of inadequate health effect studies involving RF radiation with complex novel modulations and pulse sequences, especially about 5G, ICNIRP deleted its 1998 provision of pulse exposure limits from the revised 2020 guidelines. Consequently, there are no longer specific restrictions on pulse modulations of any kind in ICNIRP 2020. Note that time-averaged SAR over a 6-min period is inadequate to account for the unique characteristics of pulse modulations or to capture the effects of pulse-modulated exposures, including the microwave auditory effect that occurs without any measurable temperature rise and at low levels of SAR [18], [19]. It is well known that the outcomes of experimental studies are affected by differences in RF parameters and exposure conditions....

In conclusion, the revised RF exposure limits make allowances only to worry about heat with RF radiation. These limits are devised for restricting short-term heating by RF radiation and aim to prevent increased tissue temperatures. Thus, they are not applicable to long-term exposure at low levels. Instead of advances in science, they are predicated on assumptions using outdated exposure metrics, thus their ability to protect children, workers, and the public from exposure to the RF radiation or people with sensitivity to electromagnetic radiation from wireless devices and systems. Furthermore, the limits are based on outdated information and circumvent important animal data. These issues are even more relevant in the case of millimeter-wave radiation from 5G mobile communications for which there are no adequate health effects studies in the published literature. Finally, the guidelines do not adequately address conclusions from scientific organizations, such as the IARC. Thus, many of the recommended limits are questionable from the standpoint of scientific justification for the safety and public health protection.

<https://ieeexplore.ieee.org/document/10121536>

SOME CONSIDERATIONS ON THE CHALLENGES RELATED TO THE USE OF THE NEW ICNIRP RESTRICTIONS FOR HUMAN EXPOSURE TO RADIOFREQUENCY FIELDS

Goiceanu C, Danulescu R, Danulescu E. Some considerations on the challenges related to the use of the new ICNIRP restrictions for human exposure to radiofrequency fields. *Radiat Prot Dosimetry*. 2023 May 24;199(8- 9):818-825. doi: 10.1093/rpd/ncad084.

Abstract

ICNIRP 2020 guidelines for limiting exposure to radiofrequency fields replace the radiofrequency part of the ICNIRP 1998 guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields. Besides setting new restrictions that prevent thermal effect they also took over the 100 kHz to 10 MHz part of the ICNIRP 2010 guidelines

for limiting exposure to low-frequency electromagnetic fields, which provides restrictions that prevent nerve stimulation effect. The latest guidelines brought many changes to the system of protection against exposure to radiofrequency fields starting with the physical quantities used to express restrictions and continuing with specific restrictions and new exposure metrics employed. For the first time, the case of brief local exposure to intense radiofrequency fields was accounted by ICNIRP for setting new types of exposure restrictions. All these changes led to more detailed and complex guidelines, but their provisions are more difficult to apply in practice. Our paper presents some of the challenges related to the use in practice of the new ICNIRP restrictions for human exposure to radiofrequency fields.

Excerpts

In the domain of radio frequencies, two established effects are taken into account for setting exposure restrictions: thermal effect and nerve stimulation effect. To protect against thermal effect, the 2020 guidelines set basic restrictions in terms of Specific Absorption Rate (SAR) assessed as whole-body average (WBA), as well as local SAR in head and torso or in limbs. At frequencies above 6 GHz, basic restrictions were set for local absorbed power density (S_{ab}) to account for heating localized at the surface of the body. These exposure limits have the same values as those used in previous guidelines from 1998, except the local absorbed power density limit that restricts the superficial heating at high frequencies. The new values of basic restriction for power density of 100 W m^{-2} for occupational exposure and of 20 W m^{-2} for general public exposure are twice the limit values set by 1998 guidelines. However, the reader should keep in mind that the new restrictions refer to absorbed power density, which is a measure of exposure of the body, while the old restrictions from 1998 concern the incident power density (S_{inc}) which is a parameter of the external field. The different values of the new basic restrictions are due to the decreased averaging area from 20 to 4 cm^2 to match the face of the averaging volume (10 g) of SAR, and, therefore, the new restrictions on power density provide a consistent transition at 6 GHz (8). In addition to previous guidelines, the latest guidelines also included new types of restrictions to protect against brief local exposure to intense fields. For exposures lasting < 6 minutes, basic restrictions in terms of local specific absorption (SA), and absorbed energy density (U_{ab}) were set. Moreover, the new guidelines also take into account the nerve stimulation effect and therefore, restrictions have been taken over from the ICNIRP 2010 guidelines on low-frequency electric and magnetic fields. Basic restrictions for nerve stimulation are expressed in terms of induced electric field strength and limit values are provided for frequencies between 100 kHz and 10 MHz .

Conclusions

The new ICNIRP 2020 guidelines are more detailed than previous guidelines and cover a wider range of exposure scenarios. New physical quantities and new metrics are used for setting restrictions on different types of exposure. Besides the whole-body exposure, the new radiofrequency guidelines provide reference levels for local exposure and brief intense local exposure. Although the guidelines are more comprehensive, their provisions might confuse the reader due to the complexity of changes, as well as the introduction of some new concepts and quantities that represents a challenge for practitioners who need to perform compliance evaluation.

Considering the complexity and novelty of the new guidelines, training of personnel involved in measurement of radiofrequency field levels and evaluating compliance with exposure

restrictions is needed. Besides additional information and advice on exposure restrictions and quantities expressing them, aspects related to practical determination of the new quantities or the use of new metrics should be approached. Guidance is needed on different technical issues as measurement of incident power density, especially within the radiative near-field zone, as well as averaging over 4 and 1-cm² areas. For the determination of the newly introduced quantity, the incident energy density, clarification is needed on methods and equipment to use and how to process the measurement data. Moreover, between 100 kHz and 10 MHz, two sets of reference levels for both, electric and magnetic field strength, one set for thermal effect and the other one for nerve stimulation effect are provided and, consequently, guidance is necessary on the way to apply them. As the authors emphasized, generally one of the two sets of reference levels is more relevant for each electric or magnetic field strength. Further clarification is needed on which of the two types of reference level prevails and should be used when evaluating compliance in real exposure scenarios.

The exact manner of measuring or calculating the physical quantities expressing all reference levels needs to be provided by relevant technical bodies. Standardized procedures should also take into account the characteristics of different types of sources and possible exposure scenarios accounting for reasonable assumable intended use, as well as for worst case exposure scenario. Moreover, manufacturers of measuring equipment should develop appropriate equipment and probes for measuring all physical quantities and cover all exposure metrics with the aim of allowing evaluation of compliance with all reference levels provided by the new guidelines.

To conclude, the amount and the complexity of changes, as well as the novelty related to concepts, quantities and specific provisions led to more detailed and precise guidelines, but more complex and more difficult to assimilate and to use in practice. Therefore, qualified advice for good practice in evaluating compliance with guidelines is needed, as well as guidance for adequate measurement methods and procedures, and appropriate selection of measuring equipment. Further advice on the entire process of exposure assessment will be required to facilitate the implementation of the new ICNIRP guidelines in practice when they are adopted as European or national regulations.

<https://pubmed.ncbi.nlm.nih.gov/37225206/>

MOBILE PHONE CALLS, GENETIC SUSCEPTIBILITY, AND NEW-ONSET HYPERTENSION: RESULTS FROM 212 046 UK BIOBANK PARTICIPANTS

Ye Z, Zhang Y, Zhang Y, Yang S, Liu M, Wu Q, Zhou C, He P, Gan X, Qin X. Mobile phone calls, genetic susceptibility, and new-onset hypertension: results from 212 046 UK Biobank participants. *European Heart Journal - Digital Health*, 2023. doi: 10.1093/ehjdh/ztad024.

Abstract

Aims The relationship between mobile phone use for making or receiving calls and hypertension risk remains uncertain. We aimed to examine the associations of mobile phone use for making or receiving calls and the use frequency with new-onset hypertension in the general population, using data from the UK Biobank.

Methods and results A total of 212 046 participants without prior hypertension in the UK Biobank were included. Participants who have been using a mobile phone at least once per week to make or receive calls were defined as mobile phone users. The primary outcome was new-onset hypertension. During a median follow-up of 12.0 years, 13 984 participants developed new-onset hypertension. Compared with mobile phone non-users, a significantly higher risk of new-onset hypertension was found in mobile phone users [hazards ratio (HR), 1.07; 95% confidence interval (CI): 1.01–1.12]. Among mobile phone users, compared with those with a weekly usage time of mobile phones for making or receiving calls <5 mins, significantly higher risks of new-onset hypertension were found in participants with a weekly usage time of 30–59 mins (HR, 1.08; 95%CI: 1.01–1.16), 1–3 h (HR, 1.13; 95%CI: 1.06–1.22), 4–6 h (HR, 1.16; 95%CI: 1.04–1.29), and >6 h (HR, 1.25; 95%CI: 1.13–1.39) (P for trend <0.001). Moreover, participants with both high genetic risks of hypertension and longer weekly usage time of mobile phones making or receiving calls had the highest risk of new-onset hypertension.

Conclusions Mobile phone use for making or receiving calls was significantly associated with a higher risk of new-onset hypertension, especially among high-frequency users

Excerpts

In this large, population-based prospective cohort study, we first demonstrated that mobile phone use for making or receiving calls was significantly related to a higher risk of new-onset hypertension. More importantly, among mobile phone users, there was a significantly positive association between the weekly usage time of mobile phones for making or receiving calls and new-onset hypertension. In addition, the association between weekly usage of mobile phones for making or receiving calls and the risk of hypertension was strengthened by the genetic susceptibility to hypertension. Nevertheless, there were no significant associations between the length of mobile phone use or hands-free device/speakerphone use to make or receive calls and the risk of new-onset hypertension. These findings suggested that it is the frequency of mobile phone use for making or receiving calls, rather than the length of start using it, that determined the effect of mobile phone use on the risk of hypertension. In other words, long-term healthy mobile phone use for making or receiving calls may not affect the risk of hypertension as long as it is used for no more than 30 min per week to make or receive calls.

... it is possible that our study underestimated the association between weekly usage time making or receiving calls and the risk of new-onset hypertension. In fact, according to the answers to the question ‘Is there any difference between your mobile phone use now compared to 2 years ago?’, only 12.8% and 13.7% of the participants at baseline and at 2012–13 follow-up in the UK biobank study reported that the mobile phone use was now less frequent. What’s more, we also found a significantly positive association between weekly usage of mobile phones for making or receiving calls and an increase in SBP levels at the 2012–13 follow-up (vs. that at baseline) (see Supplementary material online, Figure S2). This result, with a more objective outcome and having direct data indicating relatively stable mobile use during follow-up, further supported our findings of the positive association between weekly usage of mobile phones for making or receiving calls and new-onset hypertension....

In conclusion, mobile phone use for making or receiving calls was significantly associated with a higher risk of new-onset hypertension, especially in those with a longer weekly usage time, among the general population. Our findings and the underlying mechanisms should be further evaluated in more studies. If further confirmed, our study suggests that reducing the time spent using mobile phones to make or receive calls may play a role in the primary prevention of hypertension in the general population.

Open access paper:

<https://academic.oup.com/ehjdh/advance-article/doi/10.1093/ehjdh/ztad024/7131479>

EFFECTS OF MAN-MADE ELECTROMAGNETIC FIELDS ON HEART RATE VARIABILITY PARAMETERS OF GENERAL PUBLIC: A SYSTEMATIC REVIEW AND META-ANALYSIS OF EXPERIMENTAL STUDIES

Mansourian M, Marateb H, Nouri R, Mansourian M. Effects of man-made electromagnetic fields on heart rate variability parameters of general public: a systematic review and meta-analysis of experimental studies. *Rev Environ Health*. 2023 May 18. doi: 10.1515/reveh-2022-0191.

Abstract

Objectives: The effects of man-made electromagnetic fields (EMFs) on the cardiovascular system have been investigated in many studies. In this regard, the cardiac autonomic nervous system (ANS) activity due to EMFs exposure, assessed by heart rate variability (HRV), was targeted in some studies. The studies investigating the relationship between EMFs and HRV have yielded conflicting results. We performed a systematic review and meta-analysis to assess the data's consistency and identify the association between EMFs and HRV measures.

Content: Published literature from four electronic databases, including Web of Science, PubMed, Scopus, Embase, and Cochrane, were retrieved and screened. Initially, 1601 articles were retrieved. After the screening, 15 original studies were eligible to be included in the meta-analysis. The studies evaluated the association between EMFs and SDNN (standard deviation of NN intervals), SDANN (Standard deviation of the average NN intervals for each 5 min segment of a 24 h HRV recording), and PNN50 (percentage of successive RR intervals that differ by more than 50 ms).

Summary: There was a decrease in SDNN (ES=-0.227 [-0.389, -0.065], p=0.006), SDANN (ES=-0.526 [-1.001, -0.05], p=0.03) and PNN50 (ES=-0.287 [-0.549, -0.024]). However, there was no significant difference in LF (ES=0.061 [-0.267, 0.39], p=0.714) and HF (ES=-0.134 [-0.581, 0.312], p=0.556). In addition, a significant difference was not observed in LF/HF (ES=0.079 [-0.191, 0.348], p=0.566).

Outlook: Our meta-analysis suggests that exposure to the environmental artificial EMFs could significantly correlate with SDNN, SDANN, and PNN50 indices. Therefore, lifestyle modification is essential in using the devices that emit EMs, such as cell phones, to decrease some signs and symptoms due to EMFs' effect on HRV.

Excerpts

Nevertheless, the possible mechanism of EMFs' effect on the cardiovascular system (slowing of heart rate) is speculated to be due to the interaction of these fields with the control mechanisms for blood pressure and thermoregulation [84]. However, although the exact underlying mechanism of the association between EMFs exposure and HRV is unclear, the results of the present meta-analysis and previous studies could be advisable to suggest that excessive use of cell phones should be avoided to decrease some signs and symptoms caused by HRV change, as a result of EMFs exposure. More attention should also be paid to the young people frequently exposed to EMFs due to using cell phones for a long time. According to our results, EMF exposure might considerably affect the autonomic balance and provoke adverse health effects. Therefore, lifestyle modifications could be effective in decreasing the incidence of cardiovascular diseases.

Some limitations exist in our meta-analysis. First, the few case-control studies for each HRV indices affect our meta-analysis to control before-and-after studies. Second, there were not enough studies or adequate information in the results of some studies for other HRV measurements; these HRV indices were not analyzed. Third, in addition to a small number of studies in some groups, the groups participating in the study may use other communication devices that emit EMF or have different times of telephone conversations per day; more attention must be paid with caution while interpreting the findings. Finally, in our meta-analysis, studies that evaluated HRV in the electrohypersensitive subjects were not included, which assessment of these studies is highly recommended.

Conclusions

Our data indicated that EMF exposure could influence cardiac sympathetic and parasympathetic indexes such as SDNN. Our findings could support the hypothesis that exposure to RF EMFs emitted by RF fields like cell phones may cause chronic stress and various psychiatric disorders by influencing some time domain HRV indexes.

<https://pubmed.ncbi.nlm.nih.gov/37195230/>

ELECTROMAGNETIC FIELDS - DO THEY POSE A CARDIOVASCULAR RISK?

Parizek D, Visnovcova N, Hamza Sladicekova K, Misek J, Jakus J, Jakusova J, Kohan M, Visnovcová Z, Ferencova N, Tonhajzerova I. Electromagnetic fields - do they pose a cardiovascular risk? *Physiol Res*. 2023 Apr 30;72(2):199- 208.

Abstract

Mobile wireless communication technologies have now become an everyday part of our lives, 24 hours a day, 7 days a week. Monitoring the autonomous system under exposition to electromagnetic fields may play an important role in broadening of our still limited knowledge on their effect on human body. Thus, we studied the interaction of the high frequency electromagnetic field (HF EMF) with living body and its effect on the autonomic control of heart rate using Heart Rate Variability (HRV) linear and nonlinear analyses in healthy volunteers. A group of young healthy probands (n=30, age mean: 24.2 ± 3.5 years) without any symptoms of disease was exposed to EMF with $f=2400$ MHz (Wi Fi), and $f=2600$ MHz (4G) for 5 minutes applied on the chest area. The short-term heart rate variability (HRV) metrics were used as an indicator of complex cardiac autonomic control. The evaluated HRV parameters: RR interval (ms), high frequency spectral power (HF-HRV in $[\ln(\text{ms}^2)]$) as an index

of cardiovagal control, and a symbolic dynamic index of 0V %, indicating cardiac sympathetic activity. The cardiac-linked parasympathetic index HF-HRV was significantly reduced ($p=0.036$) and sympathetically mediated HRV index 0V % was significantly higher ($p=0.002$) during EMF exposure at 2400 MHz (Wi-Fi), compared to simulated 4G frequency 2600 MHz. No significant differences were found in the RR intervals. Our results revealed a shift in cardiac autonomic regulation towards sympathetic overactivity and parasympathetic underactivity indexed by HRV parameters during EMF exposure in young healthy persons. It seems that HF EMF exposure results in abnormal complex cardiac autonomic regulatory integrity which may be associated with higher risk of later cardiovascular complications already in healthy probands.

Conclusions

Our study revealed discrete abnormalities of complex cardiac autonomic regulation indexed by HRV measures dependent on the effects of 4G and Wi-Fi networks. It seems that direct exposure to high radiofrequency EMF may be associated with a higher risk of cardiovascular complications already in healthy youth. However, the results need to be validated in a future study on a larger number of young probands under the same conditions.

Open access paper: http://www.biomed.cas.cz/physiolres/pdf/72/72_199.pdf

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.

Excerpts

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-EMF exposure 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>

ELECTROMAGNETIC FIELDS EXPOSURE ON FETAL AND CHILDHOOD ABNORMALITIES: SYSTEMATIC REVIEW AND META-ANALYSIS

Kashani ZA, Pakzad R, Fakari FR, Haghparast MS, Abdi F, Kiani Z, Talebi A, Haghgoo SM. Electromagnetic fields exposure on fetal and childhood abnormalities: Systematic review and meta-analysis. *Open Med (Wars)*. 2023 May 12;18(1):20230697. doi: 10.1515/med-2023-0697.

Abstract

Today, in the modern world, people are often exposed to electromagnetic waves, which can have undesirable effects on cell components that lead to differentiation and abnormalities in cell proliferation, deoxyribonucleic acid (DNA) damage, chromosomal abnormalities, cancers, and birth defects. This study aimed to investigate the effect of electromagnetic waves on fetal and childhood abnormalities. PubMed, Scopus, Web of Science, ProQuest, Cochrane Library, and Google Scholar were searched on 1 January 2023. The Cochran's Q-test and I² statistics were applied to assess heterogeneity, a random-effects model was used to estimate the pooled odds ratio (OR), standardized mean difference (SMD), and mean difference for different outcomes, and a meta-regression method was utilized to investigate the factors affecting heterogeneity between studies. A total of 14 studies were included in the analysis, and the outcomes investigated were: change in gene expression, oxidant parameters, antioxidant parameters, and DNA damage parameters in the umbilical cord blood of the fetus and fetal developmental disorders, cancers, and childhood development disorders. Totally, the events of fetal and childhood abnormalities were more common in parents who have been exposed to EMFs compared to those who have not (SMD and 95% confidence interval [CI], 0.25 [0.15-0.35]; I², 91%). Moreover, fetal developmental disorders (OR, 1.34; CI, 1.17-1.52; I², 0%); cancer (OR, 1.14; CI, 1.05-1.23; I², 60.1%); childhood development disorders (OR, 2.10; CI, 1.00-3.21; I², 0%); changes in gene expression (mean difference [MD], 1.02; CI, 0.67-1.37; I², 93%); oxidant parameters (MD, 0.94; CI, 0.70-1.18; I², 61.3%); and DNA damage parameters (MD, 1.01; CI, 0.17-1.86; I², 91.6%) in parents who have been exposed to EMFs were more than those in parents who have not. According to meta-regression, publication year has a significant effect on heterogeneity (coefficient: 0.033; 0.009-0.057). Maternal exposure to electromagnetic fields, especially in the first trimester of pregnancy, due to the high level of stem cells and their high sensitivity to this radiation, the biochemical

parameters of the umbilical cord blood examined was shown increased oxidative stress reactions, changes in protein gene expression, DNA damage, and increased embryonic abnormalities. In addition, parental exposure to ionizing and non-ionizing radiation can lead to the enhancement of different cell-based cancers and developmental disorders such as speech problems in childhood.

Open access paper: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10183723/>

ELECTRONIC DEVICE AND SOCIAL NETWORK USE AND SLEEP OUTCOMES AMONG ADOLESCENTS: THE EHDLA STUDY

Gaya AR, Brum R, Brites K, Gaya A, de Borja Schneiders L, Duarte Junior MA, López-Gil JF. Electronic device and social network use and sleep outcomes among adolescents: the EHDLA study. BMC Public Health. 2023 May 19;23(1):919. doi: 10.1186/s12889-023-15579-x.

Abstract

Background: Considering the evident risk in the literature between the use of screen devices and sleep, there are still few studies on the relationship between each electronic screen device, media programs and sleep duration and sleep-related problems among adolescents and which variables interfere in these relationships. Therefore, this study has the following objectives: (1) to determine which are the most common electronic display devices related to sleep time and outcomes and (2) to determine which are the most common social network applications, such as Instagram and WhatsApp, associated with sleep outcomes.

Methods: This was a cross-sectional study with 1101 Spanish adolescents between 12 and 17 years old. Age, sex, sleep, psychosocial health, adherence to the Mediterranean diet (MD), sport practice, and time spent on screen devices were assessed by an ad hoc questionnaire. Linear regression analyses were applied, adjusting for several covariables. Poisson regression was applied between the sexes. A p value < 0.05 was considered statistically significant.

Results: Cell phone use was more associated with sleep time (13%). In boys, time spent on cell phones (prevalence ratio [PR] = 1.09; p < 0.001) and videogames (PR = 1.08; p = 0.005) had a higher prevalence ratio.

When psychosocial health was included in the models, we found the greatest association (Model 2: PR = 1.15; p = 0.007). For girls, time spent on the cell phone was significantly associated with sleep-related problems (PR = 1.12; p < 0.001), and adherence to the MD became the second most important in the model (PR = 1.35; p < 0.001), followed by psychosocial health and cell phone use (PR = 1.24; p = 0.007). Time spent on WhatsApp was associated with sleep-related problems only among girls (PR = 1.31; p = 0.001) and was the most important variable in the model along with MD (PR = 1.26; p = 0.005) and psychosocial health (PR = 1.41; p < 0.001).

Conclusions: Our results suggest a relationship between cell phones, video games, and social networks with sleep-related problems and time.

Open access paper: <https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-023-15579-x>

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;46(1):48-59. doi: 10.1016/j.bj.2023.01.003.

Highlights

- The earth's natural electromagnetic fields influence the circadian rhythm in humans.
- Sunspots and seasonal weakening of the geomagnetic field can affect human health.
- Seasonal geomagnetic field weakening increases infectious and chronic diseases.
- Electromagnetic pollution from wireless devices can also affect circadian rhythms.
- Grounding and reduction of electromagnetic pollution can produce health benefits.

Abstract

Living organisms have evolved within the natural electromagnetic fields (EMFs) of the earth which comprise the global atmospheric electrical circuit, Schumann resonances (SRs) 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 EMFs. 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 EMFs involve entrainment via electrons and electromagnetic waves, light-dependent radical pair formation in retina cryptochromes, and paramagnetic magnetite nanoparticles. Factors such as electromagnetic pollution from wireless devices, base antennas and low orbit internet satellites, shielding by non-conductive materials used in shoes and buildings, and local geomagnetic anomalies may also affect sensing of the earth's EMFs 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>

ELECTROMAGNETIC FIELD EXPOSURE TO HUMAN HEAD MODEL WITH VARIOUS METAL OBJECTS AT SUB-6 GHZ FREQUENCIES

İl N, Ateş K, Özen Ş. Electromagnetic field exposure to human head model with various metal objects at sub-6 GHz frequencies. *Electromagn Biol Med.* 2023 Jun 4:1-9. doi: 10.1080/15368378.2023.2220736.

Abstract

In recent years, the interactions of metal objects in human body with electromagnetic fields caused by devices working at fifth-generation (5G) frequencies have been studied by various researchers. A motivation behind this research was to evaluate the human body absorption of electromagnetic energy operating at sub-6 GHz 5G applications. According to this, the specific absorption rate (SAR) caused by new generation mobile phones was investigated in human heads wearing metal-framed spectacles and having metallic implants or earrings to

analyse electromagnetic field exposure. A realistic human head model, including some metal objects, was numerically calculated, and analysed in terms of non-ionizing dosimetry. Simulations were carried out with the finite integration technique (FIT) based commercial software in the frequencies of 0.9, 1.8, 2.1, 2.45, 3.5 and 5 GHz, respectively. The maximum SAR of 14×10^{-5} W/kg for 10 g average tissue was calculated at 2.45 GHz frequency in the head model with earrings. The highest electric field strength of 0.52 V/m was observed at a 1.8 GHz frequency in the head model with all metal objects equipped. Results show that metal objects such as spectacles, dental implants and earrings can cause an increase in the SAR values for external biological tissues, and metal objects can behave as a kind of shield for deeper tissues. However, the obtained values are below the limits of international organisations. <https://pubmed.ncbi.nlm.nih.gov/37270798/>

A MATHEMATICAL MODEL AND EXPERIMENTAL PROCEDURE TO ANALYZE THE COGNITIVE EFFECTS OF AUDIO FREQUENCY MAGNETIC FIELDS

Navarro EA, Navarro-Modesto E. A mathematical model and experimental procedure to analyze the cognitive effects of audio frequency magnetic fields. *Front Hum Neurosci*. 2023 May 12;17:1135511. doi: 10.3389/fnhum.2023.1135511.

Abstract

Audio frequency magnetic fields (20 Hz-20 kHz) are magnetic fields in extremely low frequency-very low frequency (ELF-VLF) bands that are present near audio equipment and acoustic transducers. These devices transform and operate the electrical signal from the recordings or other devices into acoustic and audio signals. The cognitive influence of sound and noise has been widely studied and recognized since the times of ancient Rome; however, the cognitive effects of the magnetic fields of these frequencies have not been studied. Due to the extensive use of audio devices that use this type of transducer near the temporal-parietal area, we believe that it is of interest to study their impact on short-term memory or working memory (WM) and to analyze their potential as they operate as a transcranial magnetic stimulation. In this study, a mathematical model and an experimental tool are introduced to analyze memory performance. The model dissociates the reaction time of a cognitive task. We analyze the model in data from a group of 65 young, healthy subjects. WM is assessed in our experimental setup by means of the Sternberg test (ST), whereby during the ST, one subgroup was exposed to an audio frequency magnetic stimulus, and the other subgroup received a sham stimulus. The magnetic stimulus was $\sim 0.1 \mu\text{T}$ and was applied to both sides of the head at the frontal cortex near the temporal-parietal area, which is where WM is expected to be located. The ST records reaction times when determining whether an object displayed on the computer screen is one of the objects to be remembered. The results are analyzed within the mathematical model and changes are observed, including the deterioration of WM, which could affect 32% of its operability.

Conclusion

In this article, we have presented a mathematical model and an experimental procedure to study cognitive effects on WM. The model distinguishes between the effects on peripheral activity and cognitive activity in the brain. This model is simple and applicable to the non-invasive study of cognitive impairment under the action of stimuli of different origins. This procedure has been applied to the study of the effects of audio frequency magnetic stimulus on the area of the brain that supports WM. The procedure has been applied to a

homogeneous set of 65 young, healthy subjects, i.e., undergraduate students. Tests performed with exposed and non-exposed groups have been analyzed and show statistically significant differences in response times that can be separated according to the mathematical model. The differences show a small reduction in the time spent in response selection, preparation, and execution of 15 ms over 428 ms (1.5%), the effect of which could resemble the activation of an alert situation. However, exposure results in 32% longer delays in memory search than in the case of non-exposure. These results indicate that exposure to magnetic fields in the audio frequency band could produce significant cognitive impairment in the young population. Finally, we believe that eddy currents play a plausible role in the biophysical mechanism of action that could be related to some physical stimulus or tissue micro heating.

Open access paper: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10218710/>

HUMAN EXPOSURE TO NON-IONIZING RADIATION FROM INDOOR DISTRIBUTED ANTENNA SYSTEM: SHOPPING MALL MEASUREMENT ANALYSIS

da L. A. Silva J, de Sousa VA Jr., Rodrigues MEC, Pinheiro FSR, da Silva GS, Mendonça HB, de F. H. Silva RQ, da Silva JVL, Galdino FES, de Carvalho VFC, Medeiros LIC. Human Exposure to Non-Ionizing Radiation from Indoor Distributed Antenna System: Shopping Mall Measurement Analysis. *Sensors*. 2023; 23(10):4579. doi: 10.3390/s23104579

Abstract

It is crucial to monitor the levels of Non-Ionizing Radiation (NIR) to which the general population may be exposed and compare them to the limits defined in the current standards, in view of the rapid rise of communication services and the prospects of a connected society. A high number of people visits shopping malls and since these locations usually have several indoor antennas close to the public, it is therefore a kind of place that must be evaluated. Thus, this work presents measurements of the electric field in a shopping mall located in Natal, Brazil. We proposed a set of six measurement points, following two criteria: places with great the flow of people and the presence of one or more Distributed Antenna System (DAS), co-sited or not with WiFi access points. Results are presented and discussed in terms of the distance to DAS (conditions: near and far) and flow density of people in the mall (scenarios: low and high number of people). The highest peaks of electric field measured were 1.96 and 3.26 V/m, respectively corresponding to 5% and 8% of the limits defined by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Brazilian National Telecommunication Agency (ANATEL).

Conclusions

This work aimed to evaluate the levels of exposure to NIR in shopping malls, considering the few scientific publications in this scenario and being aware of the importance of this study, especially regarding the high circulation of people in these environments and the large number of antennas relatively close to the public.

The measurements carried out showed that the electric fields were significantly below the limits established by ANATEL and ICNIRP. For the target frequency bands in this work, the highest average and peak electric fields were less than 8% of the limit, with values of 1.96 and 3.26 V/m, respectively. Both results correspond to the P3L2 place, characterized by having the largest number of DAS antennas together.

When comparing the change in antenna distance condition for a given number of people scenario, we also verified the strong influence of the number of nearby antennas. Places P2L1, P1L2, and P3L2 have at least two DAS antennas and/or a nearby WiFi antenna, and their measurements showed significant changes between the near and far conditions. Furthermore, these places presented the highest overall levels of exposure to NIR.

By grouping measured data corresponding to the same distance condition, we could observe the influence of the number of people on the exposure levels. The highest electric field values were verified at times when the mall was most crowded, as in [15].

Based on the results, the influence of the antenna distance and the concentration of people in the mall on the electric field levels was noted, but in none of the situations did the exposure levels rise above the safe limits established by ICNIRP and ANATEL. However, since there is not a global conclusion, neither from the academic community nor from the World Health Organization (WHO), on the harmful effects of NIR on human health, prevention is always necessary. Thus, besides the general population being oriented to a moderate use of mobile phones, the importance of an adequate project for the distribution of antennas in malls to avoid the intensification of NIR levels caused by the concentration of antennas is verified, mainly in places where the public stays for a long time.

Open access paper: <https://www.mdpi.com/1424-8220/23/10/4579>

RADIOFREQUENCY PERSONAL EXPOSIMETRY DURING OUTDOOR ENTERTAINMENT OF YOUNG ADULTS: A CASE STUDY

Vecsei Z, Szilágyi Z, Thuróczy G. Radiofrequency personal exposimetry during outdoor entertainment of young adults: a case study. *Radiat Prot Dosimetry*. 2023 May 24;199(8-9):865-871. doi: 10.1093/rpd/ncad087.

Abstract

Radiofrequency (RF) exposure has grown substantially over time in the public area. Personal dosimetry measurements are intended to estimate how human RF exposure relates to exposure limits that do not pose a health risk. For our case study, an outdoor festival was chosen to assess realistic RF exposure of young adults during their entertainment. Band-selective RF exposure-sorted along 2G-4G uplinks and downlinks, 5G and Wi-Fi bands-was evaluated. Electric field strength data subsets were classified on the basis of activities as well as crowd density. 2G contributed the most to the overall RF exposure. Highest RF exposure was associated with attendance in a concert. In moderately crowded situations, RF exposure was higher than in the most crowded ones. However, the total measured electric field values were higher than in other outdoor environment, but still far below the national and international directives of regulatory RF-EMF exposure limits.

Excerpt

Of the activities, participation in a concert was associated with the highest RF exposure. The highest exposure levels according to density were found in the medium group. The explanation for that moderately dense situations showed higher RF exposure than crowded ones might be the potential lower RF shadowing compared with the high-density situations (Figure 4). The mean exposure level from UL (uplink) connection is much lower than DL

(downlink) communications. The reason may be the different time slots between the above-mentioned two operation modes. However, when measuring UL, the proximity of the human body to the mobile phone and exposure to near-field conditions can significantly influence the results. The exposure during the resting activity shows the typical public exposure in outdoor urban situations (1, 11, 12). <https://pubmed.ncbi.nlm.nih.gov/37225187/>

EFFECTS OF 5G-MODULATED 3.5 GHZ RADIOFREQUENCY FIELD EXPOSURES ON HSF1, RAS, ERK, AND PML ACTIVATION IN LIVE FIBROBLASTS AND KERATINOCYTES CELLS

Joushomme A, Orlacchio R, Patrignoni L, Canovi A, Chappe YL, Poullietier De Gannes F, Hurtier A, Garenne A, Lagroye I, Moisan F, Cario M, Lévêque P, Arnaud-Cormos D, Percherancier Y. Effects of 5G-modulated 3.5 GHz radiofrequency field exposures on HSF1, RAS, ERK, and PML activation in live fibroblasts and keratinocytes cells. *Sci Rep.* 2023 May 23;13(1):8305. doi: 10.1038/s41598-023-35397-w.

Abstract

The potential health risks of exposure to radiofrequency electromagnetic fields from mobile communications technologies have raised societal concerns. Guidelines have been set to protect the population (e.g. non-specific heating above 1 °C under exposure to radiofrequency fields), but questions remain regarding the potential biological effects of non-thermal exposures. With the advent of the fifth generation (5G) of mobile communication, assessing whether exposure to this new signal induces a cellular stress response is one of the mandatory steps on the roadmap for a safe deployment and health risk evaluation. Using the BRET (Bioluminescence Resonance Energy-Transfer) technique, we assessed whether continuous or intermittent (5 min ON/ 10 min OFF) exposure of live human keratinocytes and fibroblasts cells to 5G 3.5 GHz signals at specific absorption rate (SAR) up to 4 W/kg for 24 h impact basal or chemically-induced activity of Heat Shock Factor (HSF), RAt Sarcoma virus (RAS) and Extracellular signal-Regulated Kinases (ERK) kinases, and Promyelocytic Leukemia Protein (PML), that are all molecular pathways involved in environmental cell-stress responses. The main results are (i), a decrease of the HSF1 basal BRET signal when fibroblasts cells were exposed at the lower SARs tested (0.25 and 1 W/kg), but not at the highest one (4 W/kg), and (ii) a slight decrease of As2O3 maximal efficacy to trigger PML SUMOylation when fibroblasts cells, but not keratinocytes, were continuously exposed to the 5G RF-EMF signal. Nevertheless, given the inconsistency of these effects in terms of impacted cell type, effective SAR, exposure mode, and molecular cell stress response, we concluded that our study show no conclusive evidence that molecular effects can arise when skin cells are exposed to the 5G RF-EMF alone or with a chemical stressor.

Open access paper: <https://www.nature.com/articles/s41598-023-35397-w>

MEASURING EMF AND THROUGHPUT BEFORE AND AFTER 5G SERVICE ACTIVATION IN A RESIDENTIAL AREA

Chiaraviglio L, Bartoletti S, Blefari-Melazzi N, Lodovisi C, Moretti A, Zampognaro F, Alouini M-S. Measuring EMF and Throughput Before and After 5G Service Activation in a Residential Area. IEEE Open Journal of the Communications Society, doi: 10.1109/OJCOMS.2023.3277782.

Abstract

The deployment of 5G networks is approaching a mature phase in many countries across the world. However, little efforts have been done so far to scientifically compare ElectroMagnetic Field (EMF) exposure and traffic levels before and after the activation of 5G service over the territory. The goal of this work is to provide a sound comparative assessment of exposure and traffic, by performing repeated measurements before and after 5G provisioning service. Our solution is based on an EMF meter and a spectrum analyzer that is remotely controlled by a measurement algorithm. In this way, we dissect the contribution of each pre-5G and 5G band radiating over the territory. In addition, we employ a traffic chain to precisely characterize the achieved throughput levels.

Results, derived from a set of measurements performed on a commercial deployment, reveal that the provisioning of 5G service over mid-band frequencies has a limited impact on the exposure. In parallel, the measured traffic is more than doubled when 5G is activated over mid-bands, reaching levels above 200 Mbps. On the other hand, the provisioning of 5G over sub-GHz bands does not introduce a substantial increase in the traffic levels. Eventually, we demonstrate that EMF exposure is impacted by the raw-land reconfiguration to host the 5G panels, which introduces changes in the sight conditions and in the power received from the main lobes.

Open access paper: <https://ieeexplore.ieee.org/document/10129117>

HOW 5G NR SIGNALS IMPACT ON THE RESPONSE OF BROADBAND ELECTRIC FIELD PROBES

Adda S, Anglesio L, Bogó F, Pasquino N, Trinchero S. How 5G NR Signals Impact on the Response of Broadband Electric Field Probes. IEEE Transactions on Instrumentation and Measurement, vol. 72, pp. 1-8, 2023, Art no. 8000208, doi: 10.1109/TIM.2022.3227979.

Abstract

New-generation mobile communication systems like long term evolution (LTE) and 5G new radio (NR) use digitally modulated signals with relevant peak-to-average power ratios that may shift the working point of diode-based wideband electric field probes, resulting in an overestimation of the field strength. This article presents a methodology to study the behavior of probes by comparing the readings of 5G signals to those obtained under continuous wave (CW) radiation. Dependence on various signal parameters like center frequency, modulation complexity, time/frequency duplex configuration, signal bandwidth, and orthogonal frequency-division multiplexing (OFDM) subcarrier spacing has been assessed experimentally by making use of test models designed by 3rd generation partnership project (3GPP). Results show that overestimation can be as large as several tens of percent and that it is greater for full-frame and larger bandwidth signals and that, therefore, calibration standards must be extended to consider the different behavior of probes with 5G and CW signals.

Conclusion

Diode-loaded electric field probes have been exposed to 5G signals to investigate the different behavior compared to continuous waves, in terms of under- or over-estimation. Test signals based on models suggested by ETSI have been used to assess the impact of signal center frequency, frame occupation, bandwidth, modulation, duplex configuration, and subcarrier spacing. Results show that, due to the high crest factor of 5G signals, probes tend to overestimate amplitude when exposed to high test fields, because the diode overcomes the quadratic region and responds to the peak strength rather than to the rms value of the incident field. A possible solution would be to adopt a variable attenuator at the diode's input that keeps the working point within the quadratic region.

The analysis of the overestimation factor K shows that overestimation can be as large as several tens of percent and that it spans from 1.07 to 1.225 at 3700 MHz with TDD configuration and $\mu=1$, being greater for full-frame and larger bandwidth signals. Experimental results prove that diode-based sensor probes should be used with caution when electromagnetic fields of expected strengths larger than 6 V/m are measured, to avoid that, due to overestimation, they return a measurement that shows not compliant with exposure limits.

Open access paper: <https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9978729>

COMPARISON OF LOW-COST 5G ELECTROMAGNETIC FIELD SENSORS

Deprez K, Colussi L, Korkmaz E, Aerts S, Land D, Littel S, Verloock L, Plets D, Joseph W, Bolte J. Comparison of Low-Cost 5G Electromagnetic Field Sensors. *Sensors*. 2023; 23(6):3312. doi:10.3390/s23063312.

Abstract

This paper compares different low-cost sensors that can measure (5G) RF-EMF exposure. The sensors are either commercially available (off-the-shelf Software Defined Radio (SDR) Adalm Pluto) or constructed by a research institution (i.e., imec-WAVES, Ghent University and Smart Sensor Systems research group (S³R), The Hague University of Applied Sciences). Both in-lab (GTEM cell) and in-situ measurements have been performed for this comparison. The in-lab measurements tested the linearity and sensitivity, which can then be used to calibrate the sensors. The in-situ testing confirmed that the low-cost hardware sensors and SDR can be used to assess the RF-EMF radiation. The variability between the sensors was 1.78 dB on average, with a maximum deviation of 5.26 dB. Values between 0.09 V/m and 2.44 V/m were obtained at a distance of about 50 m from the base station. These devices can be used to provide the general public and governments with temporal and spatial 5G electromagnetic field values.

Conclusions and Future Work

This study compared low-cost hardware sensors and SDR sensors with expensive verified measurement setups consisting of spectrum analyzer equipment for RF-EMF radiation. Both in-lab (GTEM cell) and in-situ measurements have been performed for this comparison. The in-lab testing showed the importance of selecting the correct components for the hardware sensors to ensure shielding from crosstalk. Furthermore, an in-lab calibration must be performed to guarantee an accurate response to real-life exposure.

The in-situ testing confirmed that the low-cost hardware sensors and SDR can be used to assess the RF-EMF radiation. Values between 0.09 V/m and 2.44 V/m were obtained at a distance of about 50 m from the base station. The variability between the sensors was 1.78 dB on average, with a maximum deviation of 5.26 dB. However, it must be kept in mind that these RF-EMF sensors only measured one vector component (purpose of temporal monitoring) of the field, and therefore, the given field will be an underestimation of the total field at that measurement location.

These devices can be used to provide the general public and governments only temporal and spatial 5G field behavior values. These data can then be combined with more accurate measurement systems to create highly accurate spatial-temporal EMF radiation maps.

Future research on these sensors entails including the maximum measurable field level to verify the extendibility of the conclusions presented in this paper in case of high EMFs. In addition, new tri-axial sensors must be constructed which can measure all three vector components. In addition, mm-waves hardware sensors must be made to cover all 5G NR frequencies (FR2). Furthermore, the current sensors could be recalibrated so that their response is mapped to tri-axial measurement devices.

Open access paper: <https://www.mdpi.com/1424-8220/23/6/3312>

INTERACTION OF SELECTED PARTS OF THE HUMAN BODY WITH RADIO FREQUENCY FIELDS

B. Dolník, E. Dolníková, E. Lumnitzer, E. Jurgovská, P. Liptai and L. Šárpataky. Interaction of selected parts of the human body with radio frequency fields. 2023 33rd International Conference Radioelektronika (RADIOELEKTRONIKA), Pardubice, Czech Republic, 2023, pp. 1-5, doi: 10.1109/RADIOELEKTRONIKA57919.2023.10109067.

Abstract

The issue of how electromagnetic waves interact with living organisms becomes increasingly critical with communication tools expansion that operates in the microwave region. This article deals with the human attenuation of microwaves in the 800 MHz to 6 GHz band. Experimental attenuation measurements focus on specific parts of the males aged 26 to 28: head, chest, and belly. Through measurements, we have confirmed that the attenuation of selected human body parts is from 4 dB to 23 dB. We found that the head, chest, and belly absorb electromagnetic waves differently. The chest absorbs electromagnetic waves the most and the head the least. Belly attenuation is in between head and chest attenuation. The measured data can serve as a basis for investigating the impact of microwaves on living organisms and for investigating microwave attenuation by human subjects in specific spaces. <https://ieeexplore.ieee.org/document/10109067>

IMMUNOMODULATORY ROLE OF NON-IONIZING ELECTROMAGNETIC RADIATION IN HUMAN LEUKEMIA MONOCYTIC CELL LINE

Yadav H, Singh R. Immunomodulatory role of non-ionizing electromagnetic radiation in human leukemia monocytic cell line. *Environ Pollut.* 2023 May 17;331(Pt 2):121843. doi: 10.1016/j.envpol.2023.121843.

Abstract

In daily life, people are usually exposed to radiofrequency radiations (RFR). The effects of RFR on human physiology have been a major source of controversy since the WHO declared that these radiations are a type of environmental energy that interacts with the physiological functioning of the human body. The immune system provides internal protection and promotes long-term health and survival. However, the relevant research on the innate immune system and radiofrequency radiation is scant. In this connection, we hypothesized that innate immune responses would be influenced by exposure to non-ionizing electromagnetic radiation from mobile phones in a cell-specific and time-dependent manner. To test this hypothesis, human leukemia monocytic cell lines were exposed to 2318 MHz (MHz) RFR emitted by mobile phones at a power density of 0.224 W/m² in a controlled manner for various time durations (15, 30, 45, 60, 90, and 120 min). Systematic studies on cell viability, nitric oxide (NO), superoxide (SO), pro-inflammatory cytokine production, and phagocytic assays were performed after the irradiation. The duration of exposure seems to have a substantial influence on the RFR-induced effects. It was noticed that after 30 min of exposure, the RFR dramatically enhanced the pro-inflammatory cytokine IL-1 α level as well as reactive species such as NO and SO generation as compared to the control. In contrast, the RFR dramatically reduced the phagocytic activity of monocytes during 60 min of treatment when compared to the control. Interestingly, the irradiated cells restored their normal functioning until the final 120-min of exposure. Furthermore, mobile phone exposure had no influence on cell viability or TNF- α level. The results showed that RFR exhibits a time-dependent immune-modulatory role in the human leukemia monocytic cell line. Nevertheless, more research is needed to further determine the long-term effects and precise mechanism of action of RFR.

<https://pubmed.ncbi.nlm.nih.gov/37207815/>

EFFECTS OF ARTIFICIAL ELECTROMAGNETIC FIELDS ON BEES: A GLOBAL REVIEW

Reategui-Inga M, Rojas EM, Tineo D, Aranibar-Aranibar MJ, Valdiviezo WA, Escalante CA, Ruiz Castre SJ. Effects of Artificial Electromagnetic Fields on Bees: A Global Review. *Pak J Biol Sci.* 2023 Jan;26(1):23-32. doi: 10.3923/pjbs.2023.23.32.

Abstract

Background and Objective: Electromagnetic fields coming from electric and electronic devices, mobile telephony antennas, or electrical installations are continuously growing and are in direct relation with population growth. In that sense, the purpose of this investigation was to determine what are the effects of artificial electromagnetic fields on the behavior and viability of bees through a global perspective (1968-2022).

Materials and Methods: The methodology used in this research consisted of the review of literature obtained from platforms such as Scopus, EBSCO, IEEE, Wiley, Google Scholar and Taylor & Francis.

Results: It was possible to review 36 studies on the field and to state that investigations on this topic have increased in 2019, at a compounded annual growth rate (CAGR) of 6.86% (in a period of 54 years). Poland and USA are the leading countries in the number and importance of investigations on this topic. Keywords were grouped on the basis of the advancement of the research (honeybee, animals, *Apis mellifera*; and apoideos).

Conclusion: The study of the effects of electromagnetic fields on bees makes it possible to understand its impact on the metabolism and viability of bees.

Open access paper: <https://scialert.net/fulltext/?doi=pjbs.2023.23.32>

ELECTROMAGNETIC FIELDS DISRUPT THE POLLINATION SERVICE BY HONEYBEES

Molina-Montenegro MA, Acuna-Rodriguez AS, Ballesteros GI, Baldelomar M, Torres-Diaz C, Broitman BR, Vazquez DP. Electromagnetic fields disrupt the pollination service by honeybees. *Sci. Adv.* 9, eadh1455 (2023). doi:10.1126/sciadv.adh1455.

Abstract

We assessed the effect that electromagnetic field (EMF) exerts on honeybees' pollination efficiency using field and laboratory experiments. First, we measured levels of gene and protein expression in metabolic pathways involved in stress and behavioral responses elicited by EMF. Second, we assessed the effect of EMF on honeybee behavior and seed production by the honeybee-pollinated California poppy and, lastly, by measuring the consequences of pollination failure on plants' community richness and abundance. EMF exposure exerted strong physiological stress on honeybees as shown by the enhanced expression of heat-shock proteins and genes involved in antioxidant activity and affected the expression levels of behavior-related genes. Moreover, California poppy individuals growing near EMF received fewer honeybee visits and produced fewer seeds than plants growing far from EMF. Last, we found a hump-shaped relationship between EMF and plant species richness and plant abundance. Our study provides conclusive evidence of detrimental impacts of EMF on honeybee's pollination behavior, leading to negative effects on plant community.

Excerpts

... In this study, we used a combination of observational field studies and experimental manipulations using a purpose-built solenoid to simulate and assess the impacts of EMF induced by six high-voltage towers on honeybee's physiology, behavior, and pollination service on the self-incompatible herbaceous plant *Eschscholzia californica* (California poppy) (Fig. 1A). The towers selected for this study were tall structures (20 m of height), built mainly with steel and some parts of copper, used to support a high-voltage overhead power line with an energy box storer in the upper section of the tower. These devices generate an EMF close to 10 μ T, with a peak recorded between 12 and 17 m from the base of the tower and at 25 to 30 cm of height, and decrease to almost extinction at 200 m from the base of the tower (Fig. 1, B and C)....

In summary, our findings support the notion that EMF can have direct negative impacts on pollination service by honeybees, with detrimental consequences on the seed output of insect-pollinated plant species and indirect negative impacts on plant community (abundance and richness) due to possible impairment in the pollination service required by the plant

community (40). We also highlight that the magnitude of the impact of EMF on pollination service, at local scale, can be much greater than previously thought. Honeybees use electric fields for intraspecific (within hive) and interspecific (plant-pollinator) communication (9) and are able to detect the anthropogenic EMF, and their capacity for orientation, navigation, and foraging is being impaired, which would ultimately affect their health and survival (9, 28, 45). Our study provides strong evidence of detrimental effects of EMF on honeybee's visitation and plant reproduction and may contribute to explaining, at least in part, the global pollination crisis that risks the adequate production of many crops.

Open access paper: <https://www.science.org/doi/full/10.1126/sciadv.adh1455>

WHAT EVIDENCE EXISTS ON THE IMPACT OF ANTHROPOGENIC RADIOFREQUENCY ELECTROMAGNETIC FIELDS ON ANIMALS AND PLANTS IN THE ENVIRONMENT: A SYSTEMATIC MAP

Karipidis K, Brzozek C, Mate R Bhatt CR, Loughran S, Wood AW. What evidence exists on the impact of anthropogenic radiofrequency electromagnetic fields on animals and plants in the environment: a systematic map. *Environ Evid* 12, 9 (2023). doi: 10.1186/s13750-023-00304-3.

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 harmful 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 are adequate to provide protection to the environment is a subject of active debate. There is some public concern that new telecommunications technologies, like the 5G mobile phone network may affect the natural environment. This systematic map presents a searchable database of all the available evidence on whether anthropogenic RF EMF has an effect on plants and animals in the environment. The map also identifies gaps in knowledge, recommends future research and informs environmental and radiation protection authorities.

Methods The method used was published in an a priori protocol. Searches included peer-reviewed and grey literature published in English with no time and geographic restrictions. The EMF-Portal, PubMed and Web of Science databases were searched, and the resulting articles were screened in three stages: title, abstract and full text. Studies were included with a subject population of all animals and plants, with exposures to anthropogenic RF EMF (frequency range 100 kHz–300 GHz) compared to no or lower-level exposure, and for any outcomes related to the studied populations. For each included study, metadata were extracted on key variables of interest that were used to represent the distribution of available evidence.

Review findings The initial search, search update and supplementary searches produced 24,432 articles and of those 334 articles (237 on fauna and 97 on flora) that were relevant were included in the systematic map. The vast majority of studies were experiments

conducted in a laboratory rather than observational studies of animals and plants in the natural environment. The majority of the studies investigated exposures with frequencies between 300 and 3000 MHz, and although the exposure level varied, it was mainly low and below the ICNIRP limits. Most of the animal studies investigated insects and birds, whereas grains and legumes were the most investigated plants. Reproduction, development and behaviour were the most investigated effects for animals, and germination and growth for plants. The vast majority of the studies employed poor quality methods.

Conclusion There are distinct evidence clusters: for fauna, on insect and bird reproduction, development and behaviour; and for flora, grain and legume germination and growth that would benefit from specific systematic reviews. The systematic map also highlights the clear need for investigating the effects of RF EMF on more species and more types of effects, and for an improvement in the quality of all studies.

Excerpts

The quality scores given independently by two assessors for each study are provided in Additional file 6. There was large agreement in the quality scores between the assessors (fauna $r = 0.78$, $p < 0.001$; flora $r = 0.77$, $p < 0.001$). The majority of the studies were methodologically poor (59% fauna and 66% flora) and only a very small number of studies employed good quality methods (6% fauna and 2% flora) (Fig. 12). The quality was similar between experimental and observational studies (Additional file 7a). Most experimental studies employed a control/sham condition, especially when investigating plants, but lacked in dosimetry and temperature control and not many experimental studies used positive controls or blinding (Additional file 7b).

The observational studies had varied quality in the following methodological characteristics: (a) exposure assessment, (b) having an appropriate comparison group and (c) using appropriate methods for assessing the effect of interest. The observational studies were particularly poor in assessing potential confounding factors and using a follow up period.

.... In terms of the RF EMF exposure characteristics the biggest gap is research at frequencies above 30 GHz as well the higher end of the 3–< 30 GHz band. This is because new telecommunications technologies that use these higher frequencies, like the 5G mobile network, have only recently been proliferated in the community. Future experimental research would benefit from investigating impacts on animals and plants at the specific frequency range of the 5G network in the range 26–28 GHz. Mobile communications beyond the 5G network plan to use frequencies higher than 30 GHz so research across the millimetre wave band is needed.

The majority of the studies in the systematic map employed low quality methods in a number of methodological criteria. Future experimental studies should improve the experimental design with particular attention to dosimetry and temperature control as well as including positive controls and blinding. Further, the conditions applied in highly controlled experiments may not necessarily translate into ecologically relevant effects. It is therefore also very important to investigate the effects of RF EMF under real life conditions in the natural environment. There is a limited number of observational studies in the systematic map so more such studies are needed. Future observational studies will need to fully address

possible confounding from other anthropogenic/environmental factors and use an adequate follow up time in the design of the study.

Improvements in assessing RF EMF exposure in the environment, having an appropriate comparison group and using appropriate methods for assessing the effect of interest are also important methodological criteria that will need to be addressed by future observational research.

Open access paper:

<https://environmentalevidencejournal.biomedcentral.com/articles/10.1186/s13750-023-00304-3>

A STUDY PROTOCOL FOR INVESTIGATING THE EFFECTS OF MOBILE PHONE-ORIGINATED ELECTROMAGNETIC WAVES ON THYROID GLAND AND THYROID HORMONE ACTIVITIES IN THE BRAIN

Zufry H, Rudijanto A, Soeatmadji DW et al. A study protocol for investigating the effects of mobile phone- originated electromagnetic waves on thyroid gland and thyroid hormone activities in the brain [version 2; peer review: 2 approved with reservations]. F1000Research 2023, 12:132. doi: /10.12688/f1000research.129735.2.

Abstract

With widespread users across the globe, topic on the impact of mobile phone in particular regarding its electromagnetic wave radiation deserves a priority. Carcinogenic effects of the electromagnetic wave radiation have been suggested by multiple studies. Effects of the radiation are to involve thermal and non-thermal pathways. Among human organs, thyroid gland is susceptible to the radiation exposure due to its location being superficial and close to the radiation transmitter. Previous studies have indicated the correlation between the mobile phone radiation and thyroid dysfunctions. However, a conclusion that the electromagnetic wave radiation is the causative agent of the thyroid dysfunctions has not been reached. Most of the study are unable to remove the influence of the external electromagnetic wave radiation. Hence, this study aimed to perform an investigation with true experimental design using animal model in an anechoic chamber – an isolated chamber which could minimize the electromagnetic wave noise from the outside. In this article, we present the description of the anechoic chamber along with the research protocols. Parameters affecting the investigation, including signal frequencies inside the chamber and specific absorption rate are also measured.

<https://doi.org/10.12688/f1000research.129735.2>

ZEBRAFISH LARVAL MELANOPHORES RESPOND TO ELECTROMAGNETIC FIELDS EXPOSURE

Nassisi V, Mazzei A, Del Vecchio G, Calisi A, Velardi L, Alifano P, Verri T. Applied Sciences. 2023; 13(8):4721. <https://doi.org/10.3390/app13084721>.

Abstract

Groups of zebrafish (*Danio rerio*) embryos receive radiations of different frequencies and intensities by means of new prototype devices. They are exposed to static (B0, 0 Hz), extremely low-frequency (ELF, 0.2 Hz), low- frequency (LF, 270 kHz), very-high-frequency (VHF, 100 MHz), and ultra-high-frequency (UHF, 900 MHz) field irradiations. The applied magnetic field intensities are 40 mT at 0 Hz, 40 mT at 0.2 Hz, 470 μ T at 270 kHz, 240 nT at 100

MHz, and 240 nT at 900 MHz. Such combinations are meant to cover environmental radiations from geomagnetic fields and cosmic magnetism to electromagnetic radiation of electronic instruments such as GSM and UMTS transmission-mode mobile systems. For each frequency, fish are monitored for up to 5 days.

Unexposed embryos are used as controls. Notably, exposure to the different radiations brings alterations of body pigmentation in zebrafish embryos and larvae in terms of total number, area, and morphology of (black) melanophores. This research may contribute to evaluating the roles and effects of magnetic radiation on living matter.

Open access paper: <https://www.mdpi.com/2076-3417/13/8/4721>

DO ELECTROMAGNETIC FIELDS USED IN TELECOMMUNICATIONS AFFECT WILD PLANT SPECIES? A CONTROL IMPACT STUDY CONDUCTED IN THE FIELD

Czerwiński M, Vian A, Woodcock BA, Goliński P, Virto LR, Januszkiewicz L. Ecological Indicators, 150, 2023. DOI: 10.1016/j.ecolind.2023.110267.

Abstract

Over the last three decades there has been an unprecedented increase in both the coverage of wireless communication networks and the resultant radiofrequency electromagnetic field (RF-EMF) exposure level. There is growing concern that this rapid environmental change may have unexpected consequences for living organisms. Existing research on plants has shown that RF-EMF radiation can affect their growth and development, gene expression and various metabolic activities. However, these findings are largely derived from short-time exposure of crop plants under laboratory conditions. It remains unclear to what extent plants are affected by artificial RF-EMFs in real ecosystems and what potential consequences this could have for ecosystems. This study attempts to assess these long-term effects of RF-EMF exposure on wild plants under controlled experimental field conditions. We investigated the impacts of RF-EMF exposure (866–868 MHz frequency band) from seed germination to maturation for ten common herbaceous plant species over a four-month period. The selected plant species belong to various families and have different functional and morphological traits that might affect a response to the applied RF-EMF. For most of the considered species responses to RF-EMF were undetectable or weak, and where present restricted to a single trait. Only for one species, *Trifolium arvense* [Hare's-foot clover], were effects observed at different plant development stages and for different plant characteristics. In this species RF-EMF stimulated growth and probably influenced leaf heliotropic movements, as indicated by a larger height, larger leaf area and altered leaf orientation one month after germination. However, over the growing season *Trifolium arvense* plants exposed to RF-EMF entered the phase of senescence earlier, which was manifested through a reduction of green leaf area and an increase in the area of discolored leaf. We conclude that the effects of RF-EMF exposure at environmentally relevant levels can be permanent and irreversible in plants growing in the open natural environment, however, these effects are restricted to specific species. This in turn suggests that future studies should examine whether the effects observed here occur also in more common *Trifolium* species or other legumes that are a keystone component within European grasslands. Our findings also show that *Trifolium arvense* could be a candidate indicator of man-made RF-EMFs in the environment.

Open access paper: <https://www.sciencedirect.com/science/article/pii/S1470160X23004090>

NON THERMAL 2.45 GHZ ELECTROMAGNETIC EXPOSURE CAUSES RAPID CHANGES IN ARABIDOPSIS THALIANA METABOLISM

Porcher A, Girard S, Bonnet P, Rouveure R, Guérin V, Paladian F, Vian A. Non thermal 2.45 GHz electromagnetic exposure causes rapid changes in Arabidopsis thaliana metabolism. J Plant Physiol. 2023 May 11;286:153999. doi: 10.1016/j.jplph.2023.153999.

Highlights

- In our condition, 2.45 GHz HF-EMF exposure did not induce thermal effect in plants.
- We observed rapid and transient changes of gene expression and H₂O₂ metabolism.
- Non-thermal biological responses to EMF exposure do exist in plants.

Abstract

Numerous studies report different types of responses following exposure of plants to high frequency electromagnetic fields (HF-EMF). While this phenomenon is related to tissue heating in animals, the situation is much less straightforward in plants where metabolic changes seem to occur without tissue temperature increase. We have set up an exposure system allowing reliable measurements of tissue heating (using a reflectometric probe and thermal imaging) after a long exposure (30 min) to an electromagnetic field of 2.45 GHz transmitted through a horn antenna (about 100 V m⁻¹ at the plant level). We did not observe any heating of the tissues, but we detected rapid increases (60 min) in the accumulation of transcripts of stress-related genes (TCH1 and ZAT12 transcription factor) or involved in ROS metabolism (RBOH and APX1). At the same time, the amounts of hydrogen peroxide and dehydroascorbic acid increased while glutathione (reduced and oxidized forms), ascorbic acid, and lipid peroxidation remained stable. Therefore, our results unambiguously show that molecular and biochemical responses occur rapidly (within 60min) in plants after exposure to an electromagnetic field, in absence of tissue heating.

<https://pubmed.ncbi.nlm.nih.gov/37210775/>

ASSESSMENT OF PROTEIN AND DNA POLYMORPHISMS IN CORN (ZEA MAYS) UNDER THE EFFECT OF NON-IONIZING ELECTROMAGNETIC RADIATION

Abdelhaliem E, Abdalla HM, Bolbol AA, Shehata RS. Assessment of protein and DNA polymorphisms in corn (Zea mays) under the effect of non-ionizing electromagnetic radiation. Caryologia [Internet]. 2023. 75(4).

Abstract

Many reports highlight biological responses of crop plants after non-ionizing electromagnetic radiation (EMR) exposure based on the phenotypic and physiological levels. So, this study aimed to estimate genetic alterations in proteins, isozymes, and DNA banding patterns as well as the extent of nuclear DNA damage of economic corn (Zea mays) under the stress of EMR using accurate and reliable bioassays like sodium dodecyl sulfate- polyacrylamide gel electrophoresis (SDS-PAGE), isozymes (Leucine- aminopeptidase, Esterases, Peroxidase, and Catalases), random amplified polymorphic DNA- polymerase chain reaction (RAPD-PCR), and Comet Assay, respectively. SDS-PAGE analysis showed distinct polymorphisms (96.66%) between EMR exposed and non- exposed corn seedlings depending on the number and type of bands, their intensities as well as molecular weight which ranged from (60.27 to 192.35 kDa), gain, and loss of bands. The four isozymes generated various isozymatic polymorphisms

based on relative front, zymogram number, and optical intensities. RAPD analysis generated 85 amplified DNA products with high polymorphism values ranged from 90.91 to 100% based on primers, band type, DNA sizes which ranged from 153 to 1008-bp, lose, gain, and intensity of DNA bands. Comet Assay scored highest extent of loosed DNA from nuclei (DNA damage) reached the value of (tailed ratio 20%) at EMR exposed corn nuclei for 5 days compared to non-exposed nuclei which reached the value of (tailed ratio 3%). This study concluded that each EMR exposure time had unique interaction with proteins, isozymes, and DNA of corn cells exhibiting wide range of genotoxic stress and subsequently, adversely effect on growth and yield of this sensitive crop plants.

Open access paper: <https://riviste.fupress.net/index.php/caryologia/article/view/1716>

CHANGES IN INTRACELLULAR CALCIUM CONCENTRATION LEVEL ACCOMPANY AGE-RELATED INHIBITIONS OF LONG-TERM POTENTIATION IN HIPPOCAMPUS INDUCED BY EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS

Zhao W, Dong L, Tian L, Zhao L, Zhao Y, Zheng Y. Changes in intracellular calcium concentration level accompany age-related inhibitions of Long-term potentiation in hippocampus induced by Extremely low frequency electromagnetic fields. *Eur J Neurosci*. 2023 May 18. doi: 10.1111/ejn.16046.

Abstract

Extremely low frequency electromagnetic fields (ELF-EMFs) have received increasing attention and in-depth research due to their ability to affect learning and memory functions. However, its regulation and intrinsic mechanism at different ages in early developmental stages remains unclear. In this article, the regulation of 15 Hz/2 mT ELF-EMFs on Long-term potentiation (LTP) persistence in the hippocampal CA1 region of Sprague- Dawley (SD) rats at early developmental stages (8, 15, 22, and 29-day-old) are investigated by electrophysiological techniques. The results shows that ELF-EMFs differentially inhibit LTP persistence due to age difference, and the younger age, the more significant the inhibitory effect. Secondly, the inhibitory effect of ELF-EMFs on LTP persistence disappeared after the addition of 2-Aminoethoxydiphenyl borate (2-APB) to block inositol-1,4,5-trisphosphate receptors (IP3 Rs) localized to intracellular calcium stores to reduce the intracellular calcium concentration ($[Ca^{2+}]_i$), proving that the LTP persistence regulated by ELF-EMFs is associated with the IP3 Rs-mediated intracellular calcium stores. Finally, the level of $[Ca^{2+}]_i$ was intervened by adjusting the extracellular calcium concentration($[Ca^{2+}]_e$). Interestingly, the inhibitory effect of ELF-EMFs on LTP persistence in the 15-day-old group disappeared by increasing $[Ca^{2+}]_e$, while the inhibitory effect of ELF-EMFs on LTP persistence in the 29-day-old group appeared by decreasing $[Ca^{2+}]_e$. Our findings reveal the underlying mechanism of the effect of ELF-EMFs on synaptic plasticity in hippocampal CA1 area at early developmental stages, and provide new insights into more rational application and protection of ELF-EMFs. <https://pubmed.ncbi.nlm.nih.gov/37203290/>

GROUNDING (EARTHING) AS RELATED TO ELECTROMAGNETIC HYGIENE: AN INTEGRATIVE REVIEW

Jamieson IA. Grounding (earthing) as related to electromagnetic hygiene: An integrative review. *Biomedical Journal*. 46(1):30-40. 2023. 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>

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). 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>

CELLULAR AND MOLECULAR EFFECTS OF NON-IONIZING ELECTROMAGNETIC FIELDS

Lai H, Levitt B. 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>

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, Midelthun 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>

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 countries, 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 RF exposure 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 purposes. In recent years, largely after the reviews cited in Table 3 were completed, the standards for conduct and evaluation of science have been raised, particularly for studies 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 bioeffects 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 Emerging Risks (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 into play 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 *in vivo* studies is striking. Perhaps *in vivo* 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=irab>
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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/>

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/>

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/>

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/>

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 km²). 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>

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 (T4), 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 T4 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, T4, 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

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 A β plaques, A β 40 and A β 42 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 A β plaque formation in WT mice but inhibited A β 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>-----

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/>

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.

Abstract

Background: 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>

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/>

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>

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/cm² 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>

NON-THERMAL DISRUPTION OF B-ADRENERGIC RECEPTOR-ACTIVATED CA²⁺ 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-excitabile 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 Ca²⁺ 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>

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/>

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>

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>

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.

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 Spermatoocyte 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 μ T) 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/>

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

0.1 μ T. 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 0.1 μ T, including 123 subjects over 0.4 μ T, i.e. 0.25% of the study population. These 371 calculated exposures exceeding 0.1 μ T 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/>

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 measured 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 μ T is still deeply debated, the studies collected about personal exposure measurements showed always GM values lower than 0.4 μ T. 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 population 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>

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/>

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/GSK3 β . SMF also reduced lipid droplets accumulation through decreasing Plin2 and Plin5 and regulated lipid metabolism with elevated hepatic expressions of PPAR γ and C/EBP α 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/>

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. *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/>

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>

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>

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/>

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 SAab 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>

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>

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>

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>

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>

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.

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-EMF exposure 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>

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 exposure 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.

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.

<https://pubmed.ncbi.nlm.nih.gov/36927338/>

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>

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>

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>

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>

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>

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/>

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/>

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/>

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% CO₂, 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/>

ZIP9-CENTERED PATHWAY COMPENSATES FOR RADIOFREQUENCY RADIATION-MEDIATED REDUCTION IN RESISTANCE TO H₂O₂ 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 H₂O₂ 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 resistance 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 H₂O₂. 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/>

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/>

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/cm² 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>

MONTE-CARLO BASED NUMERICAL DOSIMETRY IN REVERBERATION CHAMBER EXPOSURE SYSTEMS EMPLOYED FOR IN-VIVO RODENT BIOASSAYS

De Santis V, Di Francesco 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>

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 (FV/FM) 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>

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/>

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/>

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/>

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 μ T (RMS) in LF1 (2G, listening mode, front side) and 12.67 μ T (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 μ T, 7.5 μ T, and 6.09 μ T in the middle of the head (midbrain), 3.89 μ T, 3.98 μ T, and 2.83 μ T for the middle of the thorax (heart), and 2.03 μ T, 1.96 μ T, and 1.56 μ T 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>

RELATIONSHIP BETWEEN LOW-FREQUENCY ELECTROMAGNETIC FIELD AND COMPUTER VISION SYNDROME

Köse 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 $> 1,725 \mu\text{T}$ 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>

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>

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 administered 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>

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>

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 μ s—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/>

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 $65 \pm 15 \mu\text{W}/\text{cm}^2$ for two months. The control group (n = 10 animals) was exposed to an intensity of $35 \pm 15 \text{nW}/\text{cm}^2$. 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>

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>

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.

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>

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 $\mu\text{W}/\text{m}^2$, in office two from 6,230 to 501,000 and in office three from 13,700 to 613,000 $\mu\text{W}/\text{m}^2$. 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 $\mu\text{W}/\text{m}^2$. 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>

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].

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>

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/>

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, 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.

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

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 $\lambda_b = 10\text{--}4.5$ 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>

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>

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/>

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>

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>

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 ($A\beta$), 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 $A\beta$, 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

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>

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>

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>

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 ($\leq 1^\circ\text{C}$). 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/>

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. 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>

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. 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.

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. 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/>

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 hazards 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.

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>

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/>

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>

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 (FV/FM) 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>

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>

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 μ T (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 1 μ T magnetic flux density, while no change was observed in the expression of Bcl-6. Serum IL-6 was increased only in 500 μ T group at the post-immunization phase.

Conclusion: It seems exposure to 50-Hz MFs at 1 μ T density, suppresses AID and may cause decline in class switching and affinity maturation of Abs. On the other hand, exposure to 500 μ T, 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.

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 $2 \times 2 \times 2$ mm³ averaged E_i ($\max E_i, \text{avg}$) and the respective 99.9th, 99.5th, and 99.0th 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 cm² MF 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 $\max E_i, \text{avg}$, 99.9th, 99.5th, and 99.0th 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.

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 from 100 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/>

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>

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>

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 navigation¹. 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 field². However, the canonical CRY-centric radical-pair mechanism does not explain many physiological and behavioural observations²⁻⁸. 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>

EXTREMELY LOW-FREQUENCY ELECTROMAGNETIC FIELD (ELF-EMF) INDUCES ALTERATIONS IN EPIGENETIC REGULATION IN THE MYOMETRIUM - AN IN VITRO STUDY

Franczak A, Drzewiecka EM, Kozłowska 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/>

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^{-7} and 1.0854×10^{-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>

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.

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

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; Koepfel, 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>

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 examined 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 concerns” 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 trials. 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>

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 diastolic 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>

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 $\mu\text{W}/\text{m}^2$ were measured at three occasions in the bedroom located only 5 meters below the new 5G base station, compared to maximum (peak) 9 000 $\mu\text{W}/\text{m}^2$ 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 $\mu\text{W}/\text{m}^2$. 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-syndrom-after-installation-of-5g-emphasizes-the-need-for-protection-from-radiofrequency-radiation>

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 $\mu\text{W}/\text{cm}^2$) 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 $\mu\text{W}/\text{cm}^2$) 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.

<https://pubmed.ncbi.nlm.nih.gov/36598666/>

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>

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. *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 proapoptotic 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/>

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. 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-1 α , 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>

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. 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>

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/>

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>

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>

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 μ T) 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/>

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>

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>

BIOLOGICAL EFFECTS OF RADIOFREQUENCY ELECTROMAGNETIC FIELDS ABOVE 100 MHZ ON FAUNA AND FLORA: WORKSHOP REPORT

Pophof B, Henschenmacher B, Kattinig 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/>

BIOLOGICAL EFFECTS OF ELECTRIC, MAGNETIC, AND ELECTROMAGNETIC FIELDS FROM 0 TO 100 MHZ ON FAUNA AND FLORA: WORKSHOP REPORT

Pophof B, Henschenmacher B, Kattinig 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