

SCIENTIFIC STUDIES 2019

GLOBAL GENE EXPRESSION ANALYSIS OF ESCHERICHIA COLI K-12 DH5A AFTER EXPOSURE TO 2.4 GHZ WIRELESS FIDELITY RADIATION

Said-Salman IH, Jebaili FA, Yusef HH, Moustafa ME. Global gene expression analysis of Escherichia coli K-12 DH5 α after exposure to 2.4 GHz wireless fidelity radiation. Sci Rep. 2019 Oct 8;9(1):14425. doi: 10.1038/s41598-019-51046-7.

Abstract

This study investigated the non-thermal effects of Wi-Fi radiofrequency radiation of 2.4 GHz on global gene expression in Escherichia coli K-12 DH5 α . High-throughput RNA-sequencing of 2.4 GHz exposed and non-exposed bacteria revealed that 101 genes were differentially expressed (DEGs) at $P \leq 0.05$. The up-regulated genes were 52 while the down-regulated ones were 49. QRT-PCR analysis of *pgaD*, *fliC*, *cheY*, *malP*, *malZ*, *motB*, *alsC*, *alsK*, *appB* and *appX* confirmed the RNA-seq results. About 7% of DEGs are involved in cellular component organization, 6% in response to stress stimulus, 6% in biological regulation, 6% in localization, 5% in locomotion and 3% in cell adhesion. Database for annotation, visualization and integrated discovery (DAVID) functional clustering revealed that DEGs with high enrichment score included genes for localization of cell, locomotion, chemotaxis, response to external stimulus and cell adhesion. Kyoto encyclopedia of genes and genomes (KEGG) pathways analysis showed that the pathways for flagellar assembly, chemotaxis and two-component system were affected. Go enrichment analysis indicated that the up-regulated DEGs are involved in metabolic pathways, transposition, response to stimuli, motility, chemotaxis and cell adhesion. The down-regulated DEGs are associated with metabolic pathways and localization of ions and organic molecules. Therefore, the exposure of E. coli DH5 α to Wi-Fi radiofrequency radiation for 5 hours influenced several bacterial cellular and metabolic processes. <https://www.ncbi.nlm.nih.gov/pubmed/31595026>

OCULAR EFFECTS OF EXPOSURE TO 40, 75, AND 95 GHZ MILLIMETER WAVES

Kojima M, Suzuki Y, Sasaki K, Taki M, Wake K, Watanabe S, Mizuno M, Tasaki T, Sasaki H. Ocular Effects of Exposure to 40, 75, and 95 GHz Millimeter Waves. Journal of infrared, millimeter and terahertz waves.39(9):912-925. DOI: 10.1007/s10762-018-0497-z

Abstract

The objective of this study was to develop a model of ocular damage induced by 40, 75, and 95 GHz continuous millimeter waves (MMW), thereby allowing assessment of the clinical course of ocular damage resulting from exposure to thermal damage-inducing MMW. This study also examined the dependence of ocular damage on incident power density. Pigmented rabbit eyes were exposed to 40, 75, and 95 GHz MMW from a spot-focus-type lens antenna. Slight ocular damage was observed 10 min after MMW exposure, including reduced cornea thickness and reduced transparency. Diffuse fluorescein staining around the pupillary area indicated corneal epithelial injury. Slit-lamp examination 1 day after MMW exposure revealed a round area of opacity, accompanied by fluorescence staining, in the central pupillary zone. Corneal edema, indicative of corneal stromal damage, peaked 1 day after MMW exposure, with thickness gradually subsiding to normal. Three days after exposure, ocular conditions had almost normalized, though corneal thickness was slightly greater than that before

exposure. The 50% probability of ocular damage (DD50) was in the order $40 > 95 \approx 75$ GHz at the same incident power densities.

Conclusion

We created rabbit models of ocular disorder by exposure to 40, 75, and 95 GHz MMW. In assessing the relationship between the degree of ocular disorder and incident power density of these three frequencies, we found that ocular damage induced by exposure to 40, 75, and 95 GHz was essentially the same, with no characteristic specific to each frequency. We also found that corneal surface temperature during exposure was increased in the order $40 < 95 < 75$ GHz, but there was no relationship between degree of ocular damage and eye surface temperature. In addition, we performed probit analyses by using experimental data and estimated probabilities for incidence of ocular damage depending on the power density. DD50, defined as dose level to cause ocular damage with 50% probability, was in the order 40 GHz (206 mW/cm²) > 95 GHz (146 mW/cm²) $\approx$ 75 GHz (143 mW/cm²). At the same incident power density, the degree of ocular damage was greater in the eyes exposed for 30 min than for 6 min. These findings suggested that damage to the corneal epithelium was not induced by corneal dryness alone, but by exposure of dried corneas to MMW-induced heat to above body temperature.

Open access paper: <https://link.springer.com/article/10.1007%2Fs10762-018-0497-z>

MILLIMETER-WAVE HEATING IN IN VITRO STUDIES: EFFECT OF CONVECTION IN CONTINUOUS AND PULSE-MODULATED REGIMES

Orlacchio R, Zhadobov M, Alekseev SI, Nikolayev D, Sauleau R, Le Page Y, Le Dréan Y. Millimeter-Wave Heating in In Vitro Studies: Effect of Convection in Continuous and Pulse-Modulated Regimes. Bioelectromagnetics. Published online October 3, 2019. <https://doi.org/10.1002/bem.22223>

Abstract

Shallow penetration of millimeter waves (MMW) and non-uniform illumination in in vitro experiments result in a non-uniform distribution of the specific absorption rate (SAR). These SAR gradients trigger convective currents in liquids affecting transient and steady-state temperature distributions. We analyzed the effect of convection on temperature dynamics during MMW exposure in continuous-wave (CW) and pulsed-wave (PW) amplitude-modulated regimes using micro-thermocouples. Temperature rise kinetics are characterized by the occurrence of a temperature peak that shifts to shorter times as the SAR of the MMW exposure increases and precedes initiation of convection in bulk. Furthermore, we demonstrate that the liquid volume impacts convection.

Increasing the volume results in earlier triggering of convection and in a greater cooling rate after the end of the exposure. In PW regimes, convection strongly depends on the pulse duration that affects the heat pulse amplitude and cooling rate. The latter results in a change of the average temperature in PW regime.

Excerpt

In conclusion, our results suggest that in planning in vitro studies in the MMW band, convection is one of the parameters that has to be carefully taken into account. It may affect cellular response through indirect mechanisms, such as the local change of the concentration

of oxygen or nutrients transported by the culture medium. Deeper investigation of convection mechanisms requires numerical analysis of the multi-physics problem, which constitutes one of the perspectives of a future study.

<https://onlinelibrary.wiley.com/doi/abs/10.1002/bem.22223>

SCOPING REVIEW OF THE POTENTIAL HEALTH EFFECTS OF EXPOSURE TO EXTREMELY LOW-FREQUENCY ELECTRIC AND MAGNETIC FIELDS

Habash M, Gogna P, Krewski D, Habash RWY. Scoping Review of the Potential Health Effects of Exposure to Extremely Low-Frequency Electric and Magnetic Fields. *Crit Rev Biomed Eng*. 2019;47(4):323-347. doi: 10.1615/CritRevBiomedEng.2019030211.

Abstract

Previous studies suggest that extremely low-frequency (ELF) electric and magnetic fields (EMFs) may impact human health. However, epidemiologic studies have provided inconsistent results on the association between exposure to ELF EMFs and various health outcomes. This scoping review reports on primary investigations that were published during the ten-year period of 2007-2017 on the association between ELF EMFs and cancer,

cardiovascular disease (CVD), reproductive health effects, and neurodegenerative diseases. We identified a total of 361 articles from two bibliographic databases (PubMed and EMBASE). Of these, 39 articles (19 cancer studies, two CVD studies, nine reproductive health studies, and ten neurodegenerative disease studies [with one repeated for two outcomes]) met inclusion criteria. Articles identified in this study focus on three different types of exposure: occupational (22 studies), residential (15 studies), and electric blanket (two studies). This review suggests that ELF EMFs may be associated with neurodegenerative diseases, specifically Alzheimer's disease; however, limited evidence was found to suggest that ELF EMFs are associated with several types of cancer, CVD, and reproductive outcomes. Additional epidemiological studies in large study populations with improved exposure assessments are needed to clarify current inconclusive relationships.

<https://www.ncbi.nlm.nih.gov/pubmed/31679262>

MELATONIN LEVELS AND LOW-FREQUENCY MAGNETIC FIELDS IN HUMANS AND RATS: NEW INSIGHTS

Bouché NF, McConway K. Melatonin levels and low-frequency magnetic fields in humans and rats: New insights from a Bayesian logistic regression. *Bioelectromagnetics*. 2019 Sep 29. doi: 10.1002/bem.22218.

Abstract

The present analysis revisits the impact of extremely low-frequency magnetic fields (ELF-MF) on melatonin (MLT) levels in human and rat subjects using both a parametric and non-parametric approach. In this analysis, we use 62 studies from review articles. The parametric approach consists of a Bayesian logistic regression (LR) analysis and the non-parametric approach consists of a Support Vector analysis, both of which are robust against spurious/false results. Both approaches reveal a unique well-ordered pattern, and show that human and rat studies are consistent with each other once the MF strength is restricted to

cover the same range (with $B \lesssim 50 \mu\text{T}$). In addition, the data reveal that chronic exposure (longer than ~ 22 days) to ELF-MF appears to decrease MLT levels only when the MF strength is below a threshold of i.e., when the man-made ELF-MF intensity is below that of the static geomagnetic field. Studies reporting an association between ELF-MF and changes to MLT levels and the opposite (no association with ELF-MF) can be reconciled under a single framework. <https://www.ncbi.nlm.nih.gov/pubmed/31564068>

Conclusions

From our analysis of 62 studies on the possible variations of MLT levels in humans and rats from Jahandideh et al. [2010], Touitou and Selmaoui [2012], and Halgamuge [2013], we examined the possible relationship between a dichotomous-dependent variable (corresponding to studies showing an effect or no effect on MLT excretion pattern) and independent variables such as exposure duration and magnetic field strength using a Bayesian approach and a simple LR model. We find that:

- MF exposure duration is the most significant parameter in causing changes in the MLT levels both in human (Fig. 2) and rat (Fig. 4) studies, as others have reported [e.g., Selmaoui and Touitou, 1995; Kurokawa et al., 2003; Savitz, 2003; Jahandideh et al., 2010; Vanderstraeten et al., 2012];
- human and rat studies are entirely consistent with one another, but only after matching the MF strengths to similar ranges, i.e., $B \lesssim 50 \mu\text{T}$;
- there seems to be no dose-dependence between any change in the MLT levels with MF strengths ranging from 0.5 to $100 \mu\text{T}$ as others have reported [e.g., Kato et al., 1993; Reiter, 1993; Pfluger and Minder, 1996; Halgamuge, 2013]; and
- the impact of MF on the MLT levels does, however, depend on the ELF-MF strength, in the regime where ELF-MFs are weaker than (Fig. 5). Such a window effect was already discussed in Löscher et al. [1998].

In light of these results, we suggest performing additional research on rats with ELF-MF with intensities in the range from 20 nT to $20 \mu\text{T}$, while controlling the additional factors listed earlier in the section Limitations, because epidemiological studies have indicated that adverse effects on human health become noticeable at $\sim 0.4 \mu\text{T}$. But so far, very few rat studies involved ELF-MF with intensities below $5 \mu\text{T}$. This range 20 nT to a few μT covers the regime experienced by humans in man-made and natural environments. Indeed, the natural variations of the geomagnetic field range from 20 nT to a few hundreds of nT [Hitchman et al., 1998].

As MF strengths $> 50 \mu\text{T}$ are not found in nature, studies on rats with MF strengths $> 50 \mu\text{T}$, or mT levels, might reveal a different (likely acute effect) than the duration-dependent effect discussed here, where perhaps one of the other factors discussed earlier has become dominant.

DNA DAMAGE FROM LONG-TERM OCCUPATIONAL EXPOSURE TO EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS AMONG POWER PLANT WORKERS

Bagheri Hosseinabadi M, Khanjani N, Mirzaii M, Norouzi P, Atashi A. DNA damage from long-term occupational exposure to extremely low frequency electromagnetic fields among power plant workers. *Mutat Res.* 2019 Oct;846:403079. doi: 10.1016/j.mrgentox.2019.07.007.

Abstract

Extremely low frequency electromagnetic fields (ELF-EMFs) are not known as definite occupational carcinogens, but some studies have reported the genotoxic effects of these fields on cell lines. The present study aimed to evaluate the effects of long-term occupational exposure to these fields on DNA damage. In this cross-sectional study, blood samples were taken from 102 thermal power plant workers as the exposure group and 136 subjects as the unexposed group. DNA damage was evaluated using alkaline comet assay and flow cytometry. Exposure to ELF-EMFs was measured based on spot measurements and the IEEE Std C95.3.1 standard. The indices of comet assay, tail DNA percent, tail factor (%), and damage index were significantly higher in the exposed group compared to the unexposed group. Increased exposure to magnetic fields enhanced comet assay indices, except tail length; while exposure to electric fields had no significant effect on such indices. The percentage of cells at early apoptosis and late apoptosis phases caused by exposure to magnetic fields, respectively, decreased and increased significantly. Long-term occupational exposure to ELF-EMFs can probably cause genotoxic effects.

<https://www.ncbi.nlm.nih.gov/pubmed/31585627>

EFFECT OF LOW FREQUENCY MAGNETIC FIELD ON EFFICIENCY OF CHROMOSOME BREAK REPAIR

Burgos-Molina AM, Mercado-Sáenz S, Sendra-Portero F, Ruiz-Gómez MJ. Effect of low frequency magnetic field on efficiency of chromosome break repair. *Electromagn Biol Med.* 2019 Oct 28;1-8. doi: 10.1080/15368378.2019.1685541.

Abstract

DNA repair is essential to maintain genome integrity. There is scientific evidence that exposure to magnetic fields (MF) can produce alterations in DNA repair without clear conclusions. This work aims to study the cellular response to and repair of a very deleterious type of DNA damage, the DNA double strand break (DSB), in *S. cerevisiae*, under MF exposure. In *S. cerevisiae* cells, pairs of DSB were induced enzymatically by HO endonuclease by plating the cells on Galactose-containing media. The repair processes took place under exposure to a 50Hz, 2.45mT sinusoidal MF during 21 days. MF was generated by a pair of Helmholtz coils. MF induced 1.29- and 1.5-fold increase in the number of colonies grown at day 21 of exposure in relation to untreated controls for Pho91 and Rmd5 strain, respectively. In relation to the kinetics of DSB repair during MF exposure, a higher increase (55.56-fold) in DNA reparation was observed at day 15 for Rmd5 strain in relation to the slight increment (1.18-fold) found for Pho91 strain. The results suggest that long-term MF exposure could increase the DNA repair activity and there may be a relationship between the position of the DSB and the distance to the centromere.

<https://www.ncbi.nlm.nih.gov/pubmed/31657656>

LONG-TERM MONITORING OF EXTREMELY LOW FREQUENCY MAGNETIC FIELDS IN ELECTRIC VEHICLES

Yang L, Lu M, Lin J, Li C, Zhang C, Lai Z, Wu T. Long-Term Monitoring of Extremely Low Frequency Magnetic Fields in Electric Vehicles. *Int J Environ Res Public Health*. 2019 Oct 7;16(19). pii: E3765. doi: 10.3390/ijerph16193765.

Abstract

Extremely low frequency (ELF) magnetic field (MF) exposure in electric vehicles (EVs) has raised public concern for human health. There have been many studies evaluating magnetic field values in these vehicles. However, there has been no report on the temporal variation of the magnetic field in the cabin. This is the first study on the long-term monitoring of actual MFs in EVs. In the study, we measured the magnetic flux density (B) in three shared vehicles over a period of two years. The measurements were performed at the front and rear seats during acceleration and constant-speed driving modes. We found that the B amplitudes and the spectral components could be modified by replacing the components and the hubs, while regular checks or maintenance did not influence the B values in the vehicle. This observation highlights the necessity of regularly monitoring ELF MF in EVs, especially after major repairs or accidents, to protect car users from potentially excessive ELF MF exposure. These results should be considered in updates of the measurement standards. The ELF MF effect should also be taken into consideration in relevant epidemiological studies.

Open access paper: <https://www.mdpi.com/1660-4601/16/19/3765>

ELECTRIC FIELD EXPOSURE ASSESSMENTS AND A NOVEL CONTROL METHOD FOR BUILDINGS INSTALLED NEARBY HIGH-VOLTAGE LINES

Shemshadi A, Maleki AK. Electric Field Exposure Assessments and a Novel Control Method for Buildings Installed Nearby High-Voltage Lines. *Indian J Occup Environ Med*. 2019 May-Aug;23(2):63-67. doi: 10.4103/ijoem.IJOEM_215_18.

Abstract

This essay presents a review of new methods for electric field value assessment in high-voltage areas. For buildings that are placed near high-voltage transmission line corridor, two main scenarios are modeled using finite element method. A new approach to reduce electric field value is also simulated and the results are discussed in detail. The results are compared to related standards values. In some cases the improvement rate exceeds 65%.

<https://www.ncbi.nlm.nih.gov/pubmed/31619877>

INCREASED AGGRESSION AND REDUCED AVERSIVE LEARNING IN HONEY BEES EXPOSED TO EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS

Shepherd S, Hollands G, Godley VC, Sharkh SM, Jackson CW, Newland PL. Increased aggression and reduced aversive learning in honey bees exposed to extremely low frequency electromagnetic fields. PLoS One. 2019 Oct 10;14(10):e0223614. doi: 10.1371/journal.pone.0223614. eCollection 2019.

Abstract

Honey bees, *Apis mellifera*, are a globally significant pollinator species and are currently in decline, with losses attributed to an array of interacting environmental stressors. Extremely low frequency electromagnetic fields (ELF EMFs) are a lesser-known abiotic environmental factor that are emitted from a variety of anthropogenic sources, including power lines, and have recently been shown to have a significant impact on the cognitive abilities and behaviour of honey bees. Here we have investigated the effects of field-realistic levels of ELF EMFs on aversive learning and aggression levels, which are critical factors for bees to maintain colony strength. Bees were exposed for 17 h to 100 μ T or 1000 μ T ELF EMFs, or a sham control. A sting extension response (SER) assay was conducted to determine the effects of ELF EMFs on aversive learning, while an intruder assay was conducted to determine the effects of ELF EMFs on aggression levels. Exposure to both 100 μ T and 1000 μ T ELF EMF reduced aversive learning performance by over 20%. Exposure to 100 μ T ELF EMFs also increased aggression scores by 60%, in response to intruder bees from foreign hives. These results indicate that short-term exposure to ELF EMFs, at levels that could be encountered in bee hives placed under power lines, reduced aversive learning and increased aggression levels. These behavioural changes could have wider ecological implications in terms of the ability of bees to interact with, and respond appropriately to, threats and negative environmental stimuli.

Open access paper:

<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0223614>

SELF-ORGANIZING MAPS CLASSIFICATION WITH APPLICATION TO THE LOW-FREQUENCY MAGNETIC FIELD EMITTED BY PORTABLE COMPUTERS

Brodic D, Draganov IR. Self-organizing maps classification with application to the low-frequency magnetic field emitted by portable computers. 2017 3rd International Conference on Applied and Theoretical Computing and Communication Technology (iCATccT). 21-23 Dec. 2017. DOI: 10.1109/ICATCCT.2017.8389155

Abstract

This study presents an application of the Self-Organizing-Map method used for the classification of the extremely low-frequency magnetic field emission in the close neighborhood of the portable computers. The experiment is conducted on two different groups of portable computers: (i) laptop and (ii) tablet computers. After measuring their extremely low-frequency magnetic field emission, the Self-Organizing-Map is used for the classification of these results, which authorized the typical emission levels. Some of them are dangerous, because they are far above the valid safety standards' limit. At the end, a discussion is performed on the importance of using the classification as a possible solution for safely use of the portable computers. In this way, it is used to define and reduce the risk of the magnetic field emission negative effects to the portable computer users.

Excerpts

The measurement experiment includes the ELF magnetic field measurement of 18 different portable computers. 9 out of 18 are laptop computers, while the rest of 9 portable computers are tablet computers

If we observe Fig. 5, it is quite clear that there is no laptop computer, which is completely safe for the use. Also, we can notice high peaks of the ELF emission at some positions at the surface of the top or bottom areas. These positions are typically linked with the places where are processor, cooler or graphic cards are below inside the laptop computer. These peaks are noticeable in the laptops 7 and 9. On the contrary, the laptops 3,4,6, and 8 are the safest of all tested laptops if we compare them to the other laptop computers at the top measuring positions.

Furthermore, if we divide the ELF emission at the top and bottom positions of the laptop computers, then we can notice that higher magnetic field emission is mainly connected to the bottom representing a battery

position. However, a similar situation repeats with high level peaks as at the top of the laptop computers. The high peaks are noticeable in the laptops 1, 2, 3,4 and 7. On the contrary, the laptops 8 and 9 have the smallest level of the measured ELF magnetic field emission.

Then, if we observe Fig. 6, it is worth noting that Tablet 2 is completely safe for the use. Also, in the contrast to the laptop computers, the tablet computers are not characterized by the high-level ELF magnetic field peaks. It is quite reasonable, because they do not have active coolers and processors of such high processing power like laptop computers. Furthermore, the least safe tablet computers are tablets 1, 3 and 5.

Furthermore, if we divide the ELF emission at the top and bottom positions of the tablet computers, then we can notice that mainly higher magnetic field emission is at the top than at the bottom areas of the tablet computers. From this fact, we can conclude that the top protective cover glass (Gorilla glass 3 or 4) can reduce the level of the ELF

<https://ieeexplore.ieee.org/document/8389155>

Genotoxic effects of intermediate frequency magnetic fields on blood leukocytes in vitro

Brech A, Kubinyi G, Németh Z, Bakos J, Fiocchi S, Thuróczy G. Genotoxic effects of intermediate frequency magnetic fields on blood leukocytes in vitro.

Mutat Res. 2019 Sep;845:403060. doi: 10.1016/j.mrgentox.2019.05.016.

Abstract

The widespread presence of electromagnetic sources in daily life has initiated several studies on the effects of radiofrequency and power frequency fields. Only few investigations on the genotoxic effects of exposure to intermediate frequency magnetic fields (IF-MF) have been done so far. Therefore, the aim of this study was to evaluate possible genotoxic effects of exposure to 123.90 kHz and 250.80 kHz IF-MF on canine and human blood. Blood was exposed to IF-MF at 630 A/m (0.79 mT) and 80 A/m (0.10 mT) with exposure durations of 1-5 h (hourly), 20 and 24 h. Cylindrically divided Petri dish system was developed for in vitro

exposures where different induced current could be achieved in the samples at the same magnetic flux density level. For the assessment of genotoxicity the alkaline comet assay was applied. We detected a statistically significant increase in DNA damage only following 20 h exposure to IF-MF.

<https://www.ncbi.nlm.nih.gov/pubmed/31561904>

EFFECTS OF 171 MHZ LOW-INTENSITY ELECTROMAGNETIC FIELD ON GLUCOCORTICOID AND MINERAL CORTICOID ACTIVITY OF THE ADRENAL GLANDS OF RATS

Perov S, Rubtsova N, Balzano Q. Effects of 171 MHz Low-Intensity Electromagnetic Field on Glucocorticoid and Mineral Corticoid Activity of the Adrenal Glands of Rats. Bioelectromagnetics. 2019 Oct 22. doi: 10.1002/bem.22226.

Abstract

A sub-acute electromagnetic field (EMF) biological effect study was carried out on rats exposed in the Transverse ElectroMagnetic exposure chamber at 171 MHz Continuous Wave (CW). The experiments involved three exposure levels (15, 25, and 35 V/m) for 15 days with triplicate parallel sham-exposed controls in each series. All exposure conditions were simulated for the evaluation of the electromagnetic energy distribution and specific absorption rate (SAR) in the rat phantoms. Studies have shown a biphasic biological response depending on time and absorbed electromagnetic energy. Under low SAR, approximately 0.006 W/kg, EMF exposure leads to the stimulation of adrenal gland activity. This process is accompanied by an initial increase of daily excretion of corticosterone and Na⁺, which is seen as a higher Na⁺/K⁺ ratio, followed by a decrease of these parameters over time. It is possible that EMF exposure causes a stress response in animals, which is seen as an increased adrenal activity.

<https://www.ncbi.nlm.nih.gov/pubmed/31642089>

5G WIRELESS COMMUNICATION AND HEALTH EFFECTS-A PRAGMATIC REVIEW BASED ON AVAILABLE STUDIES REGARDING 6 TO 100 GHZ

Simkó M, Mattsson MO. 5G Wireless Communication and Health Effects-A Pragmatic Review Based on Available Studies Regarding 6 to 100 GHz. Int J Environ Res Public Health. 2019 Sep 13;16(18). pii: E3406. doi: 10.3390/ijerph16183406.

Abstract

The introduction of the fifth generation (5G) of wireless communication will increase the number of high- frequency-powered base stations and other devices. The question is if such higher frequencies (in this review, 6- 100 GHz, millimeter waves, MMW) can have a health impact. This review analyzed 94 relevant publications performing in vivo or in vitro investigations. Each study was characterized for: study type (in vivo, in vitro), biological material (species, cell type, etc.), biological endpoint, exposure (frequency, exposure duration, power density), results, and certain quality criteria. Eighty percent of the in vivo studies showed responses to exposure, while 58% of the in vitro studies demonstrated effects. The responses affected all biological endpoints studied.

There was no consistent relationship between power density, exposure duration, or frequency, and exposure effects. The available studies do not provide adequate and sufficient

information for a meaningful safety assessment, or for the question about non-thermal effects. There is a need for research regarding local heat developments on small surfaces, e.g., skin or the eye, and on any environmental impact. Our quality analysis shows that for future studies to be useful for safety assessment, design and implementation need to be significantly improved.

Funding: This research was funded by Deutsche Telekom Technik GmbH, Bonn, Germany, PO number 4806344812.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Open access paper: <https://www.mdpi.com/1660-4601/16/18/3406>

THE CONTRIBUTION OF IN VIVO MAMMALIAN STUDIES TO THE KNOWLEDGE OF ADVERSE EFFECTS OF RADIOFREQUENCY RADIATION ON HUMAN HEALTH

Vornoli A, Falcioni L, Mandrioli D, Bua L, Belpoggi F. *Int J Environ Res Public Health*. 2019 Sep 12;16(18). pii: E3379. doi: 10.3390/ijerph16183379.

Abstract

The proliferation of cellular antennas and other radiofrequency radiation (RFR) generating devices of the last decades has led to more and more concerns about the potential health effects from RFR exposure. Since the 2011 classification as a possible carcinogen by the International Agency for Research on Cancer (IARC), more experimental studies have been published that support a causal association between RFR exposure and health hazards. As regard cancer risk, two long-term experimental studies have been recently published by the US National Toxicology Program (NTP) and the Italian Ramazzini Institute (RI). Despite important experimental differences, both studies found statistically significant increases in the development of the same type of very rare glial malignant tumors. In addition to carcinogenicity, reproductive organs might be particularly exposed, as well as sensitive to RFR. In this work, we reviewed the currently available evidence from in vivo studies on carcinogenicity and reproductive toxicity studies in order to summarize the contribution of experimental research to the prevention of the adverse effects of RFR on human health.

Conclusions

In conclusion, according to NTP, there is now clear evidence that RFR causes cancer in experimental animals. RFR re-evaluation has also been listed as a priority by IARC [87]. There is also stronger evidence that RFR exposure is responsible for causing alteration of various sperm parameters, thus, affecting male fertility. Although a clear quantification of the carcinogenic and reproductive risk is still lacking, these animal findings suggest that a precautionary approach should be promoted by regulatory and health agencies, especially for children and pregnant women. Caution should also be considered in the development and spread of the upcoming 5G technology, particularly in light of the proposed higher frequencies and intensities of the signal. Long-term animal studies are urgently necessary to verify the possible health effects of 5G technology.

Open access paper: <https://www.mdpi.com/1660-4601/16/18/3379>

BUILDING SCIENCE AND RADIOFREQUENCY RADIATION: WHAT MAKES SMART AND HEALTHY BUILDINGS

Clegg FM, Sears M, Friesen M, Scarato T, Metzinger R, Russell CL, Stadtner A, Miller AB. Building science and radiofrequency radiation: What makes smart and healthy buildings. Building & Environment. Published online August 6, 2019, 106324. <https://doi.org/10.1016/j.buildenv.2019.106324>Get rights and content

Highlights

- Wireless systems increase radiofrequency radiation (RFR) in buildings.
- Scientific evidence identifies adverse effects from RFR below regulatory limits.
- Globally, some governments and public health agencies are reducing RFR exposures.
- Low RFR best practices include wired technology instead of Wi-Fi, and corded phones.
- Safer, sustainable strategies and solutions for “smart” buildings are feasible.

Abstract

Radiofrequency radiation (RFR), used for wireless communications and “smart” building technologies, including the “Internet of Things,” is increasing rapidly. As both RFR exposures and scientific evidence of harmful effects increase apace, it is timely to heed calls to include low RFR levels as a performance indicator for the health, safety and well-being of occupants and the environment.

Adverse biochemical and biological effects at commonly experienced RFR levels indicate that exposure guidelines for the U.S., Canada and other countries, are inadequate to protect public health and the environment.

Some industry liability insurance providers do not offer coverage against adverse health effects from radiation emitted by wireless technologies, and insurance authorities deem potential liability as “high.” Internationally, governments have enacted laws, and medical and public health authorities have issued recommendations, to reduce and limit exposure to RFR.

There is urgent need to implement strategies for no- or low-RFR emitting technologies, and shielding, in building design and retrofitting. These strategies include installing wired (not wireless) Internet networks, corded rather than cordless phones, and cable or wired connections in building systems (e.g., mechanical, lighting, security).

Building science can profit from decades of work to institute performance parameters, operationalizing prudent guidelines and best practices. The goal is to achieve RFR exposures that are ALARA, “As Low As Reasonably Achievable.”

We also challenge the business case of wireless systems, because wired or cabled connections are faster, more reliable and secure, emit substantially less RFR, and consume less energy in a sector with rapidly escalating green-house gas emissions.

Open access paper:

<https://www.sciencedirect.com/science/article/pii/S0360132319305347?via%3Dihub>

INFLUENCE OF RADIOFREQUENCY ELECTROMAGNETIC FIELDS ON BRAIN ACTIVITY, SLEEP AND COGNITIVE PERFORMANCE OF OLDER WOMEN

Danker-Hopfe H, Dorn H, Eggert T, Sauter C. [Influence of radiofrequency electromagnetic fields on brain activity, sleep and cognitive performance of older women.] Radiofrequency Electromagnetic Field (RF-EMF) Effects on Brain Activity During Sleep and Waking in Healthy Elderly Women Project 3614S30012. Federal Office for Radiation Protection (BfS). 2019, Departmental Research Reports on Nuclear Safety and Radiation Protection (BfS-RESFOR) 143/19: 1-226

Excerpts from Summary

The aim of the present randomized, double-blind cross-over study was to investigate acute effects of radiofrequency electromagnetic fields (RF-EMF) emitted by GSM900 mobile phones and TETRA (BOS) handheld devices on the central nervous system (CNS). Possible effects on the sleeping brain as well as on the waking brain in resting state and under cognitive demand were studied....

In the present study three different exposure signals were applied: 1) Sham exposure with a partial body SAR value of 0 W/kg (averaged over 10 g of tissue), 2) GSM 900 exposure with a partial body SAR value of 2.0 W/kg (averaged over 10 g of tissue) and 3) TETRA exposure a partial body SAR value of 6.0 W/kg (averaged over 10 g of tissue)....

Overall, 30 women with a mean age of 67.8 ± 5.7 years (range: 60-80 years) participated in the present study. At study nights subjects were exposed at the left side of the head for 30 min prior to sleep and afterwards for the duration of the whole night (7.5 hours). Sleep architecture, sleep spindle parameters and power spectra of the sleep EEG were analysed. Daytime assessments comprised the level of tonic alertness as measured by the pupillographic sleepiness test (PST), the alpha-attenuation test (AAT) and the resting state waking EEG with eyes

closed. Phasic alertness was tested by several evoked potentials (readiness potential, contingent negative variation, slow potential arising from a visual monitoring task, and auditory evoked potentials: N1, P2, and P3) with and without behavioural measures like reaction times and number of correct responses. Additionally effects on selective attention, divided attention, vigilance and working memory were investigated. Prior to testing subjects were exposed for 30 min followed by tests with parallel EEG registration for a duration of around 2.5 hours. To avoid time of day effects, all tests were performed in the afternoon starting at approximately 03:00 p.m....

In the elderly women exposure effects on brain activity during sleep showed more statistically significant differences in the macrostructure of sleep under RF exposure than in younger men. These effects point to a sleep-consolidating effect of RF exposure. Analysis of the power spectra values revealed that GSM exposure mainly resulted in a statistically significant lower EEG power in higher frequency bands at frontal electrode positions in the sleep stages N2, N3 and NREM. On the other hand, TETRA exposure mainly affected the deep delta frequency band, with statistically significant increased EEG power in sleep stage N1 at frontal electrode positions and in sleep stage N2 and NREM also at posterior electrodes. These results can also be interpreted to reflect a sleep-consolidating effect of RF exposure. The spindle analysis

revealed no important exposure- dependent variations in the investigated sleep spindle parameters. In summary, none of the observed effects can be interpreted in terms of a disturbed sleep under exposure.

While the PST and the AAT did not reveal any evidence for an RF exposure effect on the tonic level of central nervous alertness, power spectra of the waking EEG was increased in the alpha frequency range following TETRA exposure. These slight physiological variations, however, are typically not reflected in parameters of phasic alertness (exception: Contingent Negative Variation and P300 where results indicate a more efficient information processing under GSM exposure). With some exceptions [increased reaction time (mean + median) under GSM exposure in the first part of the vigilance task as well as increased reaction time (median) under GSM and TETRA exposure in the selective attention task] no systematic exposure related differences were observed for the three attention components: vigilance, selective and divided attention. There were also no systematic effects on working memory.

A pre-post exposure comparison of mood and symptoms revealed only slight variation in relation to exposure. However, with one exception, the study night questionnaire outcome parameters, which were affected by exposure, were exclusively attributable to subjective sleep perception and can be interpreted as "better sleep" under RF exposure. These subjective assessments correspond to the observations for the objectively measured sleep parameters. Results of thermal perception suggest that the subjects were neither influenced nor unblinded due to a possible heating from the antenna.

Overall the data indicate that brain activity as measured by power spectra of the wake and of the sleep EEG may differ between exposure conditions. This is in line with several other study results in this specific field of research. The slight physiological changes, however, are typically not reflected by behavioural measures and symptoms. Moreover, in particular the sleep data shows that the effects seen in elderly women differ significantly from those of young men. Whether these differences are age- and / or gender-specific can only be answered when the data of a study in elderly men (60 to 80 years) is analyzed. So far results refer to the group

level. Analyses at the individual level, which can be performed based on multiple assessments per exposure condition and subject, are still pending.

Open access paper (in German): https://doris.bfs.de/jspui/bitstream/urn:nbn:de:0221-2019013117414/3/BfS_2019_3614S30012.pdf

INCIDENCE TRENDS OF ADULT MALIGNANT BRAIN TUMORS IN FINLAND, 1990-2016

Natukka T, Raitanen J, Haapasalo H, Auvinen A. Incidence trends of adult malignant brain tumors in Finland, 1990-2016. *Acta Oncol.* 2019 Jul;58(7):990-996. doi: 10.1080/0284186X.2019.1603396.

Abstract

Background: Several studies have reported increased incidence trends of malignant gliomas in the late 1900s with a plateau in the 2000s, but also some recent increases have been reported. The purpose of our study was to analyze incidence trends of malignant gliomas in Finland by morphology and tumor location.

Material and methods: Data on 4730 malignant glioma patients were obtained from case notifications to the nationwide, population-based Finnish Cancer Registry (FCR), and less detailed data on 3590 patients up to 2016. Age-standardized incidence rates (ASR) and average annual percent changes (APCs) in the incidence rates were calculated by histological subtype and tumor location.

Results: The incidence rate of gliomas was 7.7/100,000 in 1990-2006 and 7.3 in 2007-2016. The incidence of all gliomas combined was stable during both study periods, with no departure from linearity. In an analysis by age group, increasing incidence was found only for ages 80 years and older (1990-2006). During both study periods, incidence rates were increasing in glioblastoma and decreasing in unspecified brain tumors. In 1990-2006, rates were also increasing for anaplastic oligodendroglioma, oligoastrocytoma and unspecified malignant glioma, while decreasing for astrocytoma. As for tumor location, incidence in 1990-2006 was increasing for frontal lobe and brainstem tumors, as well as those with an unspecified location, but decreasing for the parietal lobes, cerebrum and ventricles.

Conclusions: No increasing incidence trend was observed for malignant gliomas overall. An increasing incidence trend of malignant gliomas was found in the oldest age group during 1990-2006. <https://www.ncbi.nlm.nih.gov/pubmed/30985227>

Excerpts

A difference in incidence trends between histological types during 1990–2006 was evident (likelihood ratio test $p < .001$). The incidence trend of glioblastoma was slightly increasing (APC: +0.8%; 95% CI: –0.0, +1.7 for 1990–2006 and +1.9%; 95% CI: +0.2, +3.5 for 2007–2016; Tables 2 and 3. A decreasing ASR was found for unspecified tumors of the brain (APC: –4.5%; 95% CI: –6.0, –2.9 for 1990–2006 and –6.0%; 95% CI: –8.6, –3.3 for 2007–2016), whereas incidence of unspecified malignant glioma increased by +6.7% per year (95% CI: +2.6, +11.0)) in 1990–2006 and at a nearly identical rate in 2007–2016. Incidence of oligoastrocytoma increased in 1990–2006 (APC: +6.6%; 95% CI: +3.8, +9.5), but not any more during the later period. During the earlier study period, significant increase in ASRs was also observed for anaplastic oligodendroglioma (APC: +6.0%; 95% CI: +2.3, +9.8), while incidence trend of astrocytoma showed a decrease of –2.8% per year (95% CI: –4.4, –1.1). Incidence of anaplastic astrocytoma increased in 2007–2016 (APC: +7.3%; 95% CI: +2.2, +12.7). In addition, imputing specific histologic types (in similar proportion to those with known cell type) to unspecified tumors had no substantial effect on the incidence trends in 1990–2006 (Supplementary Table 1).

We also found a difference in incidence trends between anatomic locations during 1990–2006 (likelihood ratio test $p < .001$). Incidence trends were increasing for the frontal lobe (APC: +1.7%; 95% CI: +0.6, +2.8), brainstem (APC: +5.8%; 95% CI: +1.7, +10.0) and unspecified locations (APC: +2.3%; 95% CI: +0.5, +4.1) (Table 4). Trends were decreasing for the parietal lobes (APC: –2.4%; 95% CI: –4.0, –0.9), cerebrum (APC: –3.5%; 95% CI: –6.2, –0.7) and ventricles (APC: –6.0%; 95% CI: –10.4, –1.4).

EVALUATION OF RADIOFREQUENCY AND EXTREMELY LOW-FREQUENCY FIELD LEVELS AT CHILDREN'S PLAYGROUND SITES IN GREECE FROM 2013 TO 2018

Maria Christopoulou M, Karabetos E. Evaluation of radiofrequency and extremely low-frequency field levels at children's playground sites in greece from 2013 to 2018. Bioelectromagnetics. Published online September 20, 2019. <https://doi.org/10.1002/bem.22220>

Abstract

From 2013 to 2018, in-situ measurements of radiofrequency (RF) electromagnetic fields (EMF) and extremely low-frequency (ELF) electric and magnetic fields in 317 existing and under-construction children's playground facilities, in 16 municipalities all over Greece, were carried out by the Greek Atomic Energy Commission (EEAE). These measurements were conducted following legislative framework established in 2009, which requires that compliance with the established exposure limits for EMFs should be verified in playground areas. The results are presented by the value of the electric field (E) and exposure ratio (Λ) for the RF EMF, as well as the value of the electric field (E) and magnetic flux density (B) for the ELF electric and magnetic fields. Statistical analysis tools were applied on measurement data and conclusions have been made, taking into consideration: (i) environment type (urban/suburban), and (ii) vicinity to any transmitting installations. Measurement results correspond to the typical EMF background levels for each environment type. Concerning the environment type, RF EMF, and ELF electric/magnetic field measurements reveal no differentiation between urban and suburban environments.

Conclusion

In conclusion, the aim of this work was to analyze in-situ measurements of RF EMF and ELF electric and magnetic fields in 317 existing and under-construction playground facilities, conducted from 2013 to 2018. Concerning the environment type, RF EMF measurements reveal no differentiation between urban and suburban environments. Higher E-field values, e.g., 1.66 V/m for urban environment, are due to the proximity of the playground facilities to base stations. Concerning ELF measurements, median values for magnetic flux density did not differ within environment types and were kept at 0.14 μ T. Selected high-measurement values in suburban environments may be due to a larger number of low- and medium-voltage power distribution network facilities located near the playground sites. Based on both measurement datasets, RF and ELF field levels were found even lower than typical background levels in urban/suburban environments. This study is in line with the international literature's findings, confirming the children's exposure levels in urban and suburban environments. Although spot measurements provide overestimation of RF exposure levels compared to personal dosimeters' data [Gallastegi et al., 2018], EEAE intends to correlate this study's findings with personal dosimeters' data and schedule national epidemiological investigations, in order to provide a complete description of the exposure patterns.

<https://onlinelibrary.wiley.com/doi/pdf/10.1002/bem.22220>

RADIOFREQUENCY RADIATION FROM NEARBY MOBILE PHONE BASE STATIONS-A CASE COMPARISON OF ONE LOW AND ONE HIGH EXPOSURE APARTMENT

Koppel T, Ahonen M, Carlberg M, Hedendahl LK, Hardell L. Published online Sep 20, 2019. <https://doi.org/10.3892/ol.2019.10899>

Abstract

Radiofrequency (RF) radiation in the frequency range of 30-300 GHz has, since 2011, been classified as a 'possible' human carcinogen by Group 2B, International Agency for Research on Cancer (IARC) at WHO. This was based on a number of human epidemiology studies on increased risk for glioma and acoustic neuroma. Based on further human epidemiology studies and animal studies, the evidence on RF radiation carcinogenesis has increased since 2011. In previous measurement studies, it has been indicated that high environmental RF radiation levels are present in certain areas of Stockholm Sweden, including in one apartment. Field spatial distribution measurements were performed in the previously measured apartment in Stockholm, which exhibited high RF radiation from nearby base stations. Based on the RF broadband analyzer spot measurements, the maximum indoor E-field topped at 3 V m⁻¹ in the bedroom at the 7th floor. The maximum outdoor exposure level of 6 V m⁻¹ was encountered at the 8th floor balcony, located at the same elevation and only 6.16 m away from the base station antennas. For comparison, a measurement was made in a low exposure apartment in Stockholm. Here, the maximum indoor field 0.52 V m⁻¹ was measured at the corner window, with direct line of sight to the neighboring house with mobile phone base station antennas. The maximum outdoor field of 0.75 V m⁻¹ was measured at the balcony facing the same next-door building with mobile phone base station antennas. The minimum field of 0.10 V m⁻¹ was registered on the apartment area closest to the center of the building, demonstrating the shielding effects of the indoor walls. Good mobile phone reception was achieved in both apartments. Therefore, installation of base stations to risky places cannot be justified using the good reception requirement argument.

Open access paper: <https://www.spandidos-publications.com/10.3892/ol.2019.10899>

RADIATION MEASUREMENTS IN OFFICE ENVIRONMENT WITH WI-FI, 3G AND 4G USERS

Koutsis E, Deligiannis S, Sarantopoulos I, Zarbouti D, Athanasiadou G, Tsoulos G. Radiation measurements in office environment with Wi-Fi, 3G and 4G users. 2019 8th International Conference on Modern Circuits and Systems Technologies (MOCAST). 13-15 May 2019. DOI: 10.1109/MOCAST.2019.8741720

Abstract

The unprecedented explosion of wireless communications with billions of devices across several wireless and cellular systems, has increased concerns about the human exposure to electromagnetic waves. In this context, this work focuses in office operational environments and the most widely used wireless systems therein, i.e. Wi-Fi and 3G/4G networks, in order to evaluate the radiation levels with 4–5 people working in the room. The results show that even with one Wi-Fi user the radiation level can be higher than the reference level for the whole band, while the corresponding scenario for 3G/4G would be with three users. Also, with three or more users, the 4G levels are ~10% higher than the second higher Wi-Fi.

Conclusions

In this work a measurement campaign was carried out with the frequency selective NARDA SRM-3000 inside a medium sized office room. The goal of the campaign was to investigate the impact of Wi-Fi, 3G and 4G users on the E-field footprint when they maximize their activity, i.e. downloading/uploading data files from/to the web. As a reference scenario, wideband measurements were performed outside office hours when no users were present.

The results show that even one Wi-Fi downloading user drives the E-field value above the reference scenario (of no WiFi router users or cell phone users), while three 3G or 4G users are needed to overtake it. After two users, the 4G contribution dominates the E-field footprint inside the office. Specifically, compared to 3G, 4G almost doubles the E-field values which are ~10% higher compared to Wi-Fi.

It must be mentioned though that in all cases the measured E-field values were much lower (~66 times) than the existing non-ionizing radiation for public exposure safety values [8].

<https://ieeexplore.ieee.org/document/8741720>

EARLY-LIFE EXPOSURE TO PULSED LTE (4G) RADIOFREQUENCY FIELDS CAUSES PERSISTENT CHANGES IN ACTIVITY AND BEHAVIOR IN C57BL/6 J MICE

Broom KA, Findlay R, Addison DS, Goiceanu C, Sienkiewicz Z. Early-Life Exposure to Pulsed LTE Radiofrequency Fields Causes Persistent Changes in Activity and Behavior in C57BL/6 J Mice. Bioelectromagnetics. 2019 Sep 15. doi: 10.1002/bem.22217.

Abstract

Despite much research, gaps remain in knowledge about the potential health effects of exposure to radiofrequency (RF) fields. This study investigated the effects of early-life exposure to pulsed long term evolution (LTE) 1,846 MHz downlink signals on innate mouse behavior. Animals were exposed for 30 min/day, 5 days/week at a whole-body average specific energy absorption rate (SAR) of 0.5 or 1 W/kg from late pregnancy (gestation day 13.5) to weaning (postnatal day 21). A behavioral tracking system measured locomotor, drinking, and feeding behavior in the home cage from 12 to 28 weeks of age. The exposure caused significant effects on both appetitive behaviors and activity of offspring that depended on the SAR. Compared with sham-exposed controls, exposure at 0.5 W/kg significantly decreased drinking frequency ($P \leq 0.000$) and significantly decreased distance moved ($P \leq 0.001$). In contrast, exposure at 1 W/kg significantly increased drinking frequency ($P \leq 0.001$) and significantly increased moving duration ($P \leq 0.005$). In the absence of other plausible explanations, it is concluded that repeated exposure to low-level RF fields in early life may have a persistent and long-term effect on adult behavior.

<https://www.ncbi.nlm.nih.gov/pubmed/31522469>

EFFECTS OF MOBILE PHONE RADIATION ON CERTAIN HEMATOLOGICAL PARAMETERS

Christopher B, Sheena MY, Uddin Khandaker M, Bradley DA, Chew MT, Jojo PJ. Published online September 14, 2019. 108443. <https://doi.org/10.1016/j.radphyschem.2019.108443>.

Highlights

- Mobile phone radiation affects blood hemoglobin level, white blood cell and platelets count and erythrocytes sedimentation rate.
- Effects of mobile phone radiation on hematological factors studied in a controlled condition in the laboratory.
- A matched case control approach was adopted for the investigation.
- Long time and over exposure to mobile phone radiation may affect the individual health.

Abstract

Exorbitant chronic exposure to any sort of radiation is hazardous to human health. Besides ionizing radiation, exposures to electromagnetic radiation mainly from the use of mobile phones have become a matter of great health concern, especially its extortionate use even by children. At the same time there are several myths related to the ill effects including carcinogenicity of the prolonged exposure continuously. The objective of this investigation was to find the effect on certain vital hematological parameters namely hemoglobin level, white blood cell (WBC) count, platelet count and erythrocytes sedimentation rate (ESR) level due to the prolonged exposure to mobile radiations through in vitro examination of human blood samples. Matched case control methodology was adopted for the study. Blood samples were collected by clinicians from 27 voluntary subjects for investigation. From each, one sample was kept un-exposed while the other three samples were exposed to mobile microwave radiations for 60 min continuously in identical and controlled conditions. A 4G hand phone of a very popular brand having transmission frequency range from 2.3 to 2.4 GHz including uplink and downlink was used. Hematological analyses were carried out on fresh samples immediately after collection. For comparison of the levels of hematological parameters, blood exposed to 1 h of phone radiation and control were analysed. Experimental results show that there is a significant change on the hematological components. The exposed blood samples were found to have decrease in platelet count only. Hemoglobin level, ESR rate and the WBC counts were found to be increased. While these observations are performed in a controlled laboratory conditions, the tremendous growth in number of mobile phone users, the effects could be many more folds especially in work places and cities even through passive exposure.

<https://www.sciencedirect.com/science/article/abs/pii/S0969806X19305481>

CHROMOSOME DAMAGE IN HUMAN CELLS INDUCED BY UMTS (3G) MOBILE TELEPHONY RADIATION

Panagopoulos DJ. Chromosome damage in human cells induced by UMTS mobile telephony radiation. *Gen Physiol Biophys*. 2019 Sep 13. doi: 10.4149/gpb_2019032.

Abstract

Environmental exposure to modern microwave telecommunication electromagnetic fields (EMFs) has increased to unprecedented levels with consequent health complaints and concerns. Many studies have already reported genotoxic effects on a variety of organisms and cell/tissue types. Human peripheral blood lymphocytes from six healthy donors were stimulated for mitosis and exposed to microwave EMF of Universal Mobile Telecommunications System (UMTS) or third generation (3G) mobile telephony (MT) EMF/radiation emitted by a commercially available mobile phone handset. Lymphocytes exposed during the G2 phase of the cell division cycle and observed at metaphase, exhibited chromatid-type aberrations (gaps and breaks) at highly significant percentages - up to 275% - compared to the control (sham-exposed) samples. Each subject exhibited a different sensitivity to the microwave exposure. Moreover, the percentages of aberrations in the control samples among subjects were different due to genetic and environmental factors. The MT EMF exposure induced mainly achromatic lesions (gaps), and secondarily terminal deletions (breaks) in a smaller degree. In conclusion, the present study shows that microwave 3G MT EMF/radiation - within the current exposure limits - has significant genotoxic action on human cells, and human exposure to this EMF/radiation should be kept at levels as low as possible.

<https://www.ncbi.nlm.nih.gov/pubmed/31516130>

SHOULD PARENTS ALLOW THEIR CHILDREN TO USE SMART PHONES AND TABLETS? THE ISSUE OF COGNITIVE PERFORMANCE

Mortazavi SAR, Haghani M, Zarei S, Rastegarian N, Alighanbari N, Haghparast M, Darvish L. Should parents allow their children to use smart phones and tablets? The issue of cognitive performance. *J Biomed Phys Eng*. <https://doi.org/10.22086/jbpe.v0i0.535>, Published online first.

Abstract

Mobile phones, mobile phone base stations, cordless phones and power lines are among the main sources of our daily exposures to radiofrequency electromagnetic fields (RF-EMF). Today, a large proportion of children aged eight and under has used smart phones and tablets for media activities such as playing online games, watching videos or using different applications. Over the past several years, our society has witnessed a rapid growth both in the percent of children who regularly use smart phones and tablets and the time spent using these devices. Expanded access of children to these mobile devices and the games that make mobile phones attractive to young users are believed to be the key factors that increased the time spent by children for using mobile devices. In IR Iran, students are not allowed to use mobile phones in schools. On the other hand, although students do not have access to Wi-Fi in schools, as Wi-Fi provides efficient access to the Internet on the campus, Wi-Fi routers are widely used. The rapid growth of mobile phone use has raised global public concerns especially for children. Focusing on the issue of cognitive performance, this paper is aimed at

answering the following question; Should parents let their children use smart phones and tablets?

CONCLUSIONS

Nowadays in many countries, there are warnings about children mobile phone use [53]. Radiofrequency electromagnetic radiation is a Class 2B (possible). It is widely believed that children are more susceptible to radiation at least in some regions of the electromagnetic spectrum [54]. It has been reported that children absorb more radiofrequency radiation than adults [53]. Moreover, some individuals are hypersensitive to RF-EMFs [55] and this hypersensitivity may cause more problems in children. As long-term effects of the children's exposures to RF-EMF emitted from mobile phones and other wireless technologies are not fully understood, overexposure to phones and other wireless technologies should be avoided to protect their cognitive performance. In this light, setting time limits for cell phone use by children is highly recommended. Moreover, in each country authorities should adopt radiation standards which protect children's health and well-being.

Open access paper:

http://www.jbpe.ir/Journal_OJS/JBPE/index.php/jbpe/article/download/535/306

CHILDREN EXPOSURE TO FEMTOCELL IN INDOOR ENVIRONMENTS ESTIMATED BY SPARSE LOW-RANK TENSOR APPROXIMATIONS

Chiamarello E, Parazzini M, Fiocchi S, Bonato M, Ravazzani P, Wiart J. *Annals of Telecommunications*. 74(1-2):113-121. February 2019.

Abstract

The exposure of an 8-year-old child to a femtocell operating at 2600 MHz, both (child and source) freely located in random positions in an indoor environment, was assessed. In order to develop surrogate models of the exposure, stochastic dosimetry based on sparse low-rank tensor approximation method (sparse LRA) was used. The surrogate models were used for fastly estimating the specific absorption rate (SAR) in all the possible positions of femtocell and child. Results showed that, for all the possible positions in the room, the exposure values were significantly below the International Commission of Non-Ionizing Radiation Protection (ICNIRP) guidelines for general public and that the probability of reaching SAR values higher than 1% of the ICNIRP guidelines value was lower than 0.006. The variation of the distance between femtocell and child influenced greatly the exposure, resulting in quartile coefficient of dispersion values always higher than 48%.

<https://link.springer.com/article/10.1007%2Fs12243-018-0681-0>

EFFECT OF ELECTROMAGNETIC FIELD EXPOSURE ON THE TRANSCRIPTION OF REPETITIVE DNA ELEMENTS IN HUMAN CELLS

Del Re B, Bersani F, Giorgi G. Effect of electromagnetic field exposure on the transcription of repetitive DNA elements in human cells. *Electromagn Biol Med*. 2019 Sep 21:1-9. doi: 10.1080/15368378.2019.1669634.

Abstract

Repetitive DNA (RE-DNA) was long thought to be silent and inert; only recent research has shown that it can be transcribed and that transcription alteration can be induced by environmental stress conditions, causing human pathological effects. The aim of this study was to determine whether exposure to radiofrequency electromagnetic fields (RF-EMF) could affect the transcription of RE-DNA. To this purpose, three different human cell lines (HeLa, BE(2)C and SH-SY5Y) were exposed to 900 MHz GSM-modulated RF-EMF at specific absorption rate of 1 W/kg or to sham. After exposure, mRNA levels of RE-DNA were evaluated through quantitative real-time PCR. The following RE-DNA types were investigated: Long Interspersed nucleotide Element 1, DNA alpha satellite and Human Endogenous Retroviruses-like sequences. When comparing cells exposed to RF-EMF versus control samples, different results were found for the three cell lines evaluated, indicating that RF-EMF exposure can significantly affect RE-DNA transcription and that the effects strongly depend on the cellular context and the tissue type. Further studies are needed to elucidate which molecular mechanisms could be involved

<https://www.ncbi.nlm.nih.gov/pubmed/31542968>

LONG-TERM EXPOSURE TO 4G SMARTPHONE RADIOFREQUENCY ELECTROMAGNETIC RADIATION DIMINISHED MALE REPRODUCTIVE POTENTIAL BY DIRECTLY DISRUPTING SPOCK3-MMP2-BTB AXIS IN THE TESTES OF ADULT RATS

Yu G, Tang Z, Chen H, Chen Z, Wang L, Cao H, Wang G, Xing J, Shen H, Cheng Q, Li D, Wang G, Xiang Y, Guan Y, Zhu Y, Liu Z, Bai Z. Long-term exposure to 4G smartphone radiofrequency electromagnetic radiation diminished male reproductive potential by directly disrupting Spock3-MMP2-BTB axis in the testes of adult rats. *Sci Total Environ*. 2019 Aug 31;698:133860. doi: 10.1016/j.scitotenv.2019.133860.

Abstract

The correlation between long-term exposure to SRF-EMR and the decline in male fertility is gradually receiving increasing attention from the medical society. While male reproductive organs are often exposed to SRF-EMR, little is currently known about the direct effects of long-term SRF-EMR exposure on the testes and its involvement in the suppression of male reproductive potential. The present study was designed to investigate this issue by using 4G SRF-EMR in rats. A unique exposure model using a 4G smartphone achieved localized exposure to the scrotum of the rats for 6 h each day (the smartphone was kept on active talk mode and received an external call for 1 min over 10 min intervals). Results showed that SRF-EMR exposure for 150 days decreased sperm quality and pup weight, accompanied by testicular injury. However, these adverse effects were not evident in rats exposed to SRF-EMR for 50 days or 100 days. Sequencing analysis and western blotting suggested Spock3 overexpression in the testes of rats exposed to SRF-EMR for 150 days. Inhibition of Spock3 overexpression improved sperm quality decline and alleviated testicular injury and BTB

disorder in the exposed rats. Additionally, SRF-EMR exposure suppressed MMP2 activity, while increasing the activity of the MMP14- Spock3 complexes and decreasing MMP14-MMP2 complexes; these results were reversed by Spock3 inhibition. Thus, long-term exposure to 4G SRF-EMR diminished male fertility by directly disrupting the Spock3-MMP2-BTB axis in the testes of adult rats. To our knowledge, this is the first study to show direct toxicity of SRF-EMR on the testes emerging after long-term exposure.

<https://www.ncbi.nlm.nih.gov/pubmed/31514029>

REVIEW: THE INFLUENCE OF BIOACTIVE MOBILE TELEPHONY RADIATION AT THE LEVEL OF A PLANT COMMUNITY – POSSIBLE MECHANISMS AND INDICATORS OF THE EFFECTS

Czerwiński M, Januszkiewicz L, Vian A, Łazarod A. Review: 108, Jan 2020. 105683. <https://doi.org/10.1016/j.ecolind.2019.105683>.

Highlights

- There are various indicators of microwave radiation impact on herbaceous vegetation.
- The best indicators are some parameters of vegetation canopy or individual plants.
- Specific plant functional groups may be indicators of long-term community processes.
- Other organisms interacting with plants, e.g. pollinators, should also be considered.
- The selection of indicators depends on the propagation of radiation in the canopy.

Abstract

Environmental exposure to radiofrequency electromagnetic fields (RF-EMFs) from mobile telephony has rapidly increased in the last two decades and this trend is expected to continue. The effects of this exposure at plant community level are unknown and difficult to assess in a scientifically appropriate manner. Such an assessment can be scientifically adequate if a studied plant community is completely new and control-impact radiation treatment is used.

In this review we aimed to predict ecological effects and identify indicators of the impact of bioactive RF-EMFs at the mobile telephony frequency range on plant communities. We considered the scenario where a plant community was exposed to radiation generated by a base transmitting station antenna mounted on a nearby mast. This plant community can be represented by mesic meadow, ruderal or arable weed community, or other herbaceous, moderately productive vegetation type. We concentrated primarily on radiation effects that can be recorded for a year since the exposure started. To predict them we used physical theories of radiowave propagation in vegetation and the knowledge on plants physiological responses to RF-EMF. Our indicators can be used for the detection of the impact of RF-EMFs on vegetation in a control-impact experiment.

The identified indicators can be classified into the following groups:

- (1) canopy parameters;
- (2) plant characteristics to be measured in the field or laboratory in a number of individuals that represent the populations of selected species;
- (3) community weighted means/medians (CWMs) of plant traits and strategies;
- (4) the abundance of other organisms that interact with plants and can influence their fitness or population size.

The group of canopy parameters includes mean height, vertical vegetation structure and dry weight of above- ground standing phytomass. Plant characteristics requiring biometric sampling in the field are plant height, the number of fruits and seeds, as well as seed viability. The group of plant traits that are calculated as CWMs covers seed releasing height, seed dispersal mode, SLA, leaf orientation, month of germination and flowering, Ellenberg's light indicator value, and the proportion of individuals in the classes of competitors and stress tolerators according to Grime's CSR strategy scheme. The group of "non-plant" indicators includes primarily the frequency of flower visits by beetles, wasps, hoverflies, and bees that have their nests over ground. To detect ecological responses that occur for the first year since a herbaceous community has been exposed to potentially bioactive RF-EMF, the first two indicators groups should be used.

<https://www.sciencedirect.com/science/article/pii/S1470160X19306764>

HEALTH EFFECTS ASSOCIATED WITH EXPOSURE TO LOW-FREQUENCY ELECTROMAGNETIC FIELDS

French Agency for Food, Environmental and Occupational Health & Safety (ANSES). Health effects associated with exposure to low-frequency electromagnetic fields. info.

2019, ANSES OPNION Request No 2013-SA-0038: 1-14.

<https://www.anses.fr/en/system/files/AP2013SA0038EN.pdf>

ELECTROMAGNETIC FIELDS EXPOSURE FROM POWER LINES AND HUMAN FERTILITY

Esmailzadeh S, Agajani Delavar M, Gholamian SA, Ahmadi A, Hosseinpour Haydari F, Pourali M. Electromagnetic Fields Exposure from Power Lines and Human Fertility. Iran J Public Health. 2019 May;48(5):986-987.

Open access letter: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6717401/>

EFFECT OF STATIC MAGNETIC FIELD OF ELECTRIC VEHICLES ON DRIVING PERFORMANCE AND ON NEURO-PSYCHOLOGICAL COGNITIVE FUNCTIONS

He Y, Sun W, Leung PS, Chow YT. Int J Environ Res Public Health. 2019 Sep 12;16(18). pii: E3382. doi: 10.3390/ijerph16183382.

Abstract

Human neuropsychological reactions and brain activities when driving electric vehicles (EVs) are considered as an issue for traffic and public safety purposes; this paper examined the effect of the static magnetic field (SMF) derived from EVs. A lane change task was adopted to evaluate the driving performance; and the driving reaction time test and the reaction time test were adopted to evaluate the variation of the neuro-psychological cognitive functions. Both the sham and the real exposure conditions were performed with a 350 μ T localized SMF in this study; 17 student subjects were enrolled in this single-blind experiment. Electroencephalographs (EEGs) of the subjects were adopted and recorded during the experiment as an indicator of the brain activity for the variations of the driving performance and of the cognitive functions. Results of this study have indicated that the impact of the given SMF on both the human driving performance and the cognitive functions are not considerable; and that there is a correlation between beta sub-band of the EEGs and the human reaction time in the analysis.

Open access paper: <https://www.mdpi.com/1660-4601/16/18/3382>

GEOMAGNETIC DISTURBANCES DRIVEN BY SOLAR ACTIVITY ENHANCE TOTAL AND CARDIOVASCULAR MORTALITY RISK IN 263 U.S.CITIES

Zilli Vieira CL, Alvares D, Blomberg A, Schwartz J, Coull B, Huang S, Koutrakis P. Geomagnetic disturbances driven by solar activity enhance total and cardiovascular mortality risk in 263 U.S. cities. *Environmental Health*. 18(83). Sep 11, 2019.

Abstract

Background Short-term geomagnetic disturbances (GMD) driven by the quasi-periodic 11-year cycle of solar activity have been linked to a broad range of adverse health effects, including cardiovascular diseases (CVD) and total deaths. We conducted a large epidemiological study in 263 U.S. cities to assess the effects of GMD on daily deaths of total, CVD, myocardial infarction (MI), and stroke.

Methods We employed a two-step meta-analysis approach, in which we estimated city-specific and season- stratified mortality risk associated with a GMD parameter (Kp index) in 263 U.S. cities. In addition, sensitivity analysis was performed to assess whether effect modification of particulate matter (PM2.5) in the prior day changed Kp index effects on daily deaths after adjusting for confounders.

Results We found significant association between daily GMD and total, CVD, and MI deaths. The effects were even stronger when we adjusted the models for 24-h PM2.5 for different seasons. For example, in the winter and fall one standard deviation of z-score Kp index increase was associated with a 0.13 and 0.31% increase in total deaths, respectively (Winter: $p = 0.01$, 95% CI: 0.02 to 0.24; Fall: $p = 0.00001$; 95% CI: 0.23 to 0.4), without adjusting for PM2.5. The effects of GMD on total deaths were also observed in spring and summer in the models without PM2.5 ($p = 0.00001$). When the models were adjusted for PM2.5 the total deaths increased 0.47% in winter ($p = 0.00001$, 95% CI: 0.3 to 0.65) and by 0.23% in fall ($p = 0.001$, 95% CI: 0.09 to 0.37). The effects of GMD were also significant associated with MI deaths and CVD. No positive significant association were found between Kp and stroke. The GMD effects on deaths were higher than for 24 h-PM2.5 alone, especially in spring and fall.

Conclusion Our results suggest that GMD is associated with total, CVD and MI deaths in 263 U. S cities. Increased mortality in the general population during GMD should be further investigated to determine whether those human physiological dynamics driven by variations in solar activity can be related to daily clinical cardiovascular observations.

Open access paper: <https://ehjournal.biomedcentral.com/articles/10.1186/s12940-019-0516-0>

RISKS TO HEALTH AND WELL-BEING FROM RADIO-FREQUENCY RADIATION EMITTED BY CELL PHONES AND OTHER WIRELESS DEVICES

Miller AB, Sears ME, Morgan LL, Davis DL, Hardell L, Oremus M and Soskolne CL (2019) Risks to health and well-being from radio-frequency radiation emitted by cell phones and other wireless devices. *Front. Public Health* 7:223. doi: 10.3389/fpubh.2019.00223.

Abstract

Radiation exposure has long been a concern for the public, policy makers, and health researchers. Beginning with radar during World War II, human exposure to radio-frequency radiation¹ (RFR) technologies has grown substantially over time. In 2011, the International Agency for Research on Cancer (IARC) reviewed the published literature and categorized RFR as a “possible” (Group 2B) human carcinogen. A broad range of adverse human health effects associated with RFR have been reported since the IARC review. In addition, three large-scale carcinogenicity studies in rodents exposed to levels of RFR that mimic lifetime human exposures have shown significantly increased rates of Schwannomas and malignant gliomas, as well as chromosomal DNA damage. Of particular concern are the effects of RFR exposure on the developing brain in children. Compared with an adult male, a cell phone held against the head of a child exposes deeper brain structures to greater radiation doses per unit volume, and the young, thin skull's bone marrow absorbs a roughly 10-fold higher local dose. Experimental and observational studies also suggest that men who keep cell phones in their trouser pockets have significantly lower sperm counts and significantly impaired sperm motility and morphology, including mitochondrial DNA damage. Based on the accumulated evidence, we recommend that IARC re-evaluate its 2011 classification of the human carcinogenicity of RFR, and that WHO complete a systematic review of multiple other health effects such as sperm damage. In the interim, current knowledge provides justification for governments, public health authorities, and physicians/allied health professionals to warn the population that having a cell phone next to the body is harmful, and to support measures to reduce all exposures to RFR.

Open access paper: <https://www.frontiersin.org/articles/10.3389/fpubh.2019.00223/full>

RADIOFREQUENCY ELECTROMAGNETIC RADIATION-INDUCED BEHAVIORAL CHANGES AND THEIR POSSIBLE BASIS

Narayanan SN, Jetty R, Kesari KK, Kumar RS, Nayak SB, Bhat PG. Radiofrequency electromagnetic radiation- induced behavioral changes and their possible basis. *Environ Sci Pollut Res Int*. 2019 Aug 28. doi: 10.1007/s11356-019-06278-5.

Abstract

The primary objective of mobile phone technology is to achieve communication with any person at any place and time. In the modern era, it is impossible to ignore the usefulness of mobile phone technology in cases of emergency as many lives have been saved. However, the biological effects they may have on humans and other animals have been largely ignored and not been evaluated comprehensively. One of the reasons for this is the speedy uncontrollable growth of this technology which has surpassed our researching ability. Initiated with the first generation, the mobile telephony currently reaches to its fifth generation without being screened extensively for any biological effects that they may have on humans or on other animals. Mounting evidences suggest possible non-thermal biological effects of radiofrequency electromagnetic radiation (RF-EMR) on brain and behavior. Behavioral studies

have particularly concentrated on the effects of RF-EMR on learning, memory, anxiety, and locomotion. The literature analysis on behavioral effects of RF-EMR demonstrates complex picture with conflicting observations. Nonetheless, numerous reports suggest a possible behavioral effect of RF-EMR. The scientific findings about this issue are presented in the current review. The possible neural and molecular mechanisms for the behavioral effects have been proposed in the light of available evidences from the literature.

<https://www.ncbi.nlm.nih.gov/pubmed/31463749>

Conclusions

Mobile phone safety recommendations depend mainly on 'sinusoidal wave' emitted from the cell phone when it is idle. At idle mode, the RF-EMR exposure is negligible, hence, it might not be that detrimental at this level. However, chronic exposure to the 'carrier signal' emitted when phone is in 'ON' mode (when the phone is ringing/call receiving mode) would be responsible for biological effects. Exposure to RF-EMR induces an imbalance in the oxidant/antioxidant defense system in the brain indicating that the internal environment of each brain cell was getting disturbed by the insult from RFEMR. This therefore does not favor the nerve cells to function appropriately. Whenever the threshold is reached, the cell either stops functioning, functions abnormally, or dies. We call it structural change or morphological change. Most of the time, what happens at the cellular level is indicated at the behavioral level. It is highly difficult to join up biochemical change, morphological change, and then behavior. An imbalance in the biochemical homeostasis would itself alter the behavior which might not be structurally represented and vice versa. This is due to the mechanisms, which prevent or resist the insult from external stressors. Currently, we are not sure about this fact as there are no solid evidences which pin point or demonstrate this innate preventive/restrain mechanisms present in neurons under RF-EMR exposure. Further study in this regard will reveal much clearer picture of body's (especially brain) innate mechanisms which would withstand the potential threat caused by RF-EMR.

It is evident from earlier discussions that a possible behavioral effect does exist following RF-EMR exposure in rodents. However, caution should be taken while extrapolating these findings into humans. It is worth noting that an adult uses mobile phone approximately 4 to 5 h per day and this may be even more in teenagers. However, reports that analyze the behavioral, psychological, and health variables following RFEMR exposure in sensitive population like young adults are scanty. Furthermore, it would be interesting to study the effect of RF-EMR exposure in early developmental stage and see what the effects of such exposures are on the critical and sensitive periods of development using animal models. Although the current review focused principally on RFEMR-induced effects on cognition, anxiety, and locomotion, RF-EMR have been attributed to induce other behavioral effects in rodents as well as in humans. After witnessing the uncontrollable growth of this technology, everyone believes that it is high time to evaluate the health risks of continuous and chronic RF-EMR exposure effects on humans and for which further studies are warranted.

EFFECT OF RADIOFREQUENCY RADIATION ON REPRODUCTIVE HEALTH

Singh R, Nath R, Mathur AK, Sharma RS. Effect of radiofrequency radiation on reproductive health. Indian J Med Res. 2018 Dec; 148(Suppl 1): S92–S99. doi: 10.4103/ijmr.IJMR_1056_18.

Abstract

The development of cellular phone system has greatly increased the extent and magnitude of radiofrequency radiation (RFR) exposure. The RFR emitted from mobile phone and mobile phone base stations exerts thermal and non-thermal effects. The short-term and long-term exposure to RFR may have adverse effect on humans as well as animals. Most laboratory studies have indicated a direct link between exposure to RFR and adverse biological effects. Several in vitro studies have reported that RFR induces various types of cancer and DNA or chromosomal damage. On the other hand, some animal studies have not reported adverse effects of this radiation. The present review summarizes information available on the possible effects of RFR on the reproductive health.

Open access paper: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6469375/>

HEALTH EFFECTS OF RADIOFREQUENCY ELECTROMAGNETIC FIELDS (RF EMF)

Bortkiewicz A. Editorial: Health effects of radiofrequency electromagnetic fields (RF EMF). Industrial Health. 2019;57(4):403-405. doi: 10.2486/indhealth.57_400.

Conclusion: The problem of health effects of RF EMF has not been definitely resolved, but due to the results of previous research on possible health effects of RF EMF, it seems necessary to use precautionary principles and ALARA (As Low as Reasonably Achievable) principles, when the new sources of electromagnetic emissions will be planned and installed.

Open access paper: https://www.jstage.jst.go.jp/article/indhealth/57/4/57_57_400/_pdf/-char/en

ENVIRONMENTAL FACTORS AND THE RISK OF BRAIN TUMOURS IN YOUNG PEOPLE: A SYSTEMATIC REVIEW

Zumel-Marne A, Castano-Vinyals G, Kundi M, Alguacil J, Cardis E. Environmental Factors and the Risk of Brain Tumours in Young People: A Systematic Review. Neuroepidemiology. 2019 Jun 5:1-21. doi: 10.1159/000500601.

Abstract

BACKGROUND: Brain tumours (BT) are one of the most frequent tumour types in young people, although little is known about their risk factors.

OBJECTIVE: The objective of the current work was to review and summarize the scientific literature concerning exposure to environmental factors and BT risk in young people (<25 years old).

METHODS: PUBMED, Embase, Cochrane Library, Scopus, IME-Biomedina (bibliographic database of Consejo Superior de Investigaciones Científicas) and Web of science databases were searched. A score to assess the quality of the methodological information was created.

RESULTS: Some possible associations between BT risk in young people were reported for cadmium, consumption of well water, presence of nitrate or nitrate-nitrogen in tap water, mother's passive smoking, air pollution, parental handling of pesticides at home and/or professional pesticide treatment within houses, living on a farm and/or with farm animals, some parental occupations and high amount of meat consumption.

CONCLUSIONS: Although many of the studies reviewed suggest associations between the environmental exposures and BT in children and young adults, at present no reliable conclusion can be drawn as most results are based on small number of cases and exposure assessment is limited. Large-scale studies with better exposure assessment are needed to shed light on these possible associations, especially on exposure to heavy metals, tap water consumption, pesticides and parental smoking.

Excerpt: Non-Ionizing Radiation

Three articles [19, 42, 47] studied the association between extremely low frequency (ELF) exposure during pregnancy and BT risk.

Regarding the exposure to electrically heated waterbeds during pregnancy, 2 articles found non-significantly reduced risks (1 for astrocytomas and the other for BT in general) based on small samples sizes [19, 47]. No significant association was found for PNET either [19]. Regarding exposure to ELF from electrical blankets during pregnancy, 3 articles found non-statistically significantly increased risk [19, 42, 47].

Two studies focused on childhood ELF exposure [39, 47] and BT risk. One [39] found a non-significantly reduced risk for electric blanket and waterbed use based on very small numbers of cases ($n = 6$ and 1 , respectively). In the other study, the ORs were close to one.

Two studies [48, 49] focused on radiofrequency (RF) exposures in childhood and BT were found. In the large multinational study [48], a non-significantly increased risk was found, with no evidence for an exposure response relationship between mobile phones use (which emits some ELF but mainly RF) and risk of BT. Use of mobile phones was low in this population, with an average duration of use of 2.7 years and lifetime cumulative time of use of only 35 h. Another study [49], which estimated average of exposure to RF from mobile phone base stations, found a non-statistically significant risk for exposure above the median, though the authors acknowledge several methodological limitations.

Three studies focused on the exposure to magnetic fields (MF) [50-52] from high-current power lines, electric heating sources or electric appliances at home during childhood. One [50] found a significantly increased risk for $\geq 0.4 \mu\text{T}$ of MF in the children's bedroom (OR 10.9 [1.05–113] based on 3 cases and 1 control). Two [51, 52] studies found a non-statistically significant increased risk for exposure at home to high MF compared to low ones.

Open access paper: <https://www.karger.com/Article/FullText/500601>

FUNDING SOURCE, QUALITY OF PUBLICATIONS AND OUTCOME IN GENETIC DAMAGE IN MAMMALIAN CELLS EXPOSED TO NON- IONIZING RADIOFREQUENCY FIELDS

Vijayalaxmi, Prihoda TJ. Funding source, quality of publications and outcome in genetic damage in mammalian cells exposed to non-ionizing radiofrequency fields. *Radiat Res.* 2019 Aug 7. doi: 10.1667/RR15364.1.

Abstract

There has been ongoing debate and discussion concerning whether the funding source influenced the outcome of research on human health effects from exposure to radiofrequency fields (RF, electromagnetic waves that carry energy as they propagate in air and dense media). In a study of 225 publications, in which we sought to determine a possible association between the funding source(s), quality and outcome in a total of 2,160 genetic damage assessment tests of mammalian cells exposed to RF energy, we made several observations. One finding was that a great majority of researchers had acknowledged government agencies as the funding source (53%, 120 of 225 publications), while a small number of scientists mentioned mobile phone industry as the financial source (9%, 20 of 225 publications). Numerous investigators did not mention the funding source (26%, 58 of 225 publications). Secondly, industry-funded investigations were of better quality and utilized quality control measures, i.e., blind evaluation, adequate description of dosimetry, positive controls and/or sham-exposed controls, compared to those funded by the government. Another observation was that in industry-funded studies, the d values (effect size or standardized mean difference between the cells exposed to RF energy and sham-exposed controls) were consistently lower than in government-funded studies. In addition, compared to government-funded studies, a higher percentage of industry-funded studies reported no difference in genetic damage between RF- and sham-exposed cells (80% for industry-funded studies versus 49% for government- funded studies). Finally, we observed that industry-funded studies were less likely to report an increase in genetic damage in cells exposed to RF energy (10%) compared to government-funded studies (23%). In view of the large difference between the percentage of publications funded by government and industry (53% or 122 of 225 publications for government, compared to 9% or 29 of 225 publications for industry), caution should be used when debating and discussing the above observations. Overall, it is important to include the quality control measures in the investigations, and also mention the funding source in published studies.

<https://www.ncbi.nlm.nih.gov/pubmed/31390310>

HEALTH EFFECTS OF RADIOFREQUENCY ELECTROMAGNETIC ENERGY

Elwood M, Wood AW. Health effects of radiofrequency electromagnetic energy. *N Z Med J.* 2019 Aug 30;132(1501):64-72.

Abstract

The issues of real or suspected health effects of radiofrequency fields, produced by cellphones, their base stations and many other devices, are complex and controversial. We believe that the most balanced and valid assessments of these issues are given by the extensive reports produced by reputable, multidisciplinary, expert groups. These use the principles of a comprehensive review to assess all available published literature and form their conclusions by consideration of the strength of the evidence from the available studies. This paper provides links to several of these reports, and shows how others can be accessed. These

reports are large and complex, but freely available on websites. We summarise the most recent New Zealand report, which itself refers to and summarises many other reports. The scientific literature on these issues is enormous, particularly in animal and laboratory studies. There are some comprehensive reviews of these, demonstrating that the quality of the studies is very variable, and that, for example, results claiming to show increased genetic damage or other biological effects are much more common in studies of low quality, whereas higher-quality studies predominantly show no significant effects. Thus, while there are many reports which in isolation suggest health effects, there is no consistent evidence supporting important health effects caused by low intensities of radiofrequencies similar to those experienced by the general population. There are certainly many unanswered questions, and new studies need to be assessed carefully and replicated where possible. Thus, expert groups in several countries including New Zealand need to continue to regularly review new studies. <https://www.ncbi.nlm.nih.gov/pubmed/31465329>

ADVERSE EFFECTS OF WI-FI RADIATION ON MALE REPRODUCTIVE SYSTEM: A SYSTEMATIC REVIEW

Jaffar FHF, Osman K, Ismail NH, Chin KY, Ibrahim SF. Adverse Effects of Wi-Fi Radiation on Male Reproductive System: A Systematic Review. *Tohoku J Exp Med.* 2019;248(3): 169-179. doi: 10.1620/tjem.248.169.

Abstract

Extensive use of Wi-Fi has contributed to radiofrequency electromagnetic radiation (RF-EMR) pollution in environment. Various studies have been conducted to evaluate the effect of RF-EMR emitted by Wi-Fi transmitter on male reproduction health. However, there are conflicting findings between studies. Thus, this review aims to elucidate the possible effects of 2.45 GHz Wi-Fi exposure on both animal and human male reproductive system. A computerized database search performed through MEDLINE via Ovid and PUBMED with the following set of keywords: 'Wi-Fi or WiFi or wireless fidelity or Wi-Fi router or WiFi router or electromagnetic or radiofrequency radiation' AND 'sperm or spermatozoa or spermatogenesis or semen or seminal plasma or testes or testis or testosterone or male reproduction' had returned 526 articles. Only 17 studies conformed to pre-set inclusion criterion. Additional records identified through Google Scholar and reviewed article further revealed six eligible articles. A total of 23 articles were used for data extraction, including 15 studies on rats, three studies on mice, and five studies on human health. Sperm count, motility and DNA integrity were the most affected parameters when exposed to RF-EMR emitted by Wi-Fi transmitter. Unfortunately, sperm viability and morphology were inconclusive. Structural and/or physiological analyses of the testes showed degenerative changes, reduced testosterone level, increased apoptotic cells, and DNA damage. These effects were mainly due to the elevation of testicular temperature and oxidative stress activity. In conclusion, exposure towards 2.45 GHz RF-EMR emitted by Wi-Fi transmitter is hazardous on the male reproductive system.

Open access paper: https://www.jstage.jst.go.jp/article/tjem/248/3/248_169/article

SOME NOTES ON THE VERIFICATION OF THE EXPOSURE LIMITS IN 5G SYSTEMS

Migliore MD. Some Notes on the Verification of the Exposure Limits in 5G Systems. 2019 IEEE International Symposium on Measurements & Networking (M&N). 8-10 July 2019. DOI: 10.1109/IWMN.2019.880504

Abstract

The aim of this contribution is to discuss some problems regarding the measurement of the Electromagnetic Field Exposure (EFE) in 5G communication systems. The discussion clarifies how the use of the spatial resource to increase the network capacity introduces new causes of uncertainties in the estimation of the field intensity compared to previous generation of cellular networks. Simple examples regarding Massive MIMO communication systems are discussed.

Conclusions

The use of highly reconfigurable antennas represent a new challenge for the measurement of the electromagnetic exposure of population. The simple simulations discussed in this conference contribution shows that new measurement protocols that take explicitly into account the reconfigurable nature of the field must be considered for 5G. The simulations also suggest a possible approach, that consists in 'forcing' the reconfigurable antenna to synthesize a maximum toward the direction of the measurement position, for example considering a system that is seen as 'receiver' by the cellular system, while the estimation of the amplitude of the field in the close proximity of the antenna could be carried out using approaches based on near-field measurements.

<https://ieeexplore.ieee.org/document/8805045>

VALIDATION OF POTENTIAL EFFECTS ON HUMAN HEALTH OF IN VIVO EXPERIMENTAL MODELS STUDIED IN RATS EXPOSED TO SUB-THERMAL RADIOFREQUENCY. POSSIBLE HEALTH RISKS DUE TO THE INTERACTION OF ELECTROMAGNETIC POLLUTION AND ENVIRONMENTAL PARTICLES

Salas-Sánchez AA, López-Furelos A, Rodríguez-González JA, Ares-Pena FJ, López-Martín ME. IEEE Access. 7: 79186 - 79198. 17 June 2019. DOI: 10.1109/ACCESS.2019.2923581

Abstract

Studies are based on the exposure of Sprague-Dawley rats (250 male and 250 female rats) to electromagnetic fields (EMF) at different frequencies in standing and travelling wave chambers. Values of specific absorption rate (SAR) for all of these experiments were obtained from commercially available FDTD-based simulation software based on numerical phantom animals. An experimental radiation system was developed with a standing-wave cavity which keeps electromagnetic parameters constant while facilitating stress-free exposure of animals to non-thermal radiation. This makes it possible to directly measure the power absorbed by the animal and determine whole-body mean SAR according to weight. All studies using this setup were performed with global system for mobile communication (GSM) radiation at 900 MHz. The simple picotoxin model made allow to identify morphological signs of neurotoxicity in rat brain tissue. Experiments involving travelling waves were done in a commercial Gigahertz Transverse ElectroMagnetic (GTEM) chamber connected to one or two vector signal generators (to carry single or multiple EMF exposure frequencies). In the diathermy model, rat

thyroid and thymus exposed to 2.45 GHz radiation showed visible morphological and immune effects. Cellular stress in the cerebral cortex, the cerebellum or both seems to be more associated with the type of signal than with additive effects of combined frequencies. Finally, some hypothesis related with the future models about the ElectroMagnetic (EM) pollution are established. In an urban environmental that combines the electromagnetic and chemical pollution of environmental particles, cortical excitability, inflammatory response, and cell injury can be modified.

Conclusions

The experimental models of controlled exposure of animals to radiofrequency allow us to know in the short term the mechanisms and risks that can affect human health. The modulation of EEG rhythms in epileptics, the modification of the immune response and the increase in cellular stress are biological effects that could be caused in humans by radio frequency interaction. In an urban environmental that combines the electromagnetic and chemical pollution of environmental particles cortical excitability, inflammatory response and cell injury can be modified.

<https://ieeexplore.ieee.org/document/8737903>

RISK TO POLLINATORS FROM ANTHROPOGENIC ELECTRO-MAGNETIC RADIATION (EMR): EVIDENCE AND KNOWLEDGE GAPS

Vanbergen AJ, Potts SG, Vian A, Malkemper EP, Young J, Tscheulin T. Sci Total Environ. 2019 Aug 7;695:133833. doi: 10.1016/j.scitotenv.2019.133833.

Abstract

Worldwide urbanisation and use of mobile and wireless technologies (5G, Internet of Things) is leading to the proliferation of anthropogenic electromagnetic radiation (EMR) and campaigning voices continue to call for the risk to human health and wildlife to be recognised. Pollinators provide many benefits to nature and humankind, but face multiple anthropogenic threats. Here, we assess whether artificial light at night (ALAN) and anthropogenic radiofrequency electromagnetic radiation (AREMR), such as used in wireless technologies (4G, 5G) or emitted from power lines, represent an additional and growing threat to pollinators. A lack of high quality scientific studies means that knowledge of the risk to pollinators from anthropogenic EMR is either inconclusive, unresolved, or only partly established. A handful of studies provide evidence that ALAN can alter pollinator communities, pollination and fruit set. Laboratory experiments provide some, albeit variable, evidence that the honey bee *Apis mellifera* and other invertebrates can detect EMR, potentially using it for orientation or navigation, but they do not provide evidence that AREMR affects insect behaviour in ecosystems. Scientifically robust evidence of AREMR impacts on abundance or diversity of pollinators (or other invertebrates) are limited to a single study reporting positive and negative effects depending on the pollinator group and geographical location. Therefore, whether anthropogenic EMR (ALAN or AREMR) poses a significant threat to insect pollinators and the benefits they provide to ecosystems and humanity remains to be established.

<https://www.ncbi.nlm.nih.gov/pubmed/31419678>

CHANGES IN PYRAMIDAL AND GRANULAR NEURON NUMBERS IN RAT HIPPOCAMPUS 7 DAYS AFTER EXPOSURE TO CONTINUOUS 900-MHZ EMF DURING EARLY AND MID-ADOLESCENCE

Keleş AI, Nyengaard JR, Odacı EJ Chem Neuroanat. 2019 Aug 26:101681. doi: 10.1016/j.jchemneu.2019.101681.

Abstract

The aim of this study was to investigate qualitative and quantitative changes in pyramidal and granule neurons in the male rat hippocampus after exposure to a continuous 900-megahertz (MHz) electromagnetic field (EMF) for 25 days during early and mid-adolescence. Three-week-old (21 day) healthy Sprague Dawley male rats were divided equally into control (CON), pseudo-exposed (PEX) and EMF groups. EMF rats were exposed to a 900- MHz EMF in an EMF-application cage, while the PEX rats were placed in the same cage without being exposed to EMF. No procedure was performed in CON. EMF was applied for 1 h/day, every day for 25 days. Following the 900-MHz EMF and pseudo-exposed applications, behavioral tests were performed for seven days. Then, all animals were euthanized and their brains were removed. Following histological tissue procedures, sections were taken from tissues and stained with toluidine blue. The optical fractionation technique was performed to estimate the pyramidal neuron numbers in the CA1, CA2-3 and hilus regions of the hippocampus and granule neuron numbers in the dentate gyrus region. Our findings indicated that the number of pyramidal and granule neurons in the hippocampus of the EMF group was statistically higher than PEX. Furthermore, the histopathological results showed that the cytoplasm of pyramidal (in the hilus, CA1, CA2 and CA3 region) and granular (in the dentate gyrus region) cells at the hippocampus were disrupted, as evident by intensive staining around cytoplasm and some artifacts were detected in the EMF group. In addition, statistical comparisons of the mean body weights and brain weights of the study groups revealed no significant differences. There was no statistically significant difference between the PEX and EMF groups in terms of temperature ($p > 0.05$) or humidity ($p > 0.05$) in the cages. In conclusion, higher numbers of both pyramidal and granule neurons were found in the male rat hippocampus after continuous 900-MHz EMF treatment.

<https://www.ncbi.nlm.nih.gov/pubmed/31464580>

TRAFFICKING OF SYNAPTIC VESICLES IS CHANGED AT THE HYPOTHALAMUS BY EXPOSURE TO AN 835 MHZ RADIOFREQUENCY ELECTROMAGNETIC FIELD

Kim JH, Huh YH, Kim HR. Trafficking of synaptic vesicles is changed at the hypothalamus by exposure to an 835 MHz radiofrequency electromagnetic field. Gen Physiol Biophys. 2019 Aug 14. doi: 10.4149/gpb_2019020.

Abstract

With the rapidly increasing use of mobile phones and their close-contact usage to the brain, there are some concerns about the possible neuronal effects induced by exposure to excessive electromagnetic radiation. Exposure to a radiofrequency electromagnetic field (RF-EMF) of 835 MHz (4.0 W/kg specific absorption rate (SAR) 5 h/day for 12 weeks) may affect hypothalamic presynaptic neurons in C57BL/6 mice. The number and size of the synaptic vesicles (SVs) in the hypothalamic presynaptic terminals were significantly decreased after RF-EMF exposure. Further, the density (SVs numbers/ μm) of docking and fusing SVs in the active zones of the presynaptic terminal membrane was significantly decreased in

hypothalamic neurons. The expression levels of synapsin I/II and synaptotagmin 1, two regulators of SV trafficking in neurons, were also significantly decreased in the hypothalamus. In parallel, the expression of calcium channel was significantly decreased. These changes in SVs in the active zones may directly decrease the release of neurotransmitters in hypothalamic presynaptic terminals. Therefore, we further studied the possible changes in hypothalamic function by testing the core body temperature and body weight and performed the buried pellet test. The trafficking of SVs was changed by RF-EMF; however, we could not find any significant phenotypical changes in our experimental condition.

<https://www.ncbi.nlm.nih.gov/pubmed/31411574>

EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS AND CANCER: HOW SOURCE OF FUNDING AFFECTS RESULTS

Carpenter DO. Environ Res. 2019 Aug 24;178:108688. doi: 10.1016/j.envres.2019.108688.

Abstract

While there has been evidence indicating that excessive exposure to magnetic fields from 50 to 60 Hz electricity increases risk of cancer, many argue that the evidence is inconsistent and inconclusive. This is particularly the case regarding magnetic field exposure and childhood leukemia. A major goal of this study is to examine how source of funding influences the reported results and conclusions. Several meta-analyses dating from about 2000 all report significant associations between exposure and risk of leukemia. By examining subsequent reports on childhood leukemia it is clear that almost all government or independent studies find either a statistically significant association between magnetic field exposure and childhood leukemia, or an elevated risk of at least OR = 1.5, while almost all industry supported studies fail to find any significant or even suggestive association. A secondary goal of this report is to examine the level of evidence for exposure and elevated risk of various adult cancers. Based on pooled or meta-analyses as well as subsequent peer-reviewed studies there is strong evidence that excessive exposure to magnetic fields increases risk of adult leukemia, male and female breast cancer and brain cancer. There is less convincing but suggestive evidence for elevations in several other cancer types. There is less clear evidence for bias based on source of funding in the adult cancer studies. There is also some evidence that both paternal and maternal prenatal exposure to magnetic fields results in an increased risk of leukemia and brain cancer in offspring. When one allows for bias reflected in source of funding, the evidence that magnetic fields increase risk of cancer is neither inconsistent nor inconclusive. Furthermore adults are also at risk, not just children, and there is strong evidence for cancers in addition to leukemia, particularly brain and breast cancer.

<https://www.ncbi.nlm.nih.gov/pubmed/31476684>

EXPOSURE TO STATIC AND EXTREMELY-LOW FREQUENCY ELECTROMAGNETIC FIELDS AND CELLULAR FREE RADICALS

Lai H. Electromagnetic Biology Medicine. Aug 26, 2019. <https://doi.org/10.1080/15368378.2019.1656645>.

Abstract

This paper summarizes studies on changes in cellular free radical activities from exposure to static and extremely-low frequency (ELF) electromagnetic fields (EMF), particularly magnetic fields. Changes in free radical activities, including levels of cellular reactive oxygen (ROS)/nitrogen (RNS) species and endogenous antioxidant enzymes and compounds that maintain physiological free radical concentrations in cells, is one of the most consistent effects of EMF exposure. These changes have been reported to affect many physiological functions such as DNA damage; immune response; inflammatory response; cell proliferation and differentiation; wound healing; neural electrical activities; and behavior. An important consideration is the effects of EMF-induced changes in free radicals on cell proliferation and differentiation. These cellular processes could affect cancer development and proper growth and development in organisms. On the other hand, they could cause selective killing of cancer cells, for instance, via the generation of the highly cytotoxic hydroxyl free radical by the Fenton Reaction. This provides a possibility of using these electromagnetic fields as a non-invasive and low side-effect cancer therapy. Static- and ELF-EMF probably play important roles in the evolution of living organisms. They are cues used in many critical survival functions, such as foraging, migration, and reproduction. Living organisms can detect and respond immediately to low environmental levels of these fields. Free radical processes are involved in some of these mechanisms. At this time, there is no credible hypothesis or mechanism that can adequately explain all the observed effects of static- and ELF-EMF on free radical processes. We are actually at the impasse that there are more questions than answers.

Concluding remarks

1. Change in cellular free radical activity is one of the most consistent effects of static- and ELF-EMF on living organisms.
2. The mechanisms by which static- and ELF-EMF affect cellular free radical processes is not well understood. The “radical pair” hypothesis is a likely candidate, particularly the involvement of cryptochromes. It allows immediate detection and response to changes in static- and ELF-EMF in the environment, which likely play important roles in the evolution of living organisms.
3. Oxidative responses to static- and ELF-EMF are probably dependent on the characteristic of the field and exposure (such as frequency, modulation, and duration) and the exposed object (such as cell type, and states of biological activities),
4. However, chronic exposure that leads to the excessive and persistent presence of free radicals can cause oxidative stress and should be avoided.
5. Effects of static- and ELF-EMF on free radicals probably have beneficial health effects particularly relating to cell proliferation, differentiation, cell death, and cell cycle. These are effects that could influence cancer development and treatment, growth and development, regeneration, and healing.
6. In future research, it is imperative to identify the field parameters that can selectively cause beneficial or detrimental health effects.

<https://www.tandfonline.com/doi/full/10.1080/15368378.2019.1656645>

PARENTAL OCCUPATIONAL EXPOSURE TO LOW-FREQUENCY MAGNETIC FIELDS AND RISK OF LEUKEMIA IN OFFSPRING: FINDINGS FROM CHILDHOOD LEUKEMIA INTERNATIONAL CONSORTIUM

Talibov M, Olsson A, Bailey H, Erdmann F, Metayer C, Magnani C, Petridou E, Auvinen A, Spector L, Clavel J, Roman E, Dockerty J, Nikkilä A, Lohi O, Kang A, Psaltopoulou T, Miligi L, Vila J, Cardis E, Schüz J. *Occup Environ Med*. 2019 Jul 29. pii: oemed-2019- 105706. doi: 10.1136/oemed-2019-105706.

Abstract

OBJECTIVES: Previously published studies on parental occupational exposure to extremely low-frequency magnetic fields (ELF-MF) and risk of acute lymphoblastic leukaemia (ALL) and acute myeloid leukaemia (AML) in their offspring were inconsistent. We therefore evaluated this question within the Childhood Leukemia International Consortium.

METHODS: We pooled 11 case-control studies including 9723 childhood leukaemia cases and 17 099 controls. Parental occupational ELF-MF exposure was estimated by linking jobs to an ELF-MF job-exposure matrix (JEM). Logistic regression models were used to estimate ORs and 95% CIs in pooled analyses and meta-analyses.

RESULTS: ORs from pooled analyses for paternal ELF-MF exposure >0.2 microtesla (μ T) at conception were 1.04(95% CI 0.95 to 1.13) for ALL and 1.06 (95% CI 0.87 to 1.29) for AML, compared with $\leq$ 0.2 μ T. Corresponding ORs for maternal ELF-MF exposure during pregnancy were 1.00 (95% CI 0.89 to 1.12) for ALL and 0.85 (95% CI 0.61 to 1.16) for AML. No trends of increasing ORs with increasing exposure level were evident. Furthermore, no associations were observed in the meta-analyses.

CONCLUSIONS: In this large international dataset applying a comprehensive quantitative JEM, we did not find any associations between parental occupational ELF-MF exposure and childhood leukaemia.

"The major limitation of this study was potential exposure misclassification, which can arise in any study with retrospective exposure assessment. Exposure misclassification could occur because the ELF-MF JEM, like most JEMs, assigns the mean exposure level to all persons in the same occupation, while exposure heterogeneity within the occupation may be substantial. It does not specify jobs by industrial groups, and exposure intensity might vary in the same occupation by industrial group. Exposure misclassification was likely to be non-differential in our study because the JEM was applied in the same way to all parents and independently of case-control status of the child. Bias from non-differential exposure misclassification is generally towards the null for dichotomous exposures.³⁰ For polytomous exposures, non-differential misclassification can bias ORs away from the null only for intermediate exposure categories, but ORs for the highest category will be towards the null.³¹ Therefore, ORs for dichotomous ELF-MF exposures and for high categories of polytomous exposures would be underestimated if non-differential exposure misclassification was present in this study. Selection bias may also be a concern in this study"

Open access paper: <https://oem.bmj.com/content/early/2019/07/29/oemed-2019-105706.long>

EFFECTS OF EXPOSURE TO EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS ON HIPPOCAMPAL LONG-TERM POTENTIATION IN HIPPOCAMPAL CA1 REGION

Zheng Y, Cheng J, Dong L, Ma X, Kong Q. Effects of exposure to extremely low frequency electromagnetic fields on hippocampal long-term potentiation in hippocampal CA1 region. *Biochem Biophys Res Commun*. 2019 Jul 31. pii: S0006-291X(19)31439-1. doi: 10.1016/j.bbrc.2019.07.085.

Abstract

Exposure to environmental electromagnetic fields, especially to the extremely low-frequency (ELF < 300 Hz) electromagnetic fields (EMFs) might produce modulation effects on neuronal activity. Long-term changes in synaptic plasticity such as long-term potentiation (LTP) involved in learning and memory may have contributions to a number of neurological diseases. However, the modulation effects of ELF-EMFs on LTP are not yet fully understood. In our present study, we aimed to evaluate the effects of exposure to ELF-EMFs on LTP in hippocampal CA1 region in rats. Hippocampal slices were exposed to magnetic fields generated by sXcELF system with different frequencies (15, 50, and 100 Hz [Hz]), intensities (0.5, 1, and 2 mT [mT]), and duration (10 s [s], 20 s, 40 s, 60 s, and 5 min), then the baseline signal recordings for 20 min and the evoked field excitatory postsynaptic potentials (fEPSPs) were recorded. We found that the LTP amplitudes decreased after magnetic field exposure, and the LTP amplitudes decreased in proportion to exposure doses and durations, suggesting ELF-EMFs may have dose and duration-dependent inhibition effects. Among multiple exposure duration and doses combinations, upon 5 min magnetic field exposure, 15 Hz/2 mT maximally inhibited LTP. Under 15 Hz/2 mT ELF-EMFs, LTP amplitude decreases in proportion to the length of exposure durations within 5 min time frame. Our findings illustrated the potential effects of ELF-EMFs on synaptic plasticity and will lead to better understanding of the influence on learning and memory.

<https://www.ncbi.nlm.nih.gov/pubmed/31376941>

EXTREMELY LOW FREQUENCY MAGNETIC FIELD INDUCES HUMAN NEURONAL DIFFERENTIATION THROUGH NMDA RECEPTOR ACTIVATION

Özgün A, Marote A, Behie LA, Salgado A, Garipcan B. Extremely low frequency magnetic field induces human neuronal differentiation through NMDA receptor activation. *J Neural Transm (Vienna)*. 2019 Jul 17. doi: 10.1007/s00702-019-02045-5.

Abstract

Magnetic fields with different frequency and intensity parameters exhibit a wide range of effects on different biological models. Extremely low frequency magnetic field (ELF MF) exposure is known to augment or even initiate neuronal differentiation in several in vitro and in vivo models. This effect holds potential for clinical translation into treatment of neurodegenerative conditions such as autism, Parkinson's disease and dementia by promoting neurogenesis, non-invasively. However, the lack of information on underlying mechanisms hinders further investigation into this phenomenon. Here, we examine involvement of glutamatergic Ca²⁺ channel, N- methyl-D-aspartate (NMDA) receptors in the process of human neuronal differentiation under ELF MF exposure. We show that human neural progenitor cells (hNPCs) differentiate more efficiently under ELF MF exposure in vitro, as demonstrated by the abundance of neuronal markers. Furthermore, they exhibit higher intracellular Ca²⁺ levels as evidenced by c-fos expression and more elongated mature

neurites. We were able to neutralize these effects by blocking NMDA receptors with memantine. As a result, we hypothesize that the effects of ELF MF exposure on neuronal differentiation originate from the effects on NMDA receptors, which sequentially triggers Ca²⁺-dependent cascades that lead to differentiation. Our findings identify NMDA receptors as a new key player in this field that will aid further research in the pursuit of effect mechanisms of ELF MFs.

<https://www.ncbi.nlm.nih.gov/pubmed/31317262>

EXPOSURE TO 50 HZ MAGNETIC FIELD AT 100 μ T EXERT NO DNA DAMAGE IN CARDIOMYOCYTES.

Wang Y, Liu X, Zhang Y, Wan B, Zhang J, He W, Hu D, Yang Y, Lai J, He M, Chen C. Exposure to 50 Hz magnetic field at 100 μ T exert no DNA damage in cardiomyocytes. *Biol Open*. 2019 Jul 30. pii: bio.041293. doi: 10.1242/bio.041293.

Abstract

The effects of exposure to magnetic fields (MFs) at city electric frequencies (50-60 Hz) on carcinogenicity are still in debate. Besides, whether exposure to MFs affects the heart is also a debated issue. This study aimed to determine whether exposure to extremely low frequency magnetic fields (ELF-MFs) induced DNA damage in cardiomyocytes both in vitro and in vivo. Human ventricular cardiomyocytes were exposed to 50 Hz ELF-MF at 100 μ T for 1 hr continuously or 75 min intermittently. The effects of the treatments were evaluated by DNA damage, redox status changes, and relative signal molecular expression. Moreover, ten male Sprague-Dawley rats were exposed to a 50 Hz MF at 100 μ T for 7 days, while another 10 rats were sham exposed. The protein levels of p53 and Hsp70 in heart tissue were analyzed by western blot. The results showed that exposure to ELF- MF did not induce DNA damage, cell cycle distribution change, or increased ROS level. No significant differences were detected in p53 and Hsp70 expression level between the ELF-MF and sham-exposure groups both in vitro and in vivo. All these data indicated that MFs at power-frequency may not cause DNA damage in cardiomyocyte.

Open access paper: <https://bio.biologists.org/content/early/2019/07/22/bio.041293.long>

COMPARISON OF POLYMERIZATION AND STRUCTURAL BEHAVIOR OF MICROTUBULES IN RAT BRAIN AND SPERM AFFECTED BY THE EXTREMELY LOW-FREQUENCY ELECTROMAGNETIC FIELD.

Gholami D, Riazi G, Fathi R, Sharafi M, Shahverdi BMC Mol Cell Biol. 2019 Aug 29;20(1):41. doi: 10.1186/s12860-019-0224-1.

Abstract

BACKGROUND: Microtubule proteins are able to produce electromagnetic fields and have an important role in memory formation, and learning. Therefore, microtubules have the potential to be affected by exogenous electromagnetic fields. This study aimed to examine the comparison of microtubule polymerization and its structural behavior in brain and sperm affected by 50 Hz extremely low-frequency electromagnetic field (ELEF).

RESULTS: Twenties adult male rats were randomly and equally divided into control and experimental groups, to evaluate the effect of 50 Hz ELEF on the sperm and brain functions. Plus-maze, serum testosterone and corticosterone, and sperm evaluation were performed.

Next, the semen and brain samples were obtained, and they were divided into four experimental groups for investigation of microtubule polymerization. There was no significant difference in testosterone and, corticosterone levels, anxiety behaviors, and sperm morphology between control and ELEF-exposure groups. The sperm viability, total and progressive motility were significantly higher in the ELEF-exposed group than that of the control group. The microtubule polymerization in sperm ELEF was significantly higher than in other groups. The secondary and tertiary structures of tubulins were significantly affected in the brain, and sperm ELEF groups.

CONCLUSION: It seems that the polymerization of microtubules and conformational changes of tubulin dimers are improved by ELEF application.

<https://www.ncbi.nlm.nih.gov/pubmed/31464580>

CHARACTERIZATION OF LEVELS OF EXTREMELY LOW FREQUENCY MAGNETIC FIELDS EMITTED FROM PORTABLE HAND-HELD FANS

Choi S, Kim S, Bae S, Kim W, Park JH, Chung E, Park J, Park DU. Characterization of Levels of Extremely Low Frequency Magnetic Fields Emitted From Portable Hand-Held Fans. Bioelectromagnetics. 2019 Aug 2. doi: 10.1002/bem.22210.

Abstract

This study aims to assess the levels of extremely low frequency magnetic fields (ELF-MF) emitted from portable hand-held fans (HHFs) and their principal frequency and to identify factors influencing these levels. We collected a total of eleven models of HHF and monitored the ELF-MF as a function of fan speed and distance from the fan. EMDEX II was used to monitor the ELF-MF. An SMP2 EMF-meter equipped with a P400 field probe was used to determine the levels of ELF-MF and the frequency spectrum. Ten of the fans, excluding only one bladeless-fan model, emitted a high level of ELF-MF near the source of the HHF direct-current motor. The maximum measured level of ELF-MF ranged from 14.07 to 218.7 μ T. All measurements of the ELF-MF taken within 10 cm from the HHFs showed values higher than 1.0 μ T. ELF-MF levels were found to decrease markedly with distance, regardless of the HHF product. The level of ELF-MF rose noticeably with increased fan speed. The speed of and distance from the HHF significantly influenced the level of ELF-MF. All principal frequencies ranged from 1 to 300 Hz, which falls in the typical range of ELF. © 2019 Bioelectromagnetics Society.

<https://www.ncbi.nlm.nih.gov/pubmed/31373404>

COMPUTATIONAL SIMULATIONS OF THE PENETRATION OF 0.30 THZ RADIATION INTO THE HUMAN EAR

Vilagosh Z, Lajevardipour A, Wood A. Computational simulations of the penetration of 0.30 THz radiation into the human ear. *Biomed Opt Express*. 2019 Feb 28;10(3):1462-1468. doi: 10.1364/BOE.10.001462.

Abstract

There is an increasing interest in industrial and security applications and the establishment of wireless communication operating at frequencies of up to 0.30 THz. Soft tissue has a high coefficient of absorption at 0.30 THz and this limits effective penetration of the energy to a depth of 0.2 to 0.4 mm. The capacity of 0.30 THz radiation to access the deeper parts of the ear by diffusing through the ear canal and exposing the tympanic membrane (ear drum) to the radiation has not been studied. Simulations show that, with excitation parallel to the ear canal, the average power flux density within the central tympanic membrane region is 97% of the incident excitation. The structures of the outer ear are highly protective; less than 0.4% of the power flux density is directed at 45° from the parallel reached the same region. Given the sensitivity of the tympanic membrane to mechanical change, in-vivo assessment of the penetration of 0.3 THz into the ear canal is warranted to assess the suitability of the present radiation safety limits and to inform 0.3 THz emitting device design.

Open access paper: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6420278/>

Note: 0.3THz is 300 GHz.

EFFECT OF LOW FREQUENCY ELECTROMAGNETIC FIELD ON THE BEHAVIOR AND BIOENERGETICS OF THE RAGWORM

Jakubowska M, Urban-Malinga B, Otremba Z, Andruliewicz E. *Marine Environ Res*. 2019 Aug 3;150:104766. doi: 10.1016/j.marenvres.2019.104766.

Abstract

The aim of the present study was to determine the effect of an electromagnetic field (EMF) of value typically recorded in the vicinity of submarine cables (50 Hz, 1 mT) on the behavior and bioenergetics of the polychaete *Hediste diversicolor*. No avoidance or attraction behavior to EMF was shown, but the burrowing activity of *H. diversicolor* was enhanced in EMF treatment, indicating a stimulating effect on bioturbation potential. The polychaete maintained a positive energy balance and high amount (85% of assimilated energy) of energy available for individual production (scope for growth) after exposure to EMF. Food consumption and respiration rates were not affected but ammonia excretion rate was significantly reduced in EMF-exposed animals compared to the control conditions (geomagnetic field). The mechanisms behind this effect remain, however, unclear. This is the first study demonstrating the effects of environmentally realistic EMF value on the behavior and physiology of marine invertebrates, thus there is a need for more research.

<https://www.ncbi.nlm.nih.gov/pubmed/31404727>

HEADACHE, TINNITUS AND HEARING LOSS IN THE INTERNATIONAL COHORT STUDY OF MOBILE PHONE USE AND HEALTH (COSMOS) IN SWEDEN AND FINLAND

Auvinen A, Feychting M, Ahlbom A, Hillert L, Elliott P, Schüz J, Kromhout H, Toledano MB, Johansen C, Poulsen AH, Vermeulen R, Heinävaara S, Kojo K, Tettamanti G, COSMOS Study Group. *Int J Epidemiol*. 2019 Jul 13. pii: dyz127. doi: 10.1093/ije/dyz127.

Abstract

BACKGROUND: Mobile phone use and exposure to radiofrequency electromagnetic fields (RF-EMF) from it have been associated with symptoms in some studies, but the studies have shortcomings and their findings are inconsistent. We conducted a prospective cohort study to assess the association between amount of mobile phone use at baseline and frequency of headache, tinnitus or hearing loss at 4-year follow-up.

METHODS: The participants had mobile phone subscriptions with major mobile phone network operators in Sweden ($n = 21\,049$) and Finland ($n = 3120$), gave consent for obtaining their mobile phone call data from operator records at baseline, and filled in both baseline and follow-up questionnaires on symptoms, potential confounders and further characteristics of their mobile phone use.

RESULTS: The participants with the highest decile of recorded call-time (average call-time >276 min per week) at baseline showed a weak, suggestive increased frequency of weekly headaches at 4-year follow-up (adjusted odds ratio 1.13, 95% confidence interval 0.95-1.34). There was no obvious gradient of weekly headache with increasing call-time (P trend 0.06). The association of headache with call-time was stronger for the Universal Mobile Telecommunications System (UMTS) network than older Global System for Mobile Telecommunications (GSM) technology, despite the latter involving higher exposure to RF-EMF. Tinnitus and hearing loss showed no association with call-time.

CONCLUSIONS: People using mobile phones most extensively for making or receiving calls at baseline reported weekly headaches slightly more frequently at follow-up than other users, but this finding largely disappeared after adjustment for confounders and was not related to call-time in GSM with higher RF-EMF exposure. Tinnitus and hearing loss were not associated with amount of call-time. <https://www.ncbi.nlm.nih.gov/pubmed/31302690>

In conclusion, we found a small increase in weekly headache at 4-year follow-up among those in the highest decile of amount of call-time but free of weekly headache at baseline, but it largely disappeared after adjustment for confounders. There was no clear gradient in occurrence of weekly headache with amount of call-time. Any association between call-time and weekly headaches was limited to call-time in the third-generation UMTS network and was not found for the older GSM system characterized by higher RF-EMF exposure levels.

This suggests that other factors related to the amount of mobile phone use (e.g. lifestyle, when and how the phone is used) may explain the weak association, rather than an effect of RF-EMF. We observed no association in our prospective study with occurrence of tinnitus or hearing loss.

A SURVEY ON ELECTROMAGNETIC RISK ASSESSMENT AND EVALUATION MECHANISM FOR FUTURE WIRELESS COMMUNICATION SYSTEMS

Jamshed MA, Heliot F, Brown T. IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology. May 20, 2019. DOI: 10.1109/JERM.2019.2917766

Abstract

The accurate measurement of electromagnetic exposure and its application is expected to become more and more important in future wireless communication systems, given the explosion in both the number of wireless devices and equipments radiating electromagnetic fields (EMF) and the growing concerns in the general public linked to it. Indeed, the next generation of wireless systems aims at providing a higher data rate, better quality of service (QoS), and lower latency to users by increasing the number of access points, i.e. densification, which in turn will increase EMF exposure. Similarly, the multiplication of future connected devices, e.g. internet of things (IoT) devices, will also contribute to an increase in EMF exposure. This paper provides a detailed survey relating to the potential health hazards linked with EMF exposure and the different metrics that are currently used for evaluating, limiting and mitigating the effects of this type of exposure on the general public. This paper also reviews the possible impacts of new wireless technologies on EMF exposure and proposes some novel research directions for updating the EMF exposure evaluation framework and addressing these impacts in future wireless communication systems. For instance, the impact of mmWave or massive-MIMO/beamforming on EMF exposure has yet to be fully understood and included in the exposure evaluation framework.

Conclusions

A thorough survey on exposure risk assessment, evaluation, limitation and mitigation for current and future wireless devices and equipments has been provided in this paper. From the human health point of view, it seems that the possibility of brain tumor is still the main cause of concerns related to the extensive use of wireless devices, even though the effects of EMF exposure is now being investigated in new parts of the body (e.g. eyes). Meanwhile, with the advent of 5G, more efforts are now being made to understand the thermal and non-thermal effects of mmWave exposure on the human body. When it comes to the evaluation of EMF exposure, we have presented the most common evaluation frameworks and metrics that are utilized in wireless communications to measure the exposure. We have also explained how new more generic metrics have been defined by combining existing metrics to better reflect the exposure of large geographical areas and have argued that a generic metric for measuring the individual exposure would also be of interest. We have also reviewed the existing exposure guidelines and have explained how they can be updated for better reflecting the true nature of EMF exposure, i.e. by better taking into account the duration of exposure. Finally, we have provided some views on how key 5G enabling technologies such as densification, massive MIMO and mmWave will impact the EMF exposure in the near future; for instance, the dense deployment of small cells and IoT devices is very likely to increase the overall ambient exposure. We also believe that there could be some technical opportunities in 5G to increase the exposure awareness of wireless system users and to let them decide if they want to reduce it at the cost of, for instance, a lower QoS.

<https://ieeexplore.ieee.org/document/8718293>

STATISTICAL APPROACH FOR HUMAN ELECTROMAGNETIC EXPOSURE ASSESSMENT IN FUTURE WIRELESS ATTO-CELL NETWORKS

Shikhantsov S, Thielens A, Vermeeren G, Demeester P, Martens L, Torfs G, Joseph W. Statistical approach for human electromagnetic exposure assessment in future wireless ATTO-cell networks. *Radiat Prot Dosimetry*. 2019 May 1;183(3):326-331. doi: 10.1093/rpd/ncy120.

Abstract

In this article, we study human electromagnetic exposure to the radiation of an ultra dense network of nodes integrated in a floor denoted as ATTO-cell floor, or ATTO-floor. ATTO-cells are a prospective 5G wireless networking technology, in which humans are exposed by several interfering sources. To numerically estimate this exposure we propose a statistical approach based on a set of finite difference time domain simulations. It accounts for variations of antenna phases and makes use of a large number of exposure evaluations, based on a relatively low number of required simulations. The exposure was expressed in peak-spatial 10-g SAR average (psSAR10g). The results show an average exposure level of ~4.9 mW/kg and reaching 7.6 mW/kg in 5% of cases. The maximum psSAR10g value found in the studied numerical setup equals around 21.2 mW/kg. Influence of the simulated ATTO-floor size on the resulting exposure was examined. All obtained exposure levels are far below 4 W/kg ICNIRP basic restriction for general public in limbs (and 20 W/kg basic restriction for occupational exposure), which makes ATTO-floor a potential low-exposure 5 G candidate.

Open access paper: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6543880/>

MONITORING ELECTROMAGNETIC RADIATION EMISSIONS IN BUILDINGS AND DEVELOPING STRATEGIES FOR IMPROVED INDOOR ENVIRONMENTAL QUALITY.

Weldu YW, Mannan M, Al-Ghamdi SG. Monitoring electromagnetic radiation emissions in buildings and developing strategies for improved indoor environmental quality. *Health Phys*. 2019 Jul 5. doi: 10.1097/HP.0000000000001112.

Abstract

Electronic devices have become ubiquitous in daily life, but they emit electromagnetic radiation, which may have negative health impacts at excessive levels. Little is known regarding the impact of radiation emissions on building occupants or strategies for reducing its intensity. This study applied a novel approach using system analysis to quantify radiation exposure in building spaces, examine building material responses to radiation propagation, and investigate risks to human health in the country of Qatar. Radiation intensity levels varied based on the location and type of building space. Different types of construction materials showed varied responses to electromagnetic field wave propagation. Drywall exhibited the best blocking effect, whereas glass and lumber walls exhibited poor blocking effects. The field strengths quantified in this study are less than the corresponding reference values specified by some jurisdictions, but they are still significantly higher than the safety levels defined in many other countries, which could result in significant health risks. The key strategies for improving indoor environmental quality include the use of shielding materials, spatial design, reduction of exposure time, increased exposure distance, and complete avoidance of exposure in sensitive areas.

<https://www.ncbi.nlm.nih.gov/pubmed/31283546>

Conclusions

Emission intensity levels varied significantly based on locations and types of building spaces. Office building spaces exhibited relatively low electromagnetic emission intensity, and hospital building spaces exhibited relatively high power density values. The high electromagnetic emission intensities measured in surveyed green residential buildings highlight the importance of novel strategies for reducing radiation propagation. EMF intensity is greater at locations near radiation sources. Different types of building construction respond variably to EMF wave propagation. Certain materials, such as drywall, ceramic-faced lumber, tile-faced drywall, and plain or masonry-faced concrete, effectively shield EMF propagation, whereas glass and plain lumber have poor shielding effects. Drywall exhibited the best shielding effect among all compared building materials. Additionally, the magnitudes of the transmission coefficients for magnetic fields were higher than the corresponding power densities for all building wall materials. Infants, children, senior citizens, and patients all have relatively weak immune systems that are susceptible to radiation exposure. Therefore, it is important to design sensitive spaces using drywall and ceramic- or masonry-faced concrete walls. ... The exposure intensities measured in this study exceeded the safety limits defined by Switzerland, raising Table 4. significant concerns regarding adverse health effects.

MOBILE PHONE ANTENNA-MATCHING STUDY WITH DIFFERENT FINGER POSITIONS ON AN INHOMOGENEOUS HUMAN MODEL

Jeladze V, Nozadze T, Petoev-Darsavelidze I, Partsvania B. Mobile phone antenna-matching study with different finger positions on an inhomogeneous human model. *Electromagn Biol Med.* 2019 Jul 13:1-10. doi: 10.1080/15368378.2019.1641722.

Abstract

The human head and hand being in the near-field zone of a mobile phone antenna can drastically influence the antenna matching with free space. The goal of the presented research is to study this phenomenon on an inhomogeneous human model for different relative positions and distances of hand and fingers when using a mobile phone. The only safety criteria commonly used to estimate RF exposure impact on humans is the specific absorption rate (SAR). Its limits are determined by the Federal Communication Commission (FCC) in the USA and the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in Europe. The maximal values of SAR for a mobile handset are determined for each model by the manufacturer. In this paper, it is shown that the peak values provided by the manufacturers and their understanding may need refinement. It is almost impossible to consider all parameters, such as the dependence of SAR on antenna communication matching, with a variety of shapes and forms and other details during physical measurements or numerical estimation. The premise for such assumptions is based on the analysis of S11 dependency on the exposure scenario and the fact that the Automatic Gain Control (AGC) increases power when the signal strength at the base station drops.

<https://www.ncbi.nlm.nih.gov/pubmed/31303069>

ELECTROHYPERSENSITIVITY (EHS) IS AN ENVIRONMENTALLY-INDUCED DISABILITY THAT REQUIRES IMMEDIATE ATTENTION

Havas M. Electrohypersensitivity (EHS) is an Environmentally-Induced Disability that Requires Immediate Attention. Review Article. J Sci Discov. 3(1):jsd18020; DOI:10.24262/jsd.3.1.18020. 2019.

Abstract

A growing number of countries are beginning to acknowledge that electrohypersensitivity (EHS) exists and a few countries have classified it as a disability or a functional impairment attributable to the environment.

Epidemiological studies and in vivo experiments show that exposure to non-ionizing radiation (NIR) from extremely low to microwave frequency electromagnetic fields (EMF) at exposure intensities far below the maximum limits in international guidelines increases anxiety, depression, and physiological stress and impairs cognitive functions that include concentration, memory and learning. Furthermore, exposure to NIR contributes to neurodegenerative diseases including dementia, Alzheimer's disease, amyotrophic lateral sclerosis, multiple sclerosis, Parkinson's disease, attention deficit hyperactivity disorder and autism spectrum disorder. Exposure of the fetus to NIR (mobile phone) affects the neonatal heart and can lead to emotional and behavioral problems in human offspring. Similar exposures in laboratory studies report impaired cognitive performance, neuronal losses and pathological changes in the brain of rat offspring. The scientific and medical communities have repeatedly sent out urgent warnings, in the form of appeals, declarations and testimonies, that exposure to NIR needs to be reduced from a public health perspective. These warnings have been largely ignored. With continued development of wireless technology and the imminent roll out of new and densified technologies (e.g., 5G technology, satellite constellations, repeaters, wearables, Internet of Things), society will pay an enormous price for disregarding these warnings. It is long overdue for those responsible for public health, the health of children and health policy to take these warnings seriously and to provide a refuge for those afflicted by EHS. EHS is real, it is exacerbated by exposure to NIR, it is increasing among the population and when severe it becomes a disability. Action is long overdue to minimize exposure to NIR and to provide a safe environment that all can enjoy.

Open access paper:

<http://www.e-discoverypublication.com/wp-content/uploads/2019/03/JSD18020-final.pdf>

ECOLOGICAL MOMENTARY ASSESSMENT STUDY OF EXPOSURE TO RF EMF AND NON-SPECIFIC PHYSICAL SYMPTOMS WITH SELF- DECLARED ELECTROSENSITIVES

Bolte JFB, Clahsen S, Vercrujisse W, Houtveen JH, Schipper CMA, van Kamp I, Bogers R. Environ Int. 2019 Jul 6;131:104948. doi: 10.1016/j.envint.2019.104948.

Highlights

- No correlation of electromagnetic fields (EMF) and health effects at group level
- Significant within person correlation EMF and non specific physical symptoms
- Time above a level of exposure and rate of change show correlations; TWA doesn't.

Abstract

The main objective of the study is to determine if non-specific physical symptoms (NSPS) in people with self- declared sensitivity to radiofrequency electromagnetic fields (RF EMF) can be explained (across subjects) by exposure to RF EMF. Furthermore, we pioneered whether analysis at the individual level or at the group level may lead to different conclusions. By our knowledge, this is the first longitudinal study exploring the data at the individual level. A group of 57 participants was equipped with a measurement set for five consecutive days. The measurement set consisted of a body worn exposimeter measuring the radiofrequency electromagnetic field in twelve frequency bands used for communication, a GPS logger, and an electronic diary giving cues at random intervals within a two to three hour interval. At every cue, a questionnaire on the most important health complaint and nine NSPS had to be filled out. We analysed the (time-lagged) associations between RF-EMF exposure in the included frequency bands and the total number of NSPS and self-rated severity of the most important health complaint. The manifestation of NSPS was studied during two different time lags - 0-1 h, and 1- 4 h - after exposure and for different exposure metrics of RF EMF. The exposure was characterised by exposure metrics describing the central tendency and the intermittency of the signal, i.e. the time-weighted average exposure, the time above an exposure level or the rate of change metric. At group level, there was no statistically significant and relevant (fixed effect) association between the measured personal exposure to RF EMF and NSPS. At individual level, after correction for multiple testing and confounding, we found significant within-person associations between WiFi (the self-declared most important source) exposure metrics and the total NSPS score and severity of the most important complaint in one participant. However, it cannot be ruled out that this association is explained by residual confounding due to imperfect control for location or activities. Therefore, the outcomes have to be regarded very prudently. The significant associations were found for the short and the long time lag, but not always concurrently, so both provide complementary information. We also conclude that analyses at the individual level can lead to different findings when compared to an analysis at group level.

<https://www.ncbi.nlm.nih.gov/pubmed/31288182>

TRANSCRANIAL ELECTRICAL AND MAGNETIC STIMULATION FOR ADDICTION MEDICINE: CONSENSUS PAPER ON STATE OF THE SCIENCE

Ekhtiari H, Tavakoli H, Addolorato G, Baeken C, Bonci A, et al. Transcranial Electrical and Magnetic Stimulation (tES and TMS) for Addiction Medicine: A consensus paper on the present state of the science and the road ahead. *Neurosci Biobehav Rev.* 2019 Jul 1. pii: S0149-7634(19)30307-0. doi: 10.1016/j.neubiorev.2019.06.007.

Abstract

There is growing interest in non-invasive brain stimulation (NIBS) as a novel treatment option for substance-use disorders (SUDs). Recent momentum stems from a foundation of preclinical neuroscience demonstrating links between neural circuits and drug consuming behavior, as well as recent FDA-approval of NIBS treatments for mental health disorders that share overlapping pathology with SUDs. As with any emerging field, enthusiasm must be tempered by reason; lessons learned from the past should be prudently applied to future therapies.

Here, an international ensemble of experts provides an overview of the state of transcranial-electrical (tES) and transcranial-magnetic (TMS) stimulation applied in SUDs. This consensus paper provides a systematic literature review on published data - emphasizing the heterogeneity of methods and outcome measures while suggesting strategies to help bridge knowledge gaps. The goal of this effort is to provide the community with guidelines for best practices in tES/TMS SUD research. We hope this will accelerate the speed at which the community translates basic neuroscience into advanced neuromodulation tools for clinical practice in addiction medicine.

<https://www.ncbi.nlm.nih.gov/pubmed/31271802>

IMPACT OF EXPOSURE OF DIABETIC RATS TO 900 MHZ ELECTROMAGNETIC RADIATION EMITTED FROM MOBILE PHONE ANTENNA ON HEPATIC OXIDATIVE STRESS

Ismail LA, Joumaa WH, Moustafa ME. The impact of exposure of diabetic rats to 900 MHz electromagnetic radiation emitted from mobile phone antenna on hepatic oxidative stress. *Electromagn Biol Med.* 2019 Jul 13:1- 10. doi: 10.1080/15368378.2019.1641722.

Abstract

The excessive exposure of patients with type 2 diabetes mellitus (T2DM) to electromagnetic radiation (EMR) from mobile phones or their base stations antenna may influence oxidative stress and development of diabetic complications. Here, we investigated the effects of exposing type 2 diabetic rats to EMR of 900 MHz emitted from GSM mobile phone antenna for 24 hours/day over a period of 28 days on hyperglycemia and hepatic oxidative stress. Male Sprague-Dawley rats were divided into 4 groups (12 rats/group): control rats, normal rats exposed to EMR, T2DM rats generated by nicotinamide/streptozotocin administration, and T2DM rats exposed to EMR. Our results showed that the exposure of T2DM rats to EMR nonsignificantly reduced the hyperglycemia and hyperinsulinemia compared to unexposed T2DM rats. The exposure of T2DM rats to EMR for 28 days increased the hepatic levels of MDA and Nrf-2 as well as the activities of superoxide dismutase (SOD) and catalase but decreased phosphorylated Akt-2 (pAkt-2) as compared to unexposed T2DM rats. Therefore, the decrease in the hepatic pAkt-2 in T2DM rats after the exposure to EMR may result in elevated level of hepatic MDA, even though the level of Nrf-2 and the activities of SOD and catalase were increased.

Abbreviations: BGL: blood glucose level; EMR: electromagnetic radiation; GSM: global system for mobile communication; H₂O₂: hydrogen peroxide; LSD: least significance difference; MDA: malondialdehyde; Nrf-2: nuclear factor erythroid 2- related factor 2; PI3K: phosphoinositide-3-kinase; pAkt-2: phosphorylated Akt-2; Akt- 2: protein kinase; ROS: reactive oxygen species; SEM: standard error of the mean; STZ: streptozotocin; SOD: superoxide dismutase ; O₂⁻: superoxide radical; CT: threshold cycle; T2DM: type 2 diabetes mellitus.

<https://www.ncbi.nlm.nih.gov/pubmed/31304806>

REACTION OF CIRCULATORY SYSTEM TO STRESS AND ELECTROMAGNETIC FIELDS EMITTED BY MOBILE PHONES - 24-HOUR MONITORING OF ECG AND BLOOD PRESSURE

Szykowska A, Gadzicka E, Szymczak W, Bortkiewicz A. [The reaction of the circulatory system to stress and electromagnetic fields emitted by mobile phones - 24-h monitoring of ECG and blood pressure]. [Article in Polish]. Med Pr. 2019 Jun 27. pii: 102360. doi: 10.13075/mp.5893.0080.

Abstract

BACKGROUND: Experimental studies have shown cardiovascular effects of electromagnetic fields (EMF) emitted by mobile phones (e.g., prolonged QTc interval and abnormal blood pressure [BP] values). Also, stress may have an impact on the cardiovascular function. However, there are practically no data regarding the joint effect of exposure to stress and EMF, with both factors pertaining, e.g., to employees of mobile network operators.

MATERIAL AND METHODS: Out of 208 subjects who had taken part in survey research, 55 workers agreed to undergo resting ECG, 24-h ECG and ambulatory blood pressure monitoring (ABPM). Their health condition, occupational and life-stress levels and EMF exposure were also assessed.

RESULTS: Among the workers using mobile phones for more than 60 min daily, the systolic BP values in office measurement and at night-time in ABPM were significantly higher than among the workers spending less time talking on mobile phones ($p = 0.04$ and $p = 0.036$, respectively). The workers with the highest level of occupational stress showed significantly higher systolic 24-h BP ($p = 0.007$) and at day-time ($p = 0.002$), both during work ($p = 0.010$) and after work ($p = 0.005$), and higher diastolic BP values at day-time ($p = 0.028$). Cardiovascular response was strongly gender-related: males showed more BP abnormalities while females displayed more impairments in ECG records. The heart rate from 24 h was significantly correlated with the level of occupational stress, after adjusting for gender, life-stress and EMF.

CONCLUSIONS: The findings obtained thus far have indicated the need to conduct in-depth studies on the impact of stress and EMF emitted by mobile phones on the health effects, in order to clarify the observed gender-related differences in cardiovascular response to the combined exposure to stress and EMF

Open access paper: <http://medpr.imp.lodz.pl/REAKCJA-UKLADU-KRAZENIA-NA-STRES-I-POLE-ELEKTROMAGNETYCZNE-EMITOWANE-PRZEZ-TELEFONY,102360,0,2.html>

ALTERATION OF TESTICULAR REGULATORY AND FUNCTIONAL MOLECULES FOLLOWING LONG-TIME EXPOSURE TO 900 MHZ RFW EMITTED FROM BTS

Azimzadeh M, Jelodar G. Alteration of testicular regulatory and functional molecules following long-time exposure to 900 MHz RFW emitted from BTS. *Andrologia*. 2019 Jul 26:e13372. doi: 10.1111/and.13372.

Abstract

The aim of this investigation was to evaluate changes in testosterone and some of the functional and regulatory molecules of testis such as P450scc, steroidogenic acute regulatory protein (StAR), tumour necrosis factor- α (TNF- α), interleukin-1 α (IL-1 α), interleukin-1 β (IL-1 β) and nerve growth factor (NGF) following exposure to 900 MHz radio frequency (RF). Thirty adult male Sprague Dawley rats (190 ± 20 g BW) were randomly classified in three equal groups, control (sham, without any exposure), short-time exposure (2 hr) (STE) and long-time exposure (4 hr) (LTE). The exposure was performed for 30 consecutive days. The testosterone level in both exposed groups was significantly less than control ($p < .05$). Level of TNF- α in both exposed groups was significantly greater than control ($p < .05$). IL-1 α and NGF levels in LTE were significantly higher than the STE and control groups ($p < .05$). Level of IL-1 β in LTE was significantly higher than control ($p < .05$). Expression of both P450scc and StAR mRNA was significantly down-regulated in both exposed groups compared to control ($p < .05$). Our results showed that RFW can affect testis and reproductive function through changes in factors, which are important during steroidogenesis, and also through changes in inflammatory factors, which regulate Leydig cell functions.

<https://www.ncbi.nlm.nih.gov/pubmed/31347712>

NON-IONIZING RADIATION CREATED BY MOBILE PHONE PROGRESSES ENDOMETRIAL HYPERPLASIA: AN EXPERIMENTAL RAT STUDY

Fadiloglu E, Tapisiz OL, Unsal M, Fadiloglu S, Celik B, Mollamahmutoglu L. Non-Ionizing Radiation Created by Mobile Phone Progresses Endometrial Hyperplasia: An Experimental Rat Study. *Arch Med Res*. 2019 Feb;50(2):36-43. doi: 10.1016/j.arcmed.2019.05.010.

Abstract

BACKGROUND: Non-ionizing radiation is related with many pathologies.

AIM: Determine association between non-ionizing radiation and endometrial hyperplasia.

METHODS: Fifty oophorectomized Wistar albino rats were administered Estradiol hemihydrate (4 mg/kg) to induce hyperplasia, and were exposed to 1800 MHz radiation created by a mobile phone and a signal generator working as base station. This study was carried out with 5 groups in two phases. The study groups were. Control group without any exposure; group receiving estrogen in first phase of the study; group receiving estrogen in both phases; group receiving estrogen in the first phase and exposed to non-ionizing radiation during second phase and group taking estrogen in both phases and exposed to non-ionizing radiation during the second phase. Following both phases, uterine horns were excised and evaluated based on glandular density (GD), epithelial cell height (ECH), and luminal epithelial cell height (LECH).

RESULTS: Estrogen increased all parameters during both phases (LECH, GD, and ECH values were 12,2 vs. 16,5 ($p = 0.001$), 34 vs. 47 ($p < 0.001$), and 201 vs. 376.6 ($p = 0.001$), respectively during the first phase; LECH, GD and ECH values were 13,2 vs. 20,3 ($p < 0.001$), 35.5 vs. 65,5 ($p < 0.001$), 219.9 vs. 419.6 ($p < 0.001$), respectively, during the second phase). Non-ionizing radiation increased all values without estrogen exposure (LECH, GD and ECH values were 13,2 vs. 17,2 ($p = 0.074$), 35,5 vs. 59 ($p = 0.074$), and 219 vs. 318.3 ($p < 0.001$), respectively) or with estrogen exposure (LECH, GD, and ECH, values were 20,3 vs. 22,8 ($p = 0.168$), 65,5 vs. 77 ($p = 0.058$), and 419,6 vs. 541,6 ($p = 0.004$), respectively).

CONCLUSION: Non-ionizing radiation progressed endometrial hyperplasia in an experimental rat model with/without estrogen exposure.

<https://www.ncbi.nlm.nih.gov/pubmed/31349952>

EFFECTS OF RADIOFREQUENCY ELECTROMAGNETIC FIELD EXPOSURE ON NEURONAL DIFFERENTIATION AND MITOCHONDRIAL FUNCTION IN SH-SY5Y CELLS

von Niederhäusern N, Ducray A, Zielinski J, Murbach M, Mevissen M. Effects of radiofrequency electromagnetic field exposure on neuronal differentiation and mitochondrial function in SH-SY5Y cells. *Toxicol In Vitro*. 2019 Jul 24;104609. doi: 10.1016/j.tiv.2019.104609.

Abstract

Exposure to radiofrequency electromagnetic fields (RF-EMF) has dramatically increased in the last decades with expanding use of mobile phones worldwide. The aim of this study was to evaluate effects of RF-EMF on neuronal differentiation and underlying signaling pathways involved in neuronal differentiation, neurodegeneration, and mitochondrial function. Differentiation of SH-SY5Y cells was performed using all-trans retinoic acid or staurosporine to obtain cholinergic and dopaminergic neurons. Exposure of SH-SY5Y cells at 935 MHz, 4 W/kg for 24 h did not alter the neuronal phenotypes quantitatively. Markers of the signaling pathways investigated, namely the mitogen-activated protein kinases (MAPK), extracellular signal-regulated kinases (Erk) 1 and 2 (p-Erk1/2) and protein kinase B (Akt), glycogen synthase kinase 3 β (GSK3 β) and Wnt/ β -catenin were not significantly affected by RF-EMF compared to sham. RF-EMF-impaired mitochondrial respiration in cells under glucose deprivation, but glutathione levels and mitochondrial fission and fusion markers were not altered. These findings indicate that RF-EMF might lead to an impairment of mitochondrial function that is only manifest at maximal respiration and additional stressors such as glucose deprivation. Further research is needed to investigate the effects of RF-EMF on mitochondrial function in detail because mitochondrial impairment is closely related to the pathogenesis of neurodegenerative diseases.

<https://www.ncbi.nlm.nih.gov/pubmed/31351122>

PROTECTIVE EFFECTS OF ZINC ON 2.45 GHZ ELECTROMAGNETIC RADIATION-INDUCED OXIDATIVE STRESS AND APOPTOSIS IN HEK293 CELLS

Özsobacı NP, Ergün DD, Tunçdemir M, Özçelik D. Protective Effects of Zinc on 2.45 GHz Electromagnetic Radiation-Induced Oxidative Stress and Apoptosis in HEK293 Cells. *Biol Trace Elem Res.* 2019 Jul 17. doi: 10.1007/s12011-019-01811-6.

Abstract

Several epidemiological studies have shown that exposure to electromagnetic radiation (EMR) can be harmful to human health. The purpose of this study was to examine oxidative parameters and apoptosis induced by EMR in human kidney embryonic cells (HEK293) and to investigate whether zinc (Zn) has protective effect on EMR- induced apoptosis in HEK293 cells. For our experiment, HEK293 cells were divided into four main groups, control, EMR, 50 μ M Zn + EMR, and 100 μ M Zn + EMR. HEK293 cells of EMR groups were exposed to 2.45 GHz EMR for 1 h. In Zn groups, HEK293 cells were incubated with different concentrations of Zn for 48 h before EMR exposure. Oxidative stress parameters were determined by spectrophotometric method; bcl-2 and caspase-3 were assessed immunohistochemically and TUNEL method was performed for apoptotic activity. EMR group had higher malondialdehyde (MDA) level and lower superoxide dismutase (SOD) activity compared with control group. In Zn-applied groups, MDA was decreased and SOD activity was increased compared with EMR group. The number of the apoptotic cells and caspase-3 immunopositive cells at EMR group was increased significantly compared with the control group, whereas bcl-2 was decreased. Besides, Zn-treated groups showed a significant reduction in the number of apoptotic cells and caspase-3 from that of EMR group, whereas there was an increase in bcl-2 immunopositivity. Our findings show that EMR caused oxidative stress and apoptotic activation in HEK293 cells. Zn seems to have protective effects on the EMR by increasing SOD activity and bcl-2 immunopositivity, decreasing lipid peroxidation and caspas-3 immunopositivity.

<https://www.ncbi.nlm.nih.gov/pubmed/31317470>

METABOLOMICS UNVEIL ALTERATIONS OF BIOMEMBRANES PERMEABILITY IN HUMAN HACAT KERATINOCYTES UPON 60 GHZ MILLIMETER-WAVE EXPOSURE

Le Pogam P, Le Page Y, Habauzit D, Doué M, Zhadobov M, Sauleau R, Le Dréan Y, Rondeau D. Untargeted metabolomics unveil alterations of biomembranes permeability in human HaCaT keratinocytes upon 60 GHz millimeter-wave exposure. *Sci Rep.* 2019 Jun 27;9(1):9343. doi: 10.1038/s41598-019-45662-6.

Abstract

A joint metabolomic and lipidomic workflow is used to account for a potential effect of millimeter waves (MMW) around 60 GHz on biological tissues. For this purpose, HaCaT human keratinocytes were exposed at 60.4 GHz with an incident power density of 20 mW/cm², this value corresponding to the upper local exposure limit for general public in the context of a wide scale deployment of MMW technologies and devices. After a 24h-exposure, endo- and extracellular extracts were recovered to be submitted to an integrative UPLC-Q- Exactive metabolomic and lipidomic workflow. R-XCMS data processing and subsequent statistical treatment led to emphasize a limited number of altered features in lipidomic sequences and in intracellular metabolomic analyses, whatever the ionization mode (i.e 0 to 6 dysregulated features). Conversely, important dysregulations could be reported in extracellular

metabolomic profiles with 111 and 99 frames being altered upon MMW exposure in positive and negative polarities, respectively. This unexpected extent of modifications can hardly stem from the mild changes that could be reported throughout transcriptomics studies, leading us to hypothesize that MMW might alter the permeability of cell membranes, as reported elsewhere.

Open access paper: <https://www.nature.com/articles/s41598-019-45662-6>

CEO2NPS RELIEVE RADIOFREQUENCY RADIATION, IMPROVE TESTOSTERONE SYNTHESIS, AND CLOCK GENE EXPRESSION IN LEYDIG CELLS BY ENHANCING ANTIOXIDATION

Qin F, Shen T, Cao H, Qian J, Zou D, Ye M, Pei H. *Int J Nanomedicine*. CeO₂NPs relieve radiofrequency radiation, improve testosterone synthesis, and clock gene expression in Leydig cells by enhancing antioxidation. 2019 Jun 24;14:4601-4611. doi: 10.2147/IJN.S206561.

Abstract

Introduction: The ratio of Ce³⁺/Ce⁴⁺ in their structure confers unique functions on cerium oxide nanoparticles (CeO₂NPs) containing rare earth elements in scavenging free radicals and protecting against oxidative damage. The potential of CeO₂NPs to protect testosterone synthesis in primary mouse Leydig cells during exposure to 1,800 MHz radiofrequency (RF) radiation was examined in vitro.

Methods: Leydig cells were treated with different concentrations of CeO₂NPs to identify the optimum concentration for cell proliferation. The cells were pretreated with the optimum dose of CeO₂NPs for 24 hrs and then exposed to 1,800 MHz RF at a power density of 200.27 μ W/cm² (specific absorption rate (SAR), 0.116 W/kg) for 1 hr, 2 hrs, or 4 hrs. The medium was used to measure the testosterone concentration. The cells were collected to determine the antioxidant indices (catalase [CAT], malondialdehyde [MDA], and total antioxidant capacity [T-AOC]), and the mRNA expression of the testosterone synthase genes (Star, Cyp11a1, and Hsd-3 β) and clock genes (Clock, Bmal1, and Rora).

Results: Our preliminary result showed that 128 μ g/mL CeO₂NPs was the optimum dose for cell proliferation. Cells exposed to RF alone showed reduced levels of testosterone, T-AOC, and CAT activities, increased MDA content, and the downregulated genes expression of Star, Cyp11a1, Hsd-3 β , Clock, Bmal1, and Rora.

Pretreatment of the cells with 128 μ g/mL CeO₂NPs for 24 hrs followed by RF exposure significantly increased testosterone synthesis, upregulated the expression of the testosterone synthase and clock genes, and increased the resistance to oxidative damage in Leydig cells compared with those in cells exposed to RF alone.

Conclusion: Exposure to 1,800 MHz RF had adverse effects on testosterone synthesis, antioxidant levels, and clock gene expression in primary Leydig cells. Pretreatment with CeO₂NPs prevented the adverse effects on testosterone synthesis induced by RF exposure by regulating their antioxidant capacity and clock gene expression in vitro. Further studies of the mechanism underlying the protective function of CeO₂NPs against RF in the male reproductive system are required.

Open access paper: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6598754/>

COLONY COLLAPSE DISORDER (CCD) IN HONEY BEES CAUSED BY EMF RADIATION

Santhosh Kumar S. Colony Collapse Disorder (CCD) in Honey Bees Caused by EMF Radiation. Bioinformation. 2018 Dec 21;14(9):421-424. doi: 10.6026/97320630014521.

Abstract

Honey bees are one of the treasures in the world. An increase of waveform communication leads to good information exchange of mankind. In the biological view, it causes a lot of side effects and lifestyle changes in other living organisms. The drastic changes are causing the natural imbalance in the ecosystem and become a global issue. There are significant reasons for bee colony collapse disorder (CCD) like pesticides, disease and climate change. Recent studies reveal that a cell phone tower and mobile phone handset are also causing side effects to honey bees due to radiation emission. Most of the researchers concentrated on biological and behavioral changes in a honey bee due to radiation effects. For that, the real-time radiation levels have experimented but the different technical perspectives such as radiation emission levels, handset radiation emission measures and multi-sources of radiation are needed to be considered during research. This study aimed to provide possible research extensions of colony collapse disorder caused by cell tower and mobile handsets.

Open access paper: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6563664>

THE POTENTIAL FOR IMPACT OF MAN-MADE SUPER LOW AND EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS ON SLEEP

Ohayon MM, Stolc V, Freund FT, Milesi C, Sullivan SS. The potential for impact of man-made super low and extremely low frequency electromagnetic fields on sleep. Sleep Med Rev. 2019 Jun 8;47:28-38. doi: 10.1016/j.smr.2019.06.001.

Abstract

An ever-growing number of electromagnetic (EM) emission sources elicits health concerns, particularly stemming from the ubiquitous low to extremely low frequency fields from power lines and appliances, and the radiofrequency fields emitted from telecommunication devices. In this article we review the state of knowledge regarding possible impacts of electromagnetic fields on melatonin secretion and on sleep structure and the electroencephalogram of humans. Most of the studies on the effects of melatonin on humans have been conducted in the presence of EM fields, focusing on the effects of occupational or residential exposures. While some of the earlier studies indicated that EM fields may have a suppressive effect on melatonin, the results cannot be generalized because of the large variability in exposure conditions and other factors that may influence melatonin. For instance, exposure to radiofrequency EM fields on sleep architecture show little or no effect. However, a number of studies show that pulsating radiofrequency electromagnetic fields, such as those emitted from cellular phones, can alter brain physiology, increasing the electroencephalogram power in selective bands when administered immediately prior to or during sleep. Additional research is necessary that would include older populations and evaluate the interactions of EM fields in different frequency ranges to examine their effects on sleep in humans.

<https://www.ncbi.nlm.nih.gov/pubmed/31252334>

EFFECT OF LONG-TERM OCCUPATIONAL EXPOSURE TO EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS ON PROINFLAMMATORY CYTOKINE AND HEMATOLOGICAL PARAMETERS

Bagheri Hosseinabadi M, Khanjani N, Samaei E, Nazarkhani F. Effect of Long-term Occupational Exposure to Extremely Low Frequency Electromagnetic Fields on Proinflammatory Cytokine and Hematological Parameters. *Int J Radiat Biol.* 2019 Jul 22:1-23. doi: 10.1080/09553002.2019.1642542.

Abstract

Purpose: The present study aimed to investigate the effect of extremely low frequency electromagnetic fields (ELF-EMFs) on proinflammatory cytokines and hematological parameters, among the employees of a power plant, which are one of the most important occupational groups exposed to ELF-EMFs extensively.

Materials and methods: The studied population included 112 employees of a power plant as the exposed group and 138 unexposed employees who were enrolled based on inclusion and exclusion criteria. The magnetic flux density and the strength of the electric field were determined by spot measurements and according to the IEEE C95.3.1 standard. Proinflammatory cytokines including serum interleukin 1 β (IL-1 β), interleukin 6 (IL-6), and tumour necrosis factor- α (TNF- α); and hematologic parameters of all subjects were measured.

Results: The mean level of IL-1 β and IL-6, white blood cell count (WBC) and red blood cell count (RBC), lymphocyte percentage (Lym%), Mean corpuscular volume (MCV), platelet count (PLT) and procalcitonin (PCT) were significantly more in the exposed group, than the unexposed group. The mean serum levels of IL-6, IL-1 β and some of the hematological parameters including WBC, lymphocyte, RBC and haematocrit were higher in technicians which had the highest level of exposure to magnetic fields compared to other groups and these relations were linear.

Conclusions: Long-term exposure to ELF-EMFs probably affects immune responses, by stimulating the production of proinflammatory cytokines, and increasing some hematological parameters.

<https://www.ncbi.nlm.nih.gov/pubmed/31329007>

EVALUATING SHORT-TERM EXPOSURE TO WI-FI SIGNALS ON STUDENTS' REACTION TIME, SHORT-TERM MEMORY AND REASONING ABILITY

Hosseini MA, Hosseini A, Jarideh S, Argasi H, Shekoohi-Shooli F, Zamani A, Taeb S, Haghani M. Evaluating short- term exposure to Wi-Fi signals on students' reaction time, short-term memory and reasoning ability. *Radiat Prot Dosimetry.* 2019 Jun 28. pii: ncz162. doi: 10.1093/rpd/ncz162.

Abstract

This study investigated the effect of short-term exposure to Wi-Fi signals on the cognitive functions of the mind. After obtaining permission from the local Ethics Committee of Shiraz University of Medical Sciences and approval by the Iranian Registry of Clinical Trials

(IRCT2017041233398N1), 45 male and female students from Shiraz University of Medical Sciences volunteered to participate in this study. They were exposed to Wi-Fi signals in two sham and exposure sessions, each for 2 hours. After completion, they took part in reaction time, short-term memory, and reasoning ability tests. After scoring, the data were analysed by SPSS software. In addition, the electric field strength and power density were calculated. The results showed no statistically significant differences between the mean scores of reaction time, short-term memory, and reasoning ability in sham and exposure. Also, the obtained values from the electric field strength and power density ($E = 4.1 \text{ Vm}^{-1}$, $P = 0.446 \text{ Wm}^{-2}$) were lower than that of threshold values by the International Commission on Non-ionizing Radiation Protection (ICNIRP). Our results can greatly reduce concerns regarding the effects of short-term exposure to Wi-Fi waves on cognitive functions.

<https://www.ncbi.nlm.nih.gov/pubmed/31251356>

Residential distance from high-voltage overhead power lines and risk of Alzheimer's dementia and Parkinson's disease: population-based case-control study

Gervasi F, Murtas R, Decarli A, Giampiero Russo A. Residential distance from high-voltage overhead power lines and risk of Alzheimer's dementia and Parkinson's disease: a population-based case-control study in a metropolitan area of Northern Italy. *Int J Epidemiol*. 2019 Jul 6. pii: dyz139. doi: 10.1093/ije/dyz139.

Abstract

BACKGROUND: The association between the extremely low-frequency magnetic field generated by overhead power lines and neurodegenerative disease is still a matter of debate.

METHODS: A population-based case-control study was carried out on the residents in the Milan metropolitan area between 2011 and 2016 to evaluate the possible association between exposure to extremely low-frequency magnetic fields generated by high-voltage overhead power lines and Alzheimer's dementia and Parkinson's disease. A statistical analysis was performed on cases and controls matched by sex, year of birth and municipality of residence (with a case to controls ratio of 1 : 4) using conditional logistic regression models adjusted for socio-economic deprivation and distance from the major road network as potential confounders.

RESULTS: Odds ratios for residents <50 m from the source of exposure compared with residents at ≥ 600 m turned out to be 1.11 (95% confidence interval: 0.95-1.30) for Alzheimer's dementia and 1.09 (95% confidence interval: 0.92-1.30) for Parkinson's disease.

CONCLUSIONS: The finding of a weak association between exposure to the extremely low-frequency magnetic field and neurodegenerative diseases suggests the continuation of research on this topic. Moreover, the low consistency between the results of the already existing studies emphasises the importance of increasingly refined study designs.

The results of this study do not disprove the hypothesis that the ELF-MF generated by high-voltage overhead power lines can increase the risk of Alzheimer's dementia and, to a lesser extent, Parkinson's disease. The repeated suggestions regarding the existence of an association between ELF-MF and neurodegenerative diseases, both for residential exposures and for occupational exposures, constitute an incentive to continue the evaluation through

planning of specific studies. The lack of univocal and definitive results emphasizes, however, the need to adopt, for this specific field of investigation, increasingly rigorous experimental designs, with particular reference to the selection of study subjects, the quantification of exposure and the definition of confounders.
<https://www.ncbi.nlm.nih.gov/pubmed/31280302>

EFFECT OF 50-HZ MAGNETIC FIELDS ON SERUM IL-1 β AND IL-23 AND EXPRESSION OF BLIMP-1, XBP-1, AND IRF-4

Molaei S, Alahgholi-Hajibehzad M, Gholamian-Hamadan M, Zaerieghane Z, Zamani A. Effect of 50-Hz Magnetic Fields on Serum IL-1 β and IL-23 and Expression of BLIMP-1, XBP-1, and IRF-4. *Inflammation*. 2019 Jul 8. doi: 10.1007/s10753-019-01042-w.

Abstract

Investigations demonstrated that magnetic fields (MFs) change cytokine production and expression of some immune system genes. This alteration can affect the immune system function and may lead to some diseases. Therefore, this study investigated two important inflammatory cytokines, i.e., IL-1 β and IL-23 at two phases of pre- and post-immunization of the immune system. In addition, the expressions of three important genes in the humoral immunity, i.e., B lymphocyte-induced maturation protein-1 (BLIMP-1), X-box-binding protein-1 (XBP-1), and interferon regulatory factor-4 (IRF-4) were evaluated at post-immunization phase. Eighty adult male rats were divided into four experimental groups and a control. The experimental groups were exposed to 50-Hz MFs with magnetic flux densities of 1, 100, 500, and 2000 μ T, 2 h/day for 2 months. The animals were injected by human serum albumin (100 μ g/rat) on days 31, 44, and 58 of exposure. The cytokine levels in serum were measured with enzyme-linked immunosorbent assay (ELISA), and the expression of genes was evaluated with reverse transcription quantitative polymerase chain reaction (RT-qPCR). Serum IL-1 β was decreased at pre-immunization phase after exposure to 1 and 100 μ T of 50-Hz MFs. In contrast, serum IL-23 was increased at post-immunization phase in 100 μ T group. No change was observed in serum IL-1 β and IL-23 in each group at pre-immunization phase compared with post-immunization. Furthermore, exposure to 100 μ T downregulated expression of BLIMP-1, XBP-1, and IRF-4. In conclusion, exposure to 50-Hz MFs may decrease inflammation at short time and increase it at longer time exposures. In addition, 50-Hz MF exposure may decrease the humoral immune responses. It seems that 50-Hz MFs cause more alteration in immune system function at lower densities (100 μ T).

<https://www.ncbi.nlm.nih.gov/pubmed/31286334>

METHYL AND METHYLENE VIBRATIONS RESPONSE IN AMINO ACIDS OF TYPICAL PROTEINS IN WATER SOLUTION UNDER HIGH-FREQUENCY ELECTROMAGNETIC FIELD

Calabrò E, Magazù S. *Electromagn Biol Med*. 2019 Jul 11:1-8. doi: 10.1080/15368378.2019.1641720.

Abstract

The aim of this paper was to study the response of methyl (CH₃) and methylene (CH₂) vibration bands in amino acids of some typical proteins diluted in bidistilled water solution after exposure to a high-frequency electromagnetic fields using Fourier Transform Infrared (FTIR) Spectroscopy. Hemoglobin in H₂O solution and bovine serum albumin and myoglobin diluted in different D₂O solutions were exposed for 4 h to a power density of 0.95 W/m² at

the frequency of 1750 MHz, emitted by operational mobile phones Nokia model 105 and Samsung model GT-E1270, in order to study the response of stretching vibrations of CH₃ and CH₂ that are in amino acids of those proteins. The main result was that CH₃ stretching bands increased significantly in myoglobin in D₂O solution because this protein is represented by a single protein chain so that the torque induced by the applied field is larger than that induced on the other two proteins. Otherwise, CH₂ stretching vibrations decreased in intensity significantly for all exposed proteins. This result can be explained as well, assuming that, given a fixed volume, a decrease of population of CH₂ occurred after exposure because of the alignment of proteins α -helices along the direction of the applied electromagnetic field.

<https://www.ncbi.nlm.nih.gov/pubmed/31293188>

EFFECTS OF LONG-TERM EXPOSURE TO AN EXTREMELY LOW FREQUENCY MAGNETIC FIELD (15 μ T) ON SELECTED BLOOD COAGULATION VARIABLES IN OF1 MICE

Vallejo D, Hidalgo MA, Hernández JM. Effects of long-term exposure to an extremely low frequency magnetic field (15 μ T) on selected blood coagulation variables in OF1 mice. Electromagn Biol Med. 2019 Jul 13:1-8. doi: 10.1080/15368378.2019.1641719.

Abstract

The long-term exposure of OF1 mice to an extremely low frequency magnetic field (ELF-MF; 50 Hz, 15 μ T [rms]) has been associated with the appearance of leukaemia. Neoplasms are usually accompanied by changes in haemostatic processes but reports on changes in blood coagulation following exposure to an ELF-MF are scarce and rather fragmentary. The aim of the present work was to determine whether any global or partial coagulation variables are modified after such long-term exposure. A parental generation of six week-old OF1 mice was exposed to an artificial ELF-MF for 14 weeks. Mating was then allowed, and the resulting filial generation raised until the age of 31-35 weeks within the same ELF-MF. Control animals were subjected only to the magnetic field of the Earth. Whole blood samples were extracted from the anaesthetised filial generation of mice by cardiac puncture. White blood cells (WBC) were counted, the activated partial thromboplastin time (APTT) and prothrombin time (PT) determined, and plasma fibrinogen, reptilase time (RT), and factor VIII activity examined. The similarity between the results for the present control animals and those recorded in the literature for human blood render OF1 mice a suitable study model. The differences in the studied coagulation variables were largely owed simply to sex. However, the females showed a very significant shortening of the PT time associated with ELF-MF exposure. Exposure also caused significant increases in the female APTT and RT values, and in general reduced the differences between the sexes.

<https://www.ncbi.nlm.nih.gov/pubmed/31303067>

ON THE MAGNETOSENSITIVITY OF LIPID PEROXIDATION: TWO- VERSUS THREE-RADICAL DYNAMICS

Sampson C, Keens RH , Kattnig DR. On the magnetosensitivity of lipid peroxidation: two-versus three-radical dynamics. *Phys Chem Chem Phys*. 2019 Jun 26;21(25): 13526-13538. doi: 10.1039/c9cp01746a.

Abstract

We present a theoretical analysis of the putative magnetosensitivity of lipid peroxidation. We focus on the widely accepted radical pair mechanism (RPM) and a recently suggested idea based on spin dynamics induced in three-radical systems by the mutual electron-electron dipolar coupling (D3M). We show that, contrary to claims in the literature, lipid peroxides, the dominant chain carriers of the autoxidation process, have associated non- zero hyperfine coupling interactions. This suggests that their recombination could, in principle, be magnetosensitive due to the RPM. While the RPM indeed goes a long way to explaining magnetosensitivity in these systems, we show that the simultaneous interaction of three peroxy radicals via the D3M can achieve larger magnetic field effects (MFE), even if the third radical is remote from the recombining radical pair. For randomly oriented three-radical systems, the D3M induces a low-field effect comparable to that of the RPM. The mechanism furthermore immunizes the spin dynamics to the presence of large exchange coupling interactions in the recombining radical pair, thereby permitting much larger MFE at magnetic field intensities comparable to the geomagnetic field than would be expected for the RPM. Based on these characteristics, we suggest that the D3M could be particularly relevant for MFE at low fields, provided that the local radical concentration is sufficient to allow for three-spin radical correlations. Eventually, our observations suggest that MFEs could intricately depend on radical concentration and larger effects could ensue under conditions of oxidative stress.

<https://www.ncbi.nlm.nih.gov/pubmed/31210238>

MOBILE COMMUNICATIONS AND PUBLIC HEALTH

Edited by Marko Markov Boca Raton, FL: CRC Press. June 2018. ISBN-13: 978-1-138-56842-6 (Hardback); 978-0-203-70510-0 (eBook)

<https://www.taylorfrancis.com/books/e/9780203705100>

This book represents a comprehensive overview of various forms of mobile communications devices, with increasing variations and intensities that constitute a serious hazard to both the biosphere and mankind. Contributors stress the lack of controls over mobile communication signal sources, as well as the absence of monitoring the health of individuals exposed to microwave radiation. The work also entails a review of the engineering behind mobile communication technology, including a summary of basic scientific evidence of the effects of biological exposure to microwaves, and unique coverage on potential hazards of mobile communication for children.

Marko S. Markov, Ph.D., has been professor and chairman of the Department of Biophysics and Radiobiology of Sofia University for more than 20 years. With over 45 years of basic science research experience, and over 40 years in the clinical application of electromagnetic fields, he is recognized as one of the world's best experts in the subject. His list of publications includes 196 papers and 18 books.

- Presents an overview of what modern science knows about mobile communications signals;
 - Details the latest research on potential hazards related to uncontrolled use of mobile devices;
 - Provides information related to children's organisms not developed biologically prior to exposure to microwave signals;
 - Offers methods of control of the house and work environment; and
 - Explores the link between science and electromagnetics hazards.
-

THE 5G APPEAL

By Rainer Nyberg, Lennart Hardell. pp. xii – xvi

MOBILE COMMUNICATIONS AND PUBLIC HEALTH

by Marko S. Markov. Chapter 1: pp. 1-24.

Abstract

The last quarter of the 20th and the first two decades of the 21st centuries are characterized by increasing hazards of electromagnetic fields for the biosphere and public health. This anthropogenic factor has been considered in two distinct directions: low frequency electromagnetic fields (EMF) from power lines and high frequency EMF from cellular communications.

Public fear as well as scientific understanding have pointed to the serious problems for public health. World Health Organization (WHO) recognized the importance of this issue and originated “The international EMF project” which during the last two decades has organized a series of international meetings in different locations of the world with the intention to harmonize standards for EMF radiation and exposure. Unfortunately, this activity did not end with a more or less defined conclusion or at least a recommendation. With respect to EMF emitted for the purpose of mobile communications, the International Agency for Research on Cancer (IARC) has recognized the non-ionizing radiation from microwaves used in mobile communications as a possible carcinogenic source (category 2B).

This paper discussed the basic physics problems related to characterization of the non-ionizing radiation that are of importance for public health. Special attention is paid to missing definitions for basic terminology and to the non-thermal effects of EMF as well as the incorrect use of SAR [Specific Absorption Rate] for defining conditions of exposure. The core of the paper is the potential hazard of mobile communications for human health.

Conclusions

In conclusion, today the entire biosphere and mankind are subjected to signals from space and terrestrial sources, unknown by numbers and by their physical characteristics. We are at the bottom of the ocean of electromagnetic waves. What is worse—this global “experiment” is conducted without protocol, monitoring, and the possibility to produce any protections. The mobile communication industry is creating newer and newer tools in order to eventually increase the speed of communications. Smartphones and smart meters significantly change the electromagnetic environment not only for occupational conditions, but in every home.

Billions of people are not informed about the fact that their homes and they themselves are subjected to the “new and advanced” technological developments. This cohort includes babies and elderly people, schoolboys and professionals.

What is even worse, the new 5G mobile technology is being introduced even before the development of industrial standards. No health hazard estimation is planned; no guidance for protection and standards are developed. It is time to ring the bell.

CELL PHONE RADIATION: EVIDENCE FROM ELF AND RF STUDIES SUPPORTING MORE INCLUSIVE RISK IDENTIFICATION AND ASSESSMENT

By Carl Blackman. Chapter 2: pp. 25-46.

Abstract

Many national and international exposure standards for maximum radiation exposure from the use of cell phones and other similar portable devices are ultimately based on the production of heat, particularly in regions of the head, that is, thermal effects (TE). The recent elevation in some countries of the allowable exposure, that is, averaging the exposure that occurs in a 6 minute period over 10 grams (g) of tissue rather than over 1 g, allows for greater heating in small portions of the 10-g volume compared to the exposure that would be allowed averaged over a 1-g volume. There is concern that ‘hot’ spots, that is, momentary higher intensities, could occur in portions of the 10-g tissue piece, which might have adverse consequences, particularly in brain tissue.

There is another concern about exposure to cell phone radiation that has been virtually ignored except for the National Council of Radiation Protection and Measurements (NCRP) advice given in a publication in 1986 (National Council for Radiation Protection and Measurements, Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields, National Council for Radiation Protection and Measurements, 1986, 400 pp.). This NCRP review and guidance explicitly acknowledged the existence of non-thermal effects (NTE), and included provisions for reduced maximum-allowable limits should certain radiation characteristics occur during the exposure.

If we are to take most current national and international exposure standards as completely protective of thermal injury for acute exposure only (6 min time period), then the recent evidence from epidemiological studies associating increases in brain and head cancers with increased cell phone use per day and per year over 8–12 years raises concerns about the possible health consequences of NTE first acknowledged in the NCRP 1986 report (National Council for Radiation Protection and Measurements, Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields, National Council for Radiation Protection and Measurements, 1986, 400 pp.).

This paper will review some of the salient evidence that demonstrates the existence of NTE and the exposure complexities that must be considered and understood to provide appropriate, more thorough evaluation and guidance for future studies and for assessment of potential health consequences. Unfortunately, this paper is necessary because most national and international reviews of the research area since the 1986 report (National Council for Radiation Protection and Measurements, Biological Effects and Exposure Criteria

for Radiofrequency Electromagnetic Fields, National Council for Radiation Protection and Measurements, 1986, 400 pp.) have not included scientists with expertise in NTE, or have not given appropriate attention to their requests to include NTE in the establishment of public health-based radiation exposure standards. Thus, those standards are limited because they are not comprehensive.

There is substantial scientific evidence that some modulated fields (pulsed or repeated signals) are bioactive, which increases the likelihood that they could have health impacts with chronic exposure even at very low exposure levels. Modulation signals may interfere with normal, nonlinear biological processes. Modulation is a fundamental factor that should be taken into account in new public safety standards; at present it is not even a contributing factor. To properly evaluate the biological and health impacts of exposure to modulated RFR (carrier waves), it is also essential to study the impact of the modulating signal (lower frequency fields or ELF- modulated RF). Current standards have ignored modulation as a factor in human health impacts, and thus are inadequate in the protection of the public in terms of chronic exposure to some forms of ELF-modulated RF signals. The current Institute of Electrical and Electronic Engineers (IEEE) and International Commission on Non- Ionizing Radiation Protection (ICNIRP) standards are not sufficiently protective of public health with respect to chronic exposure to modulated fields (particularly new technologies that are pulse-modulated and heavily used in cellular telephony). The collective papers on modulation appear to be omitted from consideration in the recent World Health Organization (WHO) and IEEE science reviews. This body of research has been ignored by current standard setting bodies that rely only on traditional energy-based (thermal) concepts.

More laboratory as opposed to epidemiological research is needed to determine which modulation factors and combinations are bioactive and deleterious at low intensities, and are likely to result in disease-related processes and/or health risks; however, this should not delay preventative actions supporting public health and wellness. If signals need to be modulated in the development of new wireless technologies, for example, it makes sense to use what existing scientific information is available to avoid the most obviously deleterious exposure parameters and select others that may be less likely to interfere with normal biological processes in life.

The current membership on Risk Assessment committees needs to be made more inclusive by adding scientists experienced with producing nonthermal biological effects. The current practice of segregating scientific investigations (and resulting public health limits) by artificial, engineering-based divisions of frequency needs to be changed because this approach dramatically dilutes the impact of the basic science results and eliminates consideration of modulation signals, thereby reducing and distorting the weight of evidence in any evaluation process.

PUBLIC EXPOSURE TO RADIO FREQUENCY ELECTROMAGNETIC FIELDS

By Peter Gajšek. Chapter 3: pp. 47-64.

Abstract

The increasing use of various wireless devices and development of new telecommunication technologies has resulted in a fundamental change of radio frequency electromagnetic fields (RF-EMF) exposure in the everyday environment. In the last three decades, a large number of scientific studies on the exposure assessment of the general public to RF-EMF in different environments were completed. The results of numerous exposure assessment studies come to almost the same conclusions: that public RF-EMF exposures in different micro environments are only a small fraction of existing RF exposure standards.

In general, all the research studies related to exposure assessment of the general public to fixed RF-EMF sources in the environment including base stations, broadcasting, and wireless systems clearly demonstrated that the total mean value of the electric field was quite low and did not exceed 10% of the internationally recognized limit values.

It is expected that the strength and complexity of EMF exposures will increase continuously, especially in relation to expansion of the 5th generation of mobile telephony and other emerging technologies that will use different frequency bands. An increasing number of devices and processes employing these frequencies (household appliances, telecommunication, etc.) have already been introduced into everyday life. Almost nothing is known about these exposures and potential exposure levels.

It is expected that global mobile data traffic will grow at a compound annual rate of 45% in the coming years, which represents a tenfold increase between 2016 and 2022 (Ericsson, 2016). This increase is driven largely by the adoption of mobile video streaming. On top of that, the Internet of Things (IoT) is shifting from a vision to reality. The 29 billion connected devices by 2022 are expected to include 18 billion IoT or machine-to-machine (M2M) devices. Subsequently, the future 5G mobile networks will need to support new challenging and new use cases, which will demand more spectrum in ever higher frequency ranges.

Furthermore, emissions will continue to change in characteristics and levels due to new infrastructure deployments, smart environments, and novel wireless devices. Thus it is expected that the complexity of EMF exposures will increase in the future.

HEALTH EFFECTS OF CHRONIC EXPOSURE TO RADIATION FROM MOBILE COMMUNICATION

By Igor Belyaev. Chapter 4: pp. 65-100.

Abstract

Due to strong evidence showing the critical role of the exposure duration for the effects of nonthermal microwaves (NT MW), studies with prolonged chronic exposures became of key importance in assessment of the MW health effects. Given the undoubted key role of specific signal characteristics such as frequency, modulation, and polarization, the studies with chronic exposures to real signals of mobile communication become of predominant importance for assessment of health effects from mobile communication. There were a number of such studies performed recently. Most of them confirmed results of animal studies

with chronic MW exposure previously performed in Russia/The Soviet Union by showing detrimental health effects including those related to carcinogenesis.

Conclusions

Chronic exposure to nonthermal microwaves (NT MW) may result in various health effects affecting the central nervous system, fertility, immune functions, and causing/promoting cancer. Taken together, available studies indicate that response to NT MW depends on PD and duration exposure (7). The SAR based ICNIRP safety standards, which have been widely adopted for protection against acute thermal effects of MW, are insufficient to protect the public from chronic exposures to NT MW from mobile communication. New safety standards nonthermal MW effects (106). It should be anticipated that definite parts of human population, such as children, pregnant women, and hypersensitive persons, which constitute about 1%–10% of the general population in economically developed counties (113), could be especially vulnerable to chronic NT MW exposures. In general, new signals of mobile communication should be tested with chronic exposures before being put into practice.

CAN ELECTROMAGNETIC FIELD EXPOSURE CAUSED BY MOBILE COMMUNICATION SYSTEMS IN A PUBLIC ENVIRONMENT BE COUNTED AS DOMINANT?

By Jolanta Karpowicz, Dina Šimunić, Krzysztof Gryz. Chapter 5: 101-128.

Abstract

The core principle used by mobile communication systems to transfer information via the wireless links involves the emission and reception of the electromagnetic field in the radio frequency band. The entire population today is exposed to the electromagnetic field emitted by mobile terminals (mobile phone handsets, cordless phones, tablets, laptops, routers, etc.) and their base stations. The same frequency bands are also used by other technologies, such as radio and television broadcasting, wireless internet access, microwave heating, anti-theft systems, radio frequency identification systems, and so on. When discussing health hazards may be caused by electromagnetic field exposure from mobile communication systems, it must be remembered that in some cases, other sources of electromagnetic exposure may deliver a dominant or a significant exposure component of the total radio frequency electromagnetic exposure of particular individuals. This paper describes the technical aspects of various mobile communication systems. Exposure scenarios with various dominant sources of exposures are discussed in the chapter together with exposure evaluation techniques which may help recognize the exposure pattern.

Conclusions

The level of exposure to RF-EMF recorded in the discussed investigations performed in environments accessible to the public is usually significantly lower than the general public exposure limits provided by international guidelines and legislation established in various countries (4–61 V/m) (Council Recommendation, 1999, Gryz et al., 2014a, Stam, 2011). It is worth noting that, when approaching RF emitting antennas, especially BTS of mobile networks or RTV broadcasting, over a short distance the level of RF-EMF increases and may even significantly exceed the mentioned limits. However, the investigations show that in locations where many users of mobile communication tools are present in a crowded space, the components of RF-EMF exposure caused by their activities (which significantly vary over

time) may together exceed components from the stationary emitters of RF-EMF (such as mobile networks base stations and RTV broadcasting antennas). Furthermore, other studies showed that local hot spots of exposure may also be created in such locations as a result of the multipath propagation of RF-EMF. Together, this is significant in the context of the safety of the vulnerable population, such as individuals with medical implants and users of telemedicine body worn sensors, because it may cause local hot spot overexposure with respect to the limit of radio frequency exposure, which may influence the function of electronic devices. In order to avoid medical device malfunction, it is usually recommended to maintain a distance from the transmitting terminals (handsets) greater than 1 meter....

It is also important to keep in mind that the rapidly developing mobile communication services are including continuously higher frequencies – AM and FM radio transmissions initially operated at kHz and MHz frequencies

and analogue radiophones and cellular phones started from frequencies 27–450 MHz, whereas today's digital cellular phones use frequencies up to 2.2 GHz and wireless internet access explores frequencies up to almost 6 GHz, where the next generation of cellular phones is also going to be. Even much higher frequencies are explored by radio links, almost up to 100 GHz.

LOW-LEVEL THERMAL SIGNALS: AN UNDERSTUDIED ASPECT OF RADIO FREQUENCY FIELD EXPOSURES WITH POTENTIAL IMPLICATIONS ON PUBLIC HEALTH

By Lucas A. Portelli. Chapter 6: 129-162.

Abstract

Protection from the hazards of radio frequency (RF) fields is currently aimed at confining the RF-induced thermal changes in tissue to within limits which are currently considered as safe. In this regard, hazardous effects of such exposures are traditionally investigated, catalogued, and interpreted from a perspective based on presumably adequate approximations and assumptions that simplify several dosimetric and biological aspects. While these simplifications are certainly useful and convenient, they tend to obscure the existence of dosimetric artifacts and subtle biological responses which may be of relevance to human health when observed from the microdosimetric or chronic perspectives. Increasingly realistic human models, for example, can unveil the existence of localized hot-spots and thermal transients which are invisible when using simpler models or space and time averaging as is customary for the safety regulatory practice. This results in exposures which can be in reality many times greater than the supposed and reported exposures. Similarly, from the biological perspective, the classical thermal hazard paradigm assumes that thermal damage only occurs after certain relatively high temperatures are reached for short amounts of time, inducing safety regulations to limit rather acute thermal exposures accordingly. However, while this perspective is practical and apparently sufficient to protect the population under the current paradigm, it is impervious to the possibility of the existence of the effects of chronic exposures to low-levels of thermal challenges. Such exposures may cause small amounts of thermal damage directly or indirectly (e.g., via the stimulation of compensatory physiological reactions) which may add up over time.

In this regard, one must recognize that localized thermal transients (collections of which form Thermal Signals) are an unavoidable result of exposure to modulated RF fields, even if the exposure is within the limits which are currently considered as safe. One can contemplate, for example, how such a thermal signal can appear when tissue is exposed to an intermittent RF field (e.g., ...on-off-on-off...) as the deposited heat is actively or passively redistributed by physical or physiological means throughout the organism and back into the environment. The fact that such signals are inherent to RF exposures alone makes the studying of their biological effects a necessity to guarantee human safety. Nevertheless, at present, the possibility of biological effects of thermal signals is not mentioned, contemplated or investigated since they are deemed inconsequential under the current paradigm. Yet, sensitivity to minute thermal changes is an inherent aspect of physicochemical laws which govern the dynamics and function of biochemical reactions and structures. Such structures and reactions can potentially act as transducers of thermal signals into the cellular processes, which may translate into biological and ultimately health effects. Consequently, the study of thermal signals may open a myriad of possibilities for noninvasive, nonchemical interaction with biochemical signals at the cellular level which may have broad implications in the scientific, industrial, regulatory, and therapeutic arenas.

Conclusions

It is an undeniable fact that complex biological systems, from the molecular to the full organism level, are built around very rigorous thermal specifications making them very sensitive and responsive to small temperature changes in their internal or external vicinity. Hence, thermal signals which are invariably linked to the imposition of RF fields have the potential to be accompanied by compensatory biochemical responses from tissue at a local or global level in the organism. Such thermal signals might initially have modest effects on biochemical reactions and structures, however, these effects may then be amplified by the biological system into relevant biological and health effects.

From the public health perspective, a necessary question to answer is: what are the biological effects of chronic exposures to low-level thermal signals and what are the relative health risks? (i.e., compared to a smoking certain number of cigarettes a day, for example). However, to date, our currently poor understanding about the true biological relevance of thermal signals is insufficient to draw useful scientific conclusions which can affect decisions, recommendations, and policy to protect the public from potential hazards. In fact, the amount of data available is much less than would be considered the bare minimum. How “small” a thermal signal is can only be judged from a biological system perspective by generating the appropriate set of experiments and interpreting them from a paradigm that includes this possibility. While, in essence, the characteristics of this thermal signal will be a result of the antagonistic thermal processes (heat-in versus heat-out) specific to the details of the exposure, the need for consideration of the effects from the cellular spatio-temporal scale might require significant amounts of effort and complications. However, such apparent complications, in return, may hold substantial scientific, industrial, and therapeutic potential at best or understanding of realistic safety thresholds at worst.

Therefore, in view of the pervasiveness and potential relevance of low-level thermal signals, the paradigm centered around the notion of a “thermal damage threshold” on which the current safety standards and recommendations for mobile communications are currently

based might be incomplete. For this reason alone, basic research in this area is imperative. Therefore, scientists and executives who are seriously concerned about the implications of mobile communications on public health must consider directing their scientific resources towards unveiling the true biological relevance of RF-induced small thermal signals to such a degree as these are directed towards the study of RF-induced “thermal” and “nonthermal” effects. In this regard, thermal signals may not only appear as a secondary effect in other instances of intermittent energy deposition (ultrasound or light), but it could also be purposely generated to achieve therapeutic levels, should these exist....

HOW CANCER CAN BE CAUSED BY MICROWAVE FREQUENCY ELECTROMAGNETIC FIELD (EMF) EXPOSURES: EMF ACTIVATION OF VOLTAGE-GATED CALCIUM CHANNELS (VGCCS) CAN CAUSE CANCER INCLUDING TUMOR PROMOTION, TISSUE INVASION, AND METASTASIS VIA 15 MECHANISMS

By Martin L. Pall. Chapter 7: pp. 163-186.

Abstract

Thirty reviews each argue that microwave frequency electromagnetic fields (EMFs) can and do cause cancer. These conclusions should be definitive and are further buttressed by the National Toxicology Program study on 2G cell phone radiation. However, there are still claims that there cannot be a mechanism for EMF cancer causation. Such EMFs are known to act via voltage-gated calcium channel (VGCC) activation and consequent downstream increases in intracellular calcium $[Ca^{2+}]_i$ and peroxynitrite/free radicals/oxidative stress. Fifteen mechanisms are discussed here whereby these downstream effects can cause cancer. These include single strand and double strand DNA breaks and oxidized DNA bases; increased ornithine decarboxylase; lowered melatonin; increased NF-kappa B; increased tumor promotion via degradation of gap junction proteins; increased tumor promotion via DNA breaks/gene amplification; increased tissue invasion and metastasis via increased tight junction protein degradation; increased CaMKII via protein oxidation; calcium produced increased CaMKII; calcium-dependent phosphatidylserine flippase; c-src activation by calcium/calmodulin; calcium increased cellular oncogene transcription; calpain activation of tumor migration, tissue invasion, and metastasis. These 15 mechanisms and reviews on calcium roles in cancer causation together show that EMFs acting via VGCC activation can cause cancer initiation, promotion, and progression. We have, therefore, a large number of mechanisms by which microwave frequency EMFs can cause cancer.

Conclusions

This paper is based on three important findings. First, that microwave and lower frequency EMFs act via activation of VGCCs. Second, 29 different reviews have concluded that such EMFs cause cancer, raising the question of how VGCC activation can cause cancer. Third, because VGCC activation acts mainly via increased $[Ca^{2+}]_i$, it is reasonable to assume that cancer causation occurs via increased calcium signaling and via other downstream effects of $[Ca^{2+}]_i$. This paper finds that there are multiple mechanisms that fit each of these two descriptions that cause cancer based on the cancer literature. Many of them come from the downstream effects involving the peroxynitrite/free radical/oxidative stress pathway and one of the important consequences of that pathway, elevated NF-kappa B. Those downstream effects are similar or identical to the effects that are central to inflammatory carcinogenesis in the

literature. But, in addition, there are cancer causing effects that are caused by excessive calcium signaling and these are also discussed here.

These mechanisms are listed below. Mechanisms 1–6 are all reported to be raised following EMF exposures and are, therefore, particularly plausibly involved in EMF-caused carcinogenesis. Each of these 15 is produced as a consequence of either the peroxynitrite/free radical/oxidative stress pathway of action of as a consequence of excessive calcium signaling. Each is, therefore, highly plausible because each of these pathways of action are well documented downstream effects of EMF exposures....

We have, then, 15 well-documented mechanisms by which EMFs acting via VGCC activation can cause cancer. It is complete and utter to nonsense, therefore, to claim there are no such mechanisms.

A SUMMARY OF RECENT LITERATURE (2007–2017) ON NEUROBIOLOGICAL EFFECTS OF RADIO FREQUENCY RADIATION

By Henry Lai. Chapter 8: 187-222.

Abstract

Neurological effects are caused by changes in the nervous system. Factors that act directly or indirectly on the nervous system causing morphological, chemical or electrical changes in the nervous system can lead to neurological effects. The final manifestation of these effects can be seen as psychological/behavioral changes, for example, memory, learning, and perception. The nervous system is an electrical organ. Thus, it should not be surprising that exposure to electromagnetic fields could lead to neurological changes. Morphological, chemical, electrical, and behavioral changes have been reported in animals and cells after exposure to nonionizing electromagnetic fields (EMF) across a range of frequencies. The consequences of physiological changes in the nervous system are very difficult to assess. We do not quite understand how the nervous system functions and reacts to external perturbations. The highly flexible nervous system could easily compensate for external disturbances. On the other hand, the consequence of neural perturbation is also situation-dependent. For example, an EMF-induced change in brain electrical activity could lead to different consequences depending on whether a person is watching TV or driving a car.

Conclusions

1. A major concern is that in some of the studies, details of the exposure setup and dosimetry are not provided. This is important since details of the independent variables are very important in interpreting the validity of the experimental results, that is, dependent variables. In many of these studies, a cell phone was used in the exposure of animals and humans. But information on how the cell phone was activated, in many instances, was not provided. Thus, the amount of energy deposited in the body was not known....

2. Most of the studies were carried out with relatively high levels of RFR compared to environmental levels. However, if you look through the narratives, there are studies that reported effects at very low level, for example, Bak et al., (2010). Indeed, biological/health effects of RFR at levels much lower than most international RFR-exposure guidelines, for

example, International Commission on Non-ionizing Radiation Protection (ICNIRP), have been reported (see table 1 in Levitt and Lai, 2010). This raises the question on whether the guidelines used in most countries nowadays are actually obsolete and new exposure guidelines have to be set.

3. Thus, there is ample evidence that RFR exposure affects the nervous system from both acute and long-term exposure experiments. Brain electric activities, nerve cell functions and chemistry, and behavior can be affected. Some explanatory mechanisms for these effects have emerged. One consistent finding is that animals exposed to RFR suffered from memory and learning deficits. These effects can be explained by the results of numerous reports that showed RFR affected the hippocampus, a brain region involved in memory and learning. However, the location and configuration of the human hippocampus are quite different from those of a rodent. There have not been many studies on the effect of RFR on the human hippocampus. Several studies did report deficits in memory in human subjects exposed to RFR, particularly on short-term memory, a function specifically related to the hippocampus....

4. Another very consistent finding is that RFR affects free radical metabolism in the brain. This may explain some of the cellular and physiological effects of RFR on the nervous system. As a matter of fact, oxidative changes in cells and tissues after exposure to FR is a very common phenomenon (cf. Yakymenko et al., 2016). This happens in many organs of the body and can provide explanation of many reported biological effects of RFR.

5. Many of the effects of RFR on the nervous system, for example, on the hippocampus, oxidative effects, and behavioral effects are also observed with exposure to extremely low frequency electromagnetic field (cf. my section on the neurological effects of ELF EMF in the Bioinitiative Report, www.bioinitiative.info/bioInitiativeReport2012.pdf). There has been speculation whether biological effects observed with low frequency modulated RFR were actually caused by the modulation. There are two reports published in the last decade that seemed to refute this hypothesis. Another question is whether one type of modulation is different from another in causing biological effects. Cell phone technology advances from one generation to another. Do the research data of a 3G phone apply to 4G or 5G phone radiation? RFR is a complex entity. Its biological effects depend on many of its physical properties, for example, frequency, direction of the incident waves relative to the object exposed, dielectric properties, size and shape of the exposed object, polarization of the waves, and so on. Thus, it is unlikely that one can easily extrapolate the effects from one form of RFR to another. An assumption that 3G radiation is safe does not necessary imply that 5G radiation is safe. Each one of them has to be investigated separately.

6. An important area of research is on how RFR in the environment affects humans and wildlife. Environmental RFR level has become higher and higher over the past decades due to the employment of RFR wireless devices. Take the example of Bak et al. (2010) mentioned above, an effect on human event-related brain potential was reported after 20 min of exposure to a GSM signal at a power density of 0.0052 mW/cm². This is very close to the levels found in some cities. The highest power density of ambient RFR measured near schools and hospitals in Chandigarh, India, was reported to be 0.001148 mW/cm² in 2012 (Dhami, 2012). The maximum total RFR power density emitted by FM and TV broadcasting stations and mobile phone base stations in centers of the major cities in the West Bank-Palestine was

0.00386 mW/cm² (Lahham and Hammash, 2012). One also has to take into consideration that exposure in the Bak et al. (2010) study was acute (20 min), whereas environmental exposure is chronic. Related to the neurological effect is the magnetic sense possessed by many species of animals. It is essential for their survival. Interference by RFR of magnetic compass orientation in animals has been reported (e.g., Landler et al., 2015; Malkemper et al., 2015; Pakhomov et al., 2017; Schwarze et al., 2016; Vácha et al., 2009). Understanding the effects could help in preserving the ecosystem and ensure survival of the species on this earth.

RADIOBIOLOGICAL ARGUMENTS FOR ASSESSING THE ELECTROMAGNETIC HAZARD TO PUBLIC HEALTH FOR THE BEGINNING OF THE TWENTY-FIRST CENTURY: THE OPINION OF THE RUSSIAN SCIENTIST

By Yury G. Grigoriev. Chapter 9: 223-236.

Abstract

Over the past 25 years, there has been a global distribution of wireless communications which has significantly changed the electromagnetic pollution of the external environment and the methodology for assessing health risks for all population groups. In these difficult conditions, many specialists have neglected radiobiological concepts, for example, the concept of a critical organ or critical system, the possibility of accumulating adverse effects, and the determination of residual damage (remote consequences). Almost daily life-long exposure of the RF EMF to the brain has not received attention. In many countries, there is complete disregard for the precautionary principle proposed by the WHO. Children for the first time in the entire period of civilization should be included in the risk group. Even before the era of the development of mobile communications, there were significant differences in the guidelines and standards for radio frequency radiation in the radio frequency range. This paper demonstrates the significance of biological responses to the nonthermal low RF EMF. Therefore, scientists should stand firm in this “electromagnetic chaos” in the habitat of the population.

Conclusions

At present, there are no unified approaches to assessing the health hazards of the RF EMF of mobile communications. There is a wide variation in the permissible RF EMF levels. The possibility of developing long-term consequences is underestimated. The technical solutions for the creation of new types of wireless communication outrun scientific research to assess the danger to the public. The precautionary principle is ignored when placing base stations. There is a desire to ensure that all schools use Wi-Fi.

The large spread, uncontrolled, use of this connection by all groups of the population, including children, continues although the mobile phone is an open source of radiation, and the critical body is the user's brain.

A LONGITUDINAL STUDY OF PSYCHOPHYSIOLOGICAL INDICATORS IN PUPILS USERS OF MOBILE COMMUNICATIONS IN RUSSIA (2006–2017): CHILDREN ARE IN THE GROUP OF RISK

By Yury G. Grigoriev, Natalia I. Khorseva. Chapter 10: 237-252.

Abstract

The human brain is exposed to electromagnetic fields of the radio frequency range (RF EMF) constantly, around the clock, from the base stations. The decision of the IARC in 2011 has determined social and ethical problems for society and for scientists—the definition of risk for the population, including children. Children are the most active group of mobile communication users. Unfortunately, the current assessment of the impact of RF EMF on the children's brains through questionnaires conducted in epidemiological studies is not convincing. The chronic impact of RF EMR, including the radiation of mobile phones on the bodies of children and adolescents, in particular on their psychophysiological and cognitive functions, have not been studied.

This publication presents the results of a longitudinal study of the psychophysiological indicators of children and teenage mobile communication users conducted in Russia from 2006 to present. The patterns of the negative influence of mobile phone radiation on the auditory and visual system, fatigue and performance, and on the parameters of attention and memory are established. The undeniable advantage of these studies is not only the presence of a control group, but also the development and implementation of preventive measures to reduce the negative impact of mobile phone radiation.

Conclusions

...So, the longitudinal changes in the psychophysiological indicators of children who use mobile phones convincingly show that chronic exposure to electromagnetic radiation from a mobile phone may negatively affect the central nervous system of the child:

- 1.The reaction time to sound and light stimuli is increased;
- 2.There is an increase in the number of violations of phonemic perception and the number of missed signals when a sound stimulus is presented;
- 3.Indicators of arbitrary attention and semantic memory deteriorate;
- 4.There are increased parameters of fatigue and decreased parameters of working capacity

It should be especially noted that in most cases in children who are active users of mobile communication, changes in psychophysiological indicators either were within the lower limit of the norm or already go beyond it....

It was found that the safe mode of use (headphones, speakerphone, use of SMS, MMS) statistically significantly improve ALL psychophysiological indicators.

We believe that the results of our longitudinal observations clearly show that the RF EMF from mobile phones affects psychophysiological indicators of children and adolescents.

Based on our results, it can be confidently affirmed that children are located in the group at risk. It should be recognized and the efforts of the scientific community to reduce the risk of adverse effects on the organisms of children should be made. One of the possible ways of reducing the impact of electromagnetic fields on children is an understanding of the dangers by the parents and children, the use of mobile communication, and a voluntary choice of the form of communication, that is, the introduction of the concept of “voluntary risk.”

EFFECTS OF RF-EMF ON THE HUMAN RESTING-STATE EEG—THE INCONSISTENCIES IN THE CONSISTENCY. PART 1: NON- EXPOSURE-RELATED LIMITATIONS OF COMPARABILITY BETWEEN STUDIES

Danker-Hopfe H, Eggert T, Dorn H, Sauter C. Effects of RF-EMF on the Human Resting-State EEG—the Inconsistencies in the Consistency. Part 1: Non-Exposure-Related Limitations of Comparability Between Studies. Bioelectromagnetics. Published online June 18, 2019. <https://doi.org/10.1002/bem.22194>

Abstract

The results of studies on possible effects of radiofrequency electromagnetic fields (RF-EMFs) on human waking electroencephalography (EEG) have been quite heterogeneous. In the majority of studies, changes in the alpha- frequency range in subjects who were exposed to different signals of mobile phone-related EMF sources were observed, whereas other studies did not report any effects. In this review, possible reasons for these inconsistencies are presented and recommendations for future waking EEG studies are made. The physiological basis of underlying brain activity, and the technical requirements and framework conditions for conducting and analyzing the human resting-state EEG are discussed. Peer-reviewed articles on possible effects of EMF on waking EEG were evaluated with regard to non-exposure-related confounding factors. Recommendations derived from international guidelines on the analysis and reporting of findings are proposed to achieve comparability in future studies. In total, 22 peer-reviewed studies on possible RF-EMF effects on human resting- state EEG were analyzed. EEG power in the alpha frequency range was reported to be increased in 10, decreased in four, and not affected in eight studies. All reviewed studies differ in several ways in terms of the methodologies applied, which might contribute to different results and conclusions about the impact of EMF on human resting-state EEG. A discussion of various study protocols and different outcome parameters prevents a scientifically sound statement on the impact of RF-EMF on human brain activity in resting-state EEG. Further studies which apply comparable, standardized study protocols are recommended.

Open access paper: <https://onlinelibrary.wiley.com/doi/full/10.1002/bem.22194>

RELATIONSHIP BETWEEN THE USE OF ELECTRONIC DEVICES AND SUSCEPTIBILITY TO MULTIPLE SCLEROSIS

Khaki-Khatibi F, Nourazarian A, Ahmadi F, Farhoudi M, Savadi-Oskouei D, Pourostadi M, Asgharzadeh M. Relationship between the use of electronic devices and susceptibility to multiple sclerosis. *Cogn Neurodyn*. 2019 Jun;13(3):287-292. doi: 10.1007/s11571-019-09524-1.

Abstract

Multiple sclerosis (MS) is an autoimmune condition influenced by both genetic and environmental factors. Dirty electricity generated by electronic equipment is one of the environmental factors that may directly or indirectly impact MS susceptibility. The current Study aimed to evaluate the relationship between the usage time of electronic equipment and susceptibility to MS in North-West Iranian people. This approach was carried out upon 471 MS-diagnosed patients and 453 healthy participants as control group in East Province of Azerbaijan. By utilizing structured questionnaires, the information of all participants about usage status of some electronic devices was obtained. Data were analyzed by IBM SPSS Statistics version 18.0 and the quantitative variables were analyzed by Chi Square and Independent sample t tests. P values below or equal to 0.05 were considered as significant. Among the evaluated items in this approach, the utilization of cell phones and satellite television dishes were significantly higher in MS patients ($p < 0.001$, $p = 0.07$). Furthermore, a correlation was observed between sleeping with cell phone and/or laptop under the pillow ($p = 0.011$) and MS disease; however, there was no significant differences between MS patients and controls in computer using and television watching. Our study reinforces the concept that the utilization of some electronic devices and the continuous exposure to dirty electricity would increase the risk of MS disease thereupon by enhancing the cognizance of adverse effects of dirty electricity and reducing the time spent over electronic devices during adolescence and adulthood the occurrence probability of MS could be declined.

<https://www.ncbi.nlm.nih.gov/pubmed/31168332>

ELECTROMAGNETIC EXPOSURE FROM MOBILE PHONES IN A CITY LIKE ENVIRONMENT: THE CASE STUDY OF LEUVEN, BELGIUM

Ilyare RN, Volskiy V, Vandenbosch GAE. *Environmental Research*. Available online 26 May 2019. <https://doi.org/10.1016/j.envres.2019.05.029>

Highlights

- Mobile phone (MP) exposure values are far above the exposures due to base stations.
- MP exposure is considerably higher for indoor environments compared to outdoor.
- Exposure is lower for locations close to base stations than locations further away.
- All exposures are in compliance with the SAR limit recommended by ICNIRP.

Abstract

A measuring campaign for the assessment of electromagnetic exposure levels from mobile phones in the city center of Leuven, Belgium, has been carried out. The main objective of the assessment is to study the dependency of the exposure of the user by his own mobile phone in terms of location in the city (very close to base stations and at randomly selected locations).

The measurements were performed in both public and private areas in 60 outdoor and 60 indoor locations in Leuven. The campaign was focused on GSM 900 mobile communications. The results show that the exposure is considerably higher for indoor environments compared to outdoor environments, and at the randomly chosen locations compared to locations very close to base stations. However, the most important observation is that the average outdoor exposure in Leuven of the user of a mobile phone is about 8 times higher than the average outdoor exposure by base stations. Indoors, this factor rises to about 30.

Excerpts

All results obtained in this measurement campaign are for a mobile phone with an active connection (a voice call). Field values were obtained through an app installed on a mobile phone. The app called Quanta pro [48] (shown in Figure 1) gets active (records the emissions from the mobile phone) immediately when a call is made with the mobile phone. This means that RF exposures were obtained during typical phone usage. During the exposure measurement, the mobile phone user makes a phone call of six minutes duration at a specific point in the measurement environment while the app concurrently keeps track of the power values transmitted by the antenna of the mobile phone.

Conclusions:

The electromagnetic radiation exposure from mobile phones operating under GSM 900 in a typical city center, Leuven, Belgium, was assessed using a calibrated app installed on a representative mobile (smart) phone. The calibration was performed with a highly accurate spectrum analyzer based set-up. The levels averaged over the city center are: outdoors about 5.54 and 6.18 V/m for locations near base stations and arbitrarily chosen locations, respectively, and indoors about 10.36 and 30.87 V/m, also for locations near base stations and arbitrarily chosen locations, respectively. To the average, near base stations the indoor exposure is about a factor of two higher than the outdoor exposure. This smaller factor is due to the fact that the indoor exposure was measured at higher floors of buildings. At arbitrary locations the indoor exposure is about a factor of five higher than the outdoor exposure. These measurements were always done at floor level. All measured values are far above the values typically measured for the exposure due to base stations, even far above the maximum exposure level defined in the norm in Flanders, which is 3 V/m per antenna at 900 MHz. It can easily be concluded that the deployment of infrastructure, typically in the form of microcells, hotspots or distributed relays, should aim at minimizing mobile phone exposure and not necessarily the exposure by the base station itself. This may require a paradigm shift in the public opinion.

<https://www.ncbi.nlm.nih.gov/pubmed/31154230>

PERSONAL RF-EMF EXPOSURE FROM MOBILE PHONE BASE STATIONS DURING TEMPORARY EVENTS

Ramirez-Vazquez R, Gonzalez-Rubio J, Arribas E, Najera A. Personal RF-EMF exposure from mobile phone base stations during temporary events. *Environ Res.* 2019 May 21;175:266-273. doi: 10.1016/j.envres.2019.05.033.

Abstract

BACKGROUND:

In recent years, radiofrequency electromagnetic fields (RF-EMF) exposure has increased owing to new communication technologies. Simultaneously, increased exposure to RF-EMF has led to society's growing concern about the possible effects they may have on human health. Many studies have described personal RF-EMF exposure by using personal exposimeters to know a population's daily exposure to mobile phone base stations and to other sources whose installations tend to be permanent. Nonetheless during special events like concerts or fairs, where many people gather, permanent installations might not suffice to cover demand. So telephone companies install temporary stations for these events, and modify the exposure pattern of these areas or populations.

OBJECTIVE:

To study if installing temporary antennae for large events, and high concentrations of mobile phones, modify the exposure pattern compared to usual situations.

METHODS:

Personal RF-EMF exposure from mobile phones (uplink) and mobile phone base stations (downlink) installed at the 2017 Albacete Fair (Spain) was recorded. Between 7 and 17 September, more than 2,500,000 people visited this Fair. Measurements were taken by two Satimo EME SPY 140 personal exposimeters, placed one each side of a research team member's waist. These exposimeters were programmed to take measurements every 4 s at different time of day; morning, afternoon and night; and in several places, around the Fair Enclosure (zones Ejidos and Paseo) and inside the enclosure (Interior). These measurements were repeated on a weekday, at the weekend and the day after the Fair ended after temporary base stations had been removed. They were also taken for 1 h in all three zones, for each time of day; that is, 9 h were recorded for each study day.

RESULTS:

The mean RF-EMF recorded exposure from base stations (downlink-DL) on the days the Fair opened (morning, afternoon and night) for the three studied zones was 791.8 $\mu\text{W}/\text{m}^2$, while the exposure produced by mobile phones (uplink-UL) was 59.0 $\mu\text{W}/\text{m}^2$. These values were 391.2 $\mu\text{W}/\text{m}^2$ (DL) and 10.3 $\mu\text{W}/\text{m}^2$ (UL) a few days after the event ended. In study zones Ejidos and Paseo, both outside, the highest mean exposure was recorded at the weekend as 1494.1 and 848.1 $\mu\text{W}/\text{m}^2$ respectively. For the Interior zone, the mean value recorded during the Fair was 354.8 $\mu\text{W}/\text{m}^2$. These values contrast with those recorded in the three zones after the event ended: 556.37 (Ejidos), 144.1 (Paseo); 473.21 $\mu\text{W}/\text{m}^2$ (Interior). The fact that the mean exposure recorded at Interior was slightly higher after the Fair could be due to signal shielding by so many people. The reduction in exposure in Paseo after the Fair was

outstanding, probably due to the antennae being placed on low towers. Major differences were also found in the RF-EMF exposure from UL. In this case, the weekend values taken during the Fair were between 28.2 $\mu\text{W}/\text{m}^2$ at Interior (weekday) and 98.1 $\mu\text{W}/\text{m}^2$ at Ejidos (weekend), which dropped to 5.5 at Paseo after the Fair, to 11.7 $\mu\text{W}/\text{m}^2$ at Interior and to 13.6 $\mu\text{W}/\text{m}^2$ at Ejidos.

CONCLUSIONS: Installing mobile phone base stations, and a dense public using mobile phones, imply a significant increase in personal RF-EMF exposure compared to that recorded during normal periods in the same area. However, the recorded measurements were below legally established limits.

<https://www.ncbi.nlm.nih.gov/pubmed/31146098>

EMISSIONS FROM SMART METERS AND OTHER RESIDENTIAL RADIOFREQUENCY SOURCES

Aerts S, Verloock L, Van den Bossche M, Martens L, Vergara X, Joseph W. Emissions From Smart Meters and Other Residential Radiofrequency Sources. *Health Phys.* 2019 Jun;116(6):776-788. doi: 10.1097/HP.0000000000001032.

ABSTRACT

The advent of the Internet of things comes with a huge increase in wirelessly communicating devices in our environment. For example, smart energy-consumption meters are being widely deployed in residences from which they communicate their state using radiofrequency networks. Accurate characterization of the radiofrequency emissions from emerging residential wireless solutions is important to inform the public about the potential impact on their exposure to radiofrequency electromagnetic fields. A new measurement

procedure to determine the exposure from residential radiofrequency devices is proposed by assessing the peak emitted fields at various distances and the proportion of time they transmit (duty cycle). Radiofrequency emissions from 55 residential devices were measured in 10 residences (Belgium and France) and compared to environmental levels, emissions from 41 mobile phones, and international standards. Overall, residential levels of radiofrequency electromagnetic field exposure are low. In addition to the continuous environmental exposure, wireless access points (due to frequent use) and especially mobile phones and other personal communication devices (due to their use close to the body) continue to represent the bulk of the radiofrequency electromagnetic field exposure in the smart home. However, some residential devices can significantly increase the exposure if their duty cycles are high enough (>10%), especially when held or used close to the body. Individual smart meters, on the other hand, will contribute only little in general, despite emissions of up to 20 V m at 50 cm, due to their low duty cycles (maximum 1%) and locations.

<https://www.ncbi.nlm.nih.gov/pubmed/30883437>

Conclusions

In this study, a novel measurement method was designed to characterize in situ residential RF emissions from emerging wireless solutions (e.g., IoT sources and smart meters) by determining the RF transmission frequency, the peak emitted fields at various distances, and the proportion of transmission time (i.e., duty cycle), for which the spectrogram mode of a spectrum analyzer was used. This method was applied to a convenience sample of 10

residences in Belgium and France containing, in total, 55 IoT devices, smart meters, and other RF-emitting devices. The measured emissions were also compared to present levels of telecommunications and broadcasting signals, emissions by a mobile phone using three current telecommunications technologies (GSM, UMTS, and LTE), as well as to the ICNIRP guidelines for general public RF-EMF exposure.

Overall, low to very low emissions were measured for nearly all of the devices, and it is concluded that, in addition to the continuous exposure due to environmental sources, when used, wireless access points and especially mobile phones and other personal communication devices (e.g., DECT cordless phones, walkie-talkies) will continue to represent the bulk of our exposure to radiofrequency electromagnetic fields in the smart home, due to their typically high emissions and use close to the body. However, RF-emitting devices with high duty cycles (e.g., in this sample, motion sensor, baby monitor, and an IoT toothbrush) may significantly increase the potential for exposure, especially when used or located close to the body. The potential impact on the exposure due to individual smart meters, on the other hand, and in particular due to the communications modules wirelessly linked to a utility company's central network, is small, regardless of their emissions of up to 20 V m⁻¹ at 0.2 m, given their rare transmissions and usual deployment away from the residents.

ASSESSMENT OF PERSONAL OCCUPATIONAL EXPOSURE TO RF EMF IN LIBRARIES AND MEDIA LIBRARIES, USING CALIBRATED ON-BODY EXPOSIMETERS

Massardier-Pilonchery A, Nerrière E, Croidieu S, Ndagijimana F, Gaudaire F, Martinsons C, Noé N, Hours M. *Int. J. Environ. Res. Public Health* 2019, 16(12), 2087; <https://doi.org/10.3390/ijerph16122087>.

Abstract

Background and Objectives: With the spread of Wifi networks, safety concerns have arisen, with complaints of somatic disorders, notably in traditional libraries and media libraries. The aim of the present study was to describe the conditions and levels of exposure to radiofrequency electromagnetic fields in the real-life occupational conditions of those working in traditional libraries and media libraries.

Methods: Dynamic measurements, using an exposimeter, were taken in 20 radiofrequency bands from 88 to 5850 MHz. The activity of 28 library workers was analyzed on a space-time budget. An audit of exposure sources and static measurements enabled the work-places to be mapped.

Results: In seven libraries, 78,858 samples were taken over the 20 radiofrequency bands from 88 to 5850 MHz. Exposure was described for 28 working days. The median total field was 0.071 V/m (10th percentile: 0.022 V/m, 90th percentile: 0.534 V/m) and for Wifi the median field was 0.005 V/m (10th percentile: 0.005 V/m, 90th percentile: 0.028 V/m). Median individual exposure to Wifi frequency waves ranged from 0.005 to 0.040 V/m.

Conclusions: Overall, the occupational exposure in this sector was close to the exposure in the general population. Peaks were due to the use of walkie-talkies by security staff. Exposure

due to external sources depended on geographic location. Exposure in this occupation is well below the general occupational exposure levels, notably as regards Wifi.

Conclusions :

The aim of this study was to assess electromagnetic exposure of employees in libraries, notably, to Wifi. On average, occupational exposure in this branch is close to that of the general population. The highest peaks were associated with walkie-talkie use by security staff. Exposure to outside sources depended on the geographic location. Employees' exposure was largely below the occupational norms, notably as regards Wifi. Static exposure from radiofrequency outdoor emissions (UMTS, GSM) and from indoor Wifi spots is found to be 10 times lower than electromagnetic limit values defined by ICNIRP.

The exposure of workers to electromagnetic fields is rarely explored by occupational practitioners due to a lack of methodology to perform this evaluation. The present methodology for describing exposure could be transposed to other occupational radiofrequency exposure contexts, given persisting doubts about the health risks involved and the current legislation.

What is New in This Paper?

Exposure to radiofrequency electromagnetic fields due to new technologies in the real-life occupational conditions in library and media libraries is not well characterized. This study finds an exposure close to the general population. However, high peaks were due to the use of walkie-talkies by security staff. Exposure due to external sources depended on geographic location.

Open access paper: <https://www.mdpi.com/1660-4601/16/12/2087/htm>

AN EXTREMELY SAFE LOW-SAR ANTENNA WITH STUDY OF ITS ELECTROMAGNETIC BIOLOGICAL EFFECTS ON HUMAN HEAD

Nazeri A, Abdolali A, Mehdi M. An extremely safe low-SAR antenna with study of its electromagnetic biological effects on human head. *Wireless Personal Communications*. 1-14. Published online May 17, 2019. <https://doi.org/10.1007/s11277-019-06621-6>

Abstract

In this paper, a new low-Specific Absorption Rate (SAR) antenna is proposed for the sake of safe communication in all situations. The proposed antenna involves a Microstrip patch antenna and a metallic casing loop which leads to SAR reduction. The structure operates at 0.9 GHz and 2.4 GHz which produces 0.52 W/kg and 0.25 W/kg SAR value on the human head, respectively. Then, in order to guarantee the antenna safety feature, the experiments are carried out when the human wear an earring. The impact of metallic earrings in different sizes on SAR distribution is investigated. Also, the antenna orientation and rotation effect is considered in detail. It is concluded that the change of Antenna position or use of metallic earrings makes an extremely significant impact on SAR value. But, the results of the presented antenna demonstrate that the produced SAR value in all positions, do not exceed the safe rate. It makes the antenna a suitable candidate for employing in most telecommunication applications.

Conclusions

In this paper, a novel low-SAR Microstrip Antenna for using in a safe communication is designed. The proposed antenna produces 0.52 W/kg and 0.25 W/kg SAR value on the head at 0.9 and 2.4 GHz. The antenna is created of a microstrip patch and a metallic loop. An extensive study is accomplished on the destructive effects of EM- waves on the human body. Also, the effect of the human head on the antenna performance is investigated. In addition, earrings with several different sizes are employed to consider the cases which make the worst destructive effect on the human head. The effect of antenna rotation and changes in its orientation is studied as well. It is concluded that antenna rotation causes a significant impact on SAR value when earrings are used. At last, this study guarantees that the presented antenna make a safe SAR for most of the situations.

<https://link.springer.com/article/10.1007/s11277-019-06621-6>

EFFECTS OF RADIOFREQUENCY EXPOSURE AND CO-EXPOSURE ON HUMAN LYMPHOCYTES: INFLUENCE OF SIGNAL MODULATION AND BANDWIDTH

Romeo S, Sannino A, Zeni O, Angrisani L, Mass R, Scarfi MR. Effects of radiofrequency exposure and co-exposure on human lymphocytes: The influence of signal modulation and bandwidth. IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology, May 20, 2019. DOI: 10.1109/JERM.2019.2918023

Abstract

The occurrence of modulation-specific effects after co-exposures to Radiofrequency (RF) and other agents has been discussed in the literature. In this paper, the influence of modulation and bandwidth in eliciting the DNA damage of RF alone and in combination with mitomycin-C (MMC), is analyzed in human lymphocytes. Blood cultures from healthy donors were exposed to 1950 MHz, and Continuous Wave (CW), Wideband Direct- Sequence Code Division Multiple Access (WCDMA, 4.5 MHz bandwidth), and Additive White Gaussian Noise (AWGN, 9 MHz bandwidth) signals were considered. For each signal, SAR values of 0.15, 0.3, 0.6, 1.25 W/kg were tested. RF exposure alone never induced DNA damage in the micronucleus assay. When RF exposure was followed by MMC treatment, the effect depended on modulation and bandwidth. CW exposure never altered the MMC-induced DNA damage, while such damage was reduced when either signals WCDMA at 0.3 W/kg SAR or AWGN at 0.15 and 0.3 W/kg were applied. These results indicate the influence of modulation for the occurrence of the protective effect, with a relation between the bandwidth and the power absorbed by samples.

If confirmed in vivo, clinical applications using modulated RF signals could be devised, to protect cells from side effects of therapeutic treatments. RF electromagnetic fields reduce the DNA damage induced by the chemical agent Mitomycin-C (MMC) in human lymphocytes. The effect is dependent on signal modulation and bandwidth.

Conclusions

The results of the present investigation provide further evidence that RF exposure can prompt a protective effect in mammalian cells against subsequent genotoxic insults. Moreover, in the current experimental conditions, taking advantage of a systematic comparison with the CW

exposure, our findings highlight the modulation scheme and the signal bandwidth as crucial factors for the occurrence of the protective effect.

Having said the above, if proved in in vivo models, a new research horizon lies ahead of us, as a potential, innovative clinical application of RF electromagnetic fields, exploiting the protective effect, could be proved. In radio-biology the AR phenomenon has been proposed as a way to protect healthy cells from side effects of chemo/radio-therapeutic treatments, by pre-treatments with low doses of ionizing radiation. However, such proposal never moved into clinical practice due to the risk of cellular transformation as a biological consequence of protracted, low-dose rate exposures to ionizing radiation [35]. The possibility of inducing AR by RF pre- treatments may overcome this issue, due to the non-ionizing nature of these fields. Moreover, RF-induced protection has been here proved to be a tunable phenomenon depending on the electromagnetic conditions adopted, which could be able to target different cell types located at different depths in the body. In addition, potential biomedical applications exploiting the protective effect of RF could benefit from the availability of commercially established, low-cost RF sources.

Take-Home Messages

The innovative feature of RF electromagnetic fields shown here, consists in offering protection to human cells against the damaging action of a chemical agent. The protective effect of RF electromagnetic fields occurs in presence of modulated signals and depends on signal bandwidth, as well as on SAR level. RF-induced protective effect has been here proved, on an in vitro model, to be a tunable phenomenon depending on the electromagnetic conditions adopted, which provides a step towards applications targeting cells located at different depths in the body. These findings suggest the existence of a complex interaction between modulated RF fields and biological systems. Such interaction becomes detectable when samples are appropriately sensitized, such as when RF exposure is combined with other chemical or physical treatments.

<https://ieeexplore.ieee.org/document/8718560>

THERMAL ANALYSIS COMPLEMENTARY TO STANDARDIZED EXPERIMENTAL DOSIMETRY OF SAR IN HUMAN HEAD

Ilie-Săndoiu AM, Morega M, Morega AM. Thermal Analysis Complementary to Standardized Experimental Dosimetry of SAR in Human Head. 2019 11th International Symposium on Advanced Topics in Electrical Engineering (ATEE). 28-20 March 2019. DOI: 10.1109/ATEE.2019.8724859

Abstract

Cellular phones (CPs) intensive, long-term usage may raise concerns regarding collateral effects such as hyperthermia through direct exposure to electromagnetic field, and direct thermal contact to the outer ear. Among other methods used to evaluate the thermal menace posed by CPs, the physical experiments, conducted on equivalent phantoms play an important role. Replacing the head content with biologically– equivalent fluid is considered to provide for satisfactory experimental conditions with the aim to assess realistic "specific

energy absorption rate" (SAR) levels and the pending thermal load. Moreover, numerical experiments may complement physical experiments, strengthening the predictive consistency of this already standardized lab approach. A numerical model of the human head and radiation source is designed and validated in compliance with experimental electromagnetic dosimetry standards with the aim of extending and processing useful information from limited experimental output. The current study goes further by exploring the heat absorption from the CP used nearby the head, making use of numerical simulation of the coupled electromagnetic and thermal problems, applied on models with varying degrees of realism. The analysis presented here concentrates on the assessment of cumulative contributions - energy absorption through SAR and direct contact with the heated CP device - on raising the temperature.

Conclusions

Present work shows some results from a numerical study performed on a phantom-like head model, the SAM head, described by international standards that are used for the certification of mobile phone devices [6], [7]. This benchmark numerical model was initially developed and validated through experiment for SAR dosimetry [8], but its applicability is extended here for heating estimates. A combined thermal dosimetry analysis is performed, taking two heating sources into account, i.e. the well-documented temperature rise from radiofrequency power absorption and additional warming from direct contact of the ear with the casing of the phone (heated by power dissipation inside the device). The results show a highly non-uniform distribution of the temperature inside the target volume, as much as a slight increase of the local temperature on the hot spots, due to the additional ear surface warming.

One could see that all the analysis was performed on a very simplified numerical model, if compared against true anatomy and functionality of the human head (i.e. non-homogeneous anatomical structure with specific physical properties and energy transfer under the influence of subtle physiology mechanisms – metabolism, blood perfusion); realistic conditions could bring substantial differences. However, the cumulative effect of the heating sources is a reality; it depends on the emitted power and complexity of the phone and operation conditions and it is commonly sensed during long conversations because it creates discomfort to the phone user. This aspect needs to be considered more carefully in the assessment of bio-thermal effects and human protection.

<https://ieeexplore.ieee.org/document/8724859>

EVALUATION OF THE EFFECT OF CELLULAR PHONES ON SALIVARY LEVELS OF IL-10

Pedrami A, Arbabi-Kalati F. Evaluation of the Effect of Cellular Phones on Salivary Levels of IL-10. Iran J Public Health. 2019 Feb; 48(2): 367–368.

No abstract.

Open access paper: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6556189/>

GLIOMA INCIDENCE AND SURVIVAL VARIATIONS BY COUNTY-LEVEL SOCIOECONOMIC MEASURES

Cote DJ, Ostrom QT, Gittleman H, Duncan KR, CreveCoeur T, Kruchko C, Smith TR, Stampfer MJ, Barnholtz-Sloan J. Glioma incidence and survival variations by county-level socioeconomic measures. Cancer. 2019 Jun 17. doi: 10.1002/cncr.32328.

Abstract

BACKGROUND: Multiple studies have reported higher rates of glioma in areas with higher socioeconomic status (SES) but to the authors' knowledge have not stratified by other factors, including race/ethnicity or urban versus rural location.

METHODS: The authors identified the average annual age-adjusted incidence rates and calculated hazard ratios for death for gliomas of various subtypes, stratified by a county-level index for SES, race/ethnicity, US region, and rural versus urban status.

RESULTS: Rates of glioma were highest in counties with higher SES (rate ratio, 1.18; 95% CI, 1.15-1.22 comparing the highest with the lowest quintiles [$P < .001$]). Stratified by race/ethnicity, higher rates in high SES counties persisted for white non-Hispanic individuals. Stratified by rural versus urban status, differences in incidence by SES were more pronounced among urban counties. Survival was higher for residents of high SES counties after adjustment for age and extent of surgical resection (hazard ratio, 0.82; 95% CI, 0.76-0.87 comparing the highest with the lowest quintile of SES [$P < .001$]). Survival was higher among white Hispanic, black, and Asian/Pacific Islander individuals compared with white non-Hispanic individuals, after adjustment for age, SES, and extent of surgical resection, and when restricted to those individuals with glioblastoma who received radiation and chemotherapy.

CONCLUSIONS: The incidence of glioma was higher in US counties of high compared with low SES. These differences were most pronounced among white non-Hispanic individuals and white Hispanic individuals residing in urban areas. Better survival was observed in high SES counties, even when adjusting for extent of surgical resection, and when restricted to those who received radiation and chemotherapy for glioblastoma. Differences in incidence and survival were associated with SES and race, rather than rural versus urban status.

Conflict of Interest Disclosures

Quinn T. Ostrom was supported by a Research Training Grant from the Cancer Prevention and Research Institute of Texas (RP160097T). Meir J. Stampfer has served as a paid expert witness for Verizon (represented by the Alston Bird Law firm) in a lawsuit regarding the alleged link between cell phones and brain cancer for work performed outside of the current study. The law firm and company had no knowledge of or influence on the current study. The other authors made no disclosures.

<https://www.ncbi.nlm.nih.gov/pubmed/31206646>

CONTROVERSIES AROUND ELECTROMAGNETIC FIELDS AND ELECTROMAGNETIC HYPERSENSITIVITY. THE CONSTRUCTION OF "LOW NOISE" PUBLIC PROBLEMS

Dieudonné M. [Controversies around electromagnetic fields and electromagnetic hypersensitivity. The construction of "low noise" public problems]. [Article in French] . Sante Publique. 2019 January February;Vol. 31(1):43-51. doi: 10.3917/spub.191.0043.

Abstract

For two decades, health effects of electromagnetic fields (EMF) and electromagnetic hypersensitivity (EHS) have become increasingly controversial topics in France. They constitute "low noise" public problems, whose construction seems impossible to complete : they can neither be eliminated from the political agenda nor durably included. This article analyses the political process leading to this situation using qualitative data. In line with previous studies of the dispute surrounding mobile phone base stations, it shows how the controversy around EMF health effects emerged from an urban planning problem subsequently converted into a public health issue. This conversion gave rise to a spin-off controversy surrounding EHS, which quickly grew to become a controversy of its own. The study of these controversies reveals how the democracy crisis affecting public risk management increases the risk of false health alarms. It also explains why EHS fails to get as medically recognized as other functional somatic syndromes, like fibromyalgia. Medically unexplained symptoms thus appear likely to contribute significantly to health controversies.

<https://www.ncbi.nlm.nih.gov/pubmed/31210515>

CHRONOTOXICITY OF 1.8 GHZ RADIO-FREQUENCY RADIATION ON PLASMA STRESS HORMONES AND IMMUNE FACTORS IN MICE

Qin F, Shen T, Li J, Xu B, Chen Y, Zheng ZA, Zou D. [Chronotoxicity of 1.8 GHz radio-frequency radiation on plasma stress hormones and immune factors in mice]. [Article in Chinese]. Wei Sheng Yan Jiu. 2019 May;48(3):482-487.

Abstract

OBJECTIVE: To study the chronotoxicity of radio-frequency radiation(RF) on the plasma stress hormones and immune factors in mice.

METHODS: A total of 72 healthy C57 BL mice with circadian rhythm were divided into twelve groups: 6 Sham group and 6 RF groups. RF groups were exposed to 1.8 GHz RF at 226 $\mu\text{W}/\text{cm}^2$ for 60 days with 2 h/day respectively at corresponding zeitgeber time(ZT 0:00, ZT 4:00, ZT 8:00, ZT 12:00, ZT 16:00, ZT 20:00). The Sham group mice were exposed to the same condition without electromagnetic signal. At the end of last RF exposure, blood samples were collected from each animal. The concentrations of plasma stress hormones(ACTH, CORT) and immune factors(GM-CSF, TNF- α) were determined by enzyme linked immunosorbent assay(ELISA) method.

RESULTS: The daily average levels of ACTH, CORT, GM-CSF and TNF- α were 84.12, 60.14, 1112.02 and 594.49ng/L, which were decreased to 62.07, 41.21, 84.18 and 305.08 ng/L after 60 days of RF exposure. Compared to sham-exposed animals, the daily average levels of ACTH, CORT, GM-CSF and TNF- α were all significantly decreased($P<0.05$). Circadian rhythms in the

secreting of CORT, GM-CSF, TNF- α were disappeared($P>0.05$), circadian rhythms of ACTH was shifted in RF-exposed mice, with the amplitude reduced from 12.45 to 4.88 and peak time postponed from 1:39 to 5:29.

CONCLUSION: 1.8 GHz RF may weaken the function of stress and immune, and disturb their circadian rhythmicities. <https://www.ncbi.nlm.nih.gov/pubmed/31133139>

SENSITIVITY OF EMF EFFECTS ON CHILDHOOD LEUKEMIA TO CONFOUNDING BY RESIDENTIAL MOBILITY

Amoon AT, Arah OA, Kheifets L. The sensitivity of reported effects of EMF on childhood leukemia to uncontrolled confounding by residential mobility: a hybrid simulation study and an empirical analysis using CAPS data. Cancer Causes Control. 2019 May 29. doi: 10.1007/s10552-019-01189-9.

Abstract

PURPOSE: Residential mobility is considered as a potential source of confounding in studies assessing environmental exposures, including in studies of electromagnetic field (EMF) exposures and childhood leukemia.

METHODS: We present a hybrid simulation study where we simulate a synthetic dataset based on an existing study and use it to assess the sensitivity of EMF-leukemia associations to different scenarios of uncontrolled confounding by mobility under two major hypotheses of the infectious etiology of childhood leukemia. We then used the findings to conduct sensitivity analysis and empirically offset the potential bias due to unmeasured mobility in the California Power Line Study dataset.

RESULTS: As expected, the stronger the assumed relationship between mobility and exposure and outcome, the greater the potential bias. However, no scenario created a bias strong enough to completely explain away previously observed associations.

CONCLUSIONS: We conclude that uncontrolled confounding by residential mobility had some impact on the estimated effect of EMF exposures on childhood leukemia, but that it was unlikely to be the primary explanation behind previously observed largely consistent, but unexplained associations.

<https://www.ncbi.nlm.nih.gov/pubmed/31144088>

AMPLITUDE-MODULATED RF EMF BLOCKS GROWTH OF HEPATOCELLULAR CARCINOMA VIA VOLTAGE-GATED CALCIUM CHANNELS AND CALCIUM ION INFLUX

Jimenez H, Wang M, Zimmerman JW, et al. , Blackman CF, Pasche BC. Tumour-specific amplitude-modulated radiofrequency electromagnetic fields induce differentiation of hepatocellular carcinoma via targeting Cav3.2 T- type voltage-gated calcium channels and Ca²⁺ influx. EBioMedicine. 2019 May 24. pii: S2352-3964(19)30342-1. doi: 10.1016/j.ebiom.2019.05.034.

Abstract

BACKGROUND: Administration of amplitude modulated 27.12 MHz radiofrequency electromagnetic fields (AM RF EMF) by means of a spoon-shaped applicator placed on the patient's tongue is a newly approved treatment for advanced hepatocellular carcinoma (HCC). The mechanism of action of tumour-specific AM RF EMF is largely unknown.

METHODS: Whole body and organ-specific human dosimetry analyses were performed. Mice carrying human HCC xenografts were exposed to AM RF EMF using a small animal AM RF EMF exposure system replicating human dosimetry and exposure time. We performed histological analysis of tumours following exposure to AM RF EMF. Using an agnostic genomic approach, we characterized the mechanism of action of AM RF EMF.

FINDINGS: Intrabuccal administration results in systemic delivery of athermal AM RF EMF from head to toe at levels lower than those generated by cell phones held close to the body. Tumour shrinkage results from differentiation of HCC cells into quiescent cells with spindle morphology. AM RF EMF targeted antiproliferative effects and cancer stem cell inhibiting effects are mediated by Ca²⁺ influx through Cav3.2 T-type voltage-gated calcium channels (CACNA1H) resulting in increased intracellular calcium concentration within HCC cells only.

INTERPRETATION: Intrabuccally-administered AM RF EMF is a systemic therapy that selectively block the growth of HCC cells. AM RF EMF pronounced inhibitory effects on cancer stem cells may explain the exceptionally long responses observed in several patients with advanced HCC.

FUND: Research reported in this publication was supported by the National Cancer Institute's Cancer Centre Support Grant award number P30CA012197 issued to the Wake Forest Baptist Comprehensive Cancer Centre (BP) and by funds from the Charles L. Spurr Professorship Fund (BP). DWG is supported by R01 AA016852 and P50 AA026117.

Open access paper: [https://www.ebiomedicine.com/article/S2352-3964\(19\)30342-1/fulltext](https://www.ebiomedicine.com/article/S2352-3964(19)30342-1/fulltext)

SYNERGISTIC EFFECT OF RADIOFREQUENCY EMF OF DENTAL LIGHT CURE DEVICES AND MOBILE PHONES ACCELERATES MICROLEAKAGE OF AMALGAM RESTORATIONS

Mortazavi SMJ, Dehghani Nazhvani A, Paknahad M. Synergistic Effect of Radiofrequency Electromagnetic Fields of Dental Light Cure Devices and Mobile Phones Accelerates the Microleakage of Amalgam Restorations: An in vitro Study. J Biomed Phys Eng. 2019 Apr 1;9(2):227-232.

Abstract

Background: Previous studies have shown that exposure to electromagnetic fields produced by magnetic resonance imaging or mobile phones can lead to increased microleakage of dental amalgam.

Objective: The aim of the present study was to investigate the effect of electromagnetic field of a commercial dental light cure device and a common GSM mobile phone on microleakage of amalgam restorations.

Materials and Methods: Identical class V cavities were prepared on the buccal surfaces of 60 non-carious extracted human teeth. The samples were randomly divided into 4 groups of 20 samples each. The samples in the first group were not exposed to electromagnetic fields, while the second and the third groups were exposed to electromagnetic fields produced by a commercial light cure device, or mobile phone radiation (60 min), respectively. The fourth group was exposed to electromagnetic radiations emitted by both mobile phone for 60 min and light cure device. Then, teeth samples were scored for microleakage according to a standard dye penetration protocol by examination under a stereomicroscope.

Results: The mean score of microleakage in the fourth group (light cure + mobile phone) was significantly higher than that of the control group ($P = 0.030$). Moreover, the scores of microleakage in this group were significantly higher than that of the second group (light cure only) ($P = 0.043$).

Conclusion: Exposure of amalgam restorations to electromagnetic fields produced by both light cure devices and mobile phones can synergistically increase the microleakage of amalgam restorations.

Open access paper: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6538905/>

SIGNIFICANT CELLULAR VIABILITY DEPENDENCE ON TIME EXPOSITION AT ELF-EMF AND RF-EMF IN VITRO STUDIES

García-Minguillán López O, Jiménez Valbuena A, 2 Maestú Unturbe C. Significant Cellular Viability Dependence on Time Exposition at ELF-EMF and RF-EMF In Vitro Studies. *Int. J. Environ. Res. Public Health* 2019, 16(12), 2085; <https://doi.org/10.3390/ijerph16122085>.

Abstract

The human concern about the effect of electromagnetic fields (EMFs) has changed over time from the effects produced by EMFs of extremely low frequencies (ELFs) to the effects produced by exposure to a radio frequency (RF), with concerns shifting toward EMFs due to the development of new technologies and forms of communication. Previous studies have analysed the effects produced at different frequencies without considering in detail the effect of the time of exposure. Therefore, in the present study, we analysed in vitro the effect produced by a 100 μ T EMF at different ELFs and exposure times in glioblastomas, as well as the effect produced in a fibroblast by an RF-EMF of 2.54 GHz. Our results indicate a significant time dependence in cell viability of fibroblasts exposed to an RF-EMF of 2.54 GHz and a non-time-dependent effect in cell viability of glioblastomas exposed to an ELF-EMF, highlighting the possible relation between frequency and time of exposure.

Conclusions

In most of the in vitro studies that have been done with EMFs, the time of exposure has not been considered in detail, even though cellular responses, such as cell proliferation, viability and death, clearly vary between chronic and acute exposure.

Our results demonstrate a time dependence of NIH/3T3 cell viability when exposed to an RF-EMF of 2.54 GHz, which decreases with time to obtain a 71.12% decline in viability after 21 h of exposure.

On the other hand, our results for an ELF-EMF of 100 μ T have demonstrated non-time-dependent effects. Frequency dependence effects were observed, obtaining a primary increase in cell viability at 50 Hz and a reduction in cell viability at 30 Hz, showing that even the recommended exposure level affects cell viability.

Therefore, the relationship between the frequency and time of exposure could determine the cellular response, demonstrating a need for further research.

Open access paper: <https://www.mdpi.com/1660-4601/16/12/2085/htm>

DNA EFFECTS OF LOW LEVEL OCCUPATIONAL EXPOSURE TO EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS (50/60 HZ)

Zendehdel R, Yu IJ, Hajipour-Verdom B, Panjali Z. DNA effects of low level occupational exposure to extremely low frequency electromagnetic fields (50/60 Hz).

Toxicol Ind Health. 2019 May 28;748233719851697. doi: 10.1177/0748233719851697.

Abstract

AIMS: Exposure to extremely low frequency magnetic fields (ELF-MF) occurs from natural and artificial sources. Although ELF-MF has been classified as a suspected humans carcinogen agent by the International Agency for Research on Cancer, little is known of the effects of ELF-MF at lower exposure levels of the recommended range. In the present study, DNA damage in the peripheral blood cells of power line workers was investigated.

MATERIALS AND METHODS: Occupational exposure to ELF-MF in a power plant was measured using the National Institute for Occupational Safety and Health (NIOSH) manual. Single-strand breaks (SSBs) in DNA were evaluated in 29 male utility workers as the exposed population and 28 male support personnel as the control subjects using the comet assay. Effects of ELF-MF on subjects were evaluated using DNA percent in tails, tail length, olive length, and tail moment.

RESULTS: Occupational exposure levels to ELF-MF in the utility workers were less than the threshold limit values (TLV) recommended by the American Conference of Government Industrial Hygienist (ACGIH). The median value of the magnetic field at the working sites was 0.85 μ T. Induction of DNA damage was observed for the exposed workers compared with the controls. Olive length, tail moment, and tail DNA percent increased significantly ($p < 0.05$) in the utility workers.

CONCLUSIONS: Exposure to ELF-MF at levels less than the ACGIH exposure limit can produce DNA strand breaks. <https://www.ncbi.nlm.nih.gov/pubmed/31138035>

IMPACT OF RF AND LEDS ON PLANTS GROWTH

Al Saadi A, ; Al Rashdi M, Al-Nassri H, Nadir Z, Khan M. Impact of RF and leds on plants growth. 7th Brunei International Conference on Engineering and Technology 2018 (BICET 2018). 12-14 Nov. 2018. DOI: 10.1049/cp.2018.1500.

Abstract

The agriculture sector is one of the most important sectors supporting the Gross National Product of many countries throughout globe. Improving the agricultural productivity with minimal natural resources is the possible solution to mitigate the worldwide food shortage. This paper discusses a new useful agricultural method by using electromagnetic fields to improve the seed germination and crop yields. Also, this study explored the possible impacts of LEDs with different colours to enhance seed germination. These applications may also have had a positive effect on increasing crop production in the longer term. This research focuses in studying the impact of electromagnetic field, red and blue LEDs on cucumber and marigold plants and analysing the plants after the application of these electromagnetic field treatments. The EM field was produced using RF transmitter of 2.4 GHz with horn antenna to expose the experiment plants to the maximum in order to get the best possible outcome.

Conclusion

Overall results exhibited that the exposure to electromagnetic field treatment yielded a slightly stressed environment, which affected the cucumber plant growth and especially marigold plants development. Increasing the electromagnetic field yielded to reduce plant length and flowering rate. Higher electrolyte leakage coupled with reduced plant growth may be a function of free radical processes. It has been reported earlier that free radicals are potentially detrimental in disrupting biological systems e. g. membrane (lipid peroxidation), DNA, proteins, damage. Apparently, our preliminary results showed similar mechanism of free radical process a source of abiotic stress factor in plants; however repeated experiments on diverse crops are underway to validate our initial results on marigold. The plants in different light boxes were affected with the heat produced by the LEDs. This factor should be taken seriously in any upcoming work with limited closed space. Also, the Biology or microscopic analysis is recommended to investigate it in more depth to conclude accordingly. The cucumber seeds inside the boxes did not germinate because of external effects (not related to our system) since even the seeds outside the boxes did not germinate.

<https://ieeexplore.ieee.org/document/8726925>

EFFECTS OF MOBILE PHONE EXPOSURE ON MAST CELLS IN RAT DURA MATER

Tumkaya L, Kalkan Y, Gokce FM, Erdivanli B, Yilmaz A, Bahceci I, Yazici ZA, Mercantepe T. The Effects of Mobile Phone Exposure on Mast Cells in Rat Dura Mater. *Int J Morphology*. 37(2):719-723. Jun 2019.

Abstract

Mobile phone use has increased rapidly. The central nervous system has been shown to be adversely affected by its electromagnetic field (EMF) resulting in headache and sleep disturbances. How the cells make up the CNS and are affected by EMF is unclear. However, because of their central role in inflammation through diverse stimuli including radiation, this study aimed to investigate the effects of electromagnetic fields induced by mobile phones on mast cells in rat dura mater. A total of 18 adult, female, Sprague-Dawley rats were divided into two groups. The choice of female rats for his study was based on recent surveys demonstrating that mobile phone use is more frequent and prolonged among females. The study group was exposed to 900 MHz electromagnetic field (1 h/day for 45 days). In the end of the study, duramater tissue was extracted and stained using Toluidine blue. Mast cells were counted and results were analysed using Student t test. Mean mast cell number was 202.33 +/- 982 and 456.78 +/- 35.01 in the control and study groups, respectively ($p < 0.05$). Analysis of serum electrolyte and immunoglobulin E levels showed no statistically significant difference between the two groups ($p > 0.05$). The study showed that mobile phone exposure increased mast cell number and degranulation in rat dura mater. Further studies are required to evaluate the clinical implications of these findings.

Open access paper: <https://scielo.conicyt.cl/pdf/ijmorphol/v37n2/0717-9502-ijmorphol-37-02-00719.pdf>

EFFECT OF EXTREMELY LOW-FREQUENCY (ELF) ELECTROMAGNETIC FIELDS ON MUSCULOSKELETAL DISORDERS AND ROLE OF OXIDATIVE STRESS

Hosseiniabadi MB, Khanjani N. The Effect of Extremely Low-Frequency Electromagnetic Fields on the Prevalence of Musculoskeletal Disorders and the Role of Oxidative Stress. *Bioelectromagnetics*. Published online June 18, 2019. <https://doi.org/10.1002/bem.22198>

Abstract

Extremely low-frequency electromagnetic fields (ELF-EMFs) may cause negative health effects. This study aimed to investigate the direct and indirect effects of chronic exposure to extremely low-frequency electric and magnetic fields on the prevalence of musculoskeletal disorders (MSDs).

In this cross-sectional study, 152 power plant workers were enrolled. The exposure level of employees was measured based on the IEEE Std C95.3.1 standard. Superoxide dismutase (SOD), catalase (Cat), glutathione peroxidase (GPx), total antioxidant capacity (TAC), and malondialdehyde (MDA) (independent variables) were measured in the serum of subjects. The Nordic musculoskeletal questionnaire was used to assess MSDs (dependent variable).

The mean exposure of electric and magnetic fields were 4.09 V/m (standard deviation [SD] = 4.08) and 16.27 μ T (SD = 22.99), respectively. Increased levels of SOD, Cat, GPx, and MDA had a direct significant relation with MSDs. In the logistic regression model, SOD (odds ratio [OR] = 0.952, P = 0.026), GPx (OR = 0.991, P = 0.048), and MDA (OR = 0.741, P = 0.021) were significant predictors of MSDs.

ELF-EMFs were not related to MSDs directly; however, increased levels of oxidative stress may cause MSDs. <https://onlinelibrary.wiley.com/doi/abs/10.1002/bem.22198>

EVIDENCE OF PLASMA MEMBRANE-MEDIATED ROS GENERATION UPON ELF EXPOSURE IN NEUROBLASTOMA CELLS

Merla C, Liberti M, Consales C, Denzi A, Apollonio F, Marino C, Benassi B. Evidences of plasma membrane- mediated ROS generation upon ELF exposure in neuroblastoma cells. *Biochim Biophys Acta Biomembr.* 2019 Jun 11. pii: S0005-2736(19)30137-3. doi: 10.1016/j.bbamem.2019.06.005.

Abstract

BACKGROUND: Molecular mechanisms of interaction between cells and extremely low frequency magnetic fields (ELF-MFs) still represent a matter of scientific debate. In this paper, to identify the possible primary source of oxidative stress induced by ELF-MF in SH-SY5Y human neuroblastoma cells, we estimated the induced electric field and current density at the cell level.

METHODS: We followed a computational multiscale approach, estimating the local electric field and current density from the whole sample down to the single cell level. The procedure takes into account morphological modeling of SH-SY5Y cells, arranged in different topologies. Experimental validation has been carried out: neuroblastoma cells have been treated with Diphenyleneiodonium (DPI) -an inhibitor of the plasma membrane enzyme NADPH oxidase (Nox)- administered 24 h before exposure to 50 Hz (1 mT) MF.

RESULTS: Macroscopic and microscopic dosimetric evaluations suggest that increased current densities are induced at the plasma membrane/extra-cellular medium interface; identifying the plasma membrane as the main site of the ELF-neuroblastoma cell interaction. The in vitro results provide an experimental proof that plasma membrane Nox exerts a key role in the redox imbalance elicited by ELF, as DPI treatment reverts the generation of reactive oxygen species induced by ELF exposure.

GENERAL SIGNIFICANCE: Microscopic current densities induced at the plasma membrane are likely to play an active physical role in eliciting ELF effects related to redox imbalance. Multiscale computational dosimetry, supported by an in vitro approach for validation, is proposed as the innovative and rigorous paradigm to unveil mechanisms underlying the complex ELF-MF interactions.

<https://www.ncbi.nlm.nih.gov/pubmed/31199897>

EXTREMELY LOW FREQUENCY ELECTROMAGNETIC RADIATION ENHANCED ENERGY METABOLISM AND INDUCED OXIDATIVE STRESS IN CAENORHABDITIS ELEGANS

Sun YY, Wang YH, Li ZH, Shi ZH, Liao YY, Tang C, Cai P. [Extremely low frequency electromagnetic radiation enhanced energy metabolism and induced oxidative stress in *Caenorhabditis elegans*]. [Article in Chinese] . Sheng Li Xue Bao. 2019 Jun 25;71(3):388-394.

Abstract

The aim of this study was to determine the effects of extremely low frequency electromagnetic field (ELF-EMF) on energy metabolism and oxidative stress in *Caenorhabditis elegans* (*C. elegans*). Worms in three adult stages (young adult stage, egg-laying stage and peak egg-laying stage) were investigated under 50 Hz, 3 mT ELF-EMF exposure. ATP levels, ATP synthase activity in vivo, reactive oxygen species (ROS) content, and changes of total antioxidant capacity (TAC) were detected, and worms' oxidative stress responses were also evaluated under ELF- EMF exposure. The results showed that ATP levels were significantly increased under this ELF-EMF exposure, and mitochondrial ATP synthase activity was upregulated simultaneously. In young adult stage, worms' ROS level was significantly elevated, together with upregulated TAC but with a decreased ROS-TAC score indicated by principal component analysis. ROS level and TAC of worms had no significant changes in egg-laying and peak egg-laying stages. Based on these results, we concluded that ELF-EMF can enhance worm energy metabolism and elicit oxidative stress, mainly manifesting as ATP and ROS level elevation together with ATP synthase upregulation and ROS-TAC score decrease in young adult *C. elegans*.

<https://www.ncbi.nlm.nih.gov/pubmed/31218329>

EFFECT OF LOW FREQUENCY ELECTROMAGNETIC RADIATION ON THE MORPHOLOGY OF DENTAL AND PERIODONTAL TISSUES

Markovskaya IV. The effect of low frequency electromagnetic radiation on the morphology of dental and periodontal tissues (experimental investigation). Wiad Lek. 2019;72(5 cz 1):773-778.

Abstract

OBJECTIVE: Low intensity electromagnetic effects possess a high biological activity, reduce the adaptive reserves of the body, impair immunity, adversely affect the functional state of the organs and body systems. The aim of the study was to identify in the experiment the effect of low-frequency electromagnetic radiation on the morphological state of the dental and periodontal tissue.

PATIENTS AND METHODS: The experiment was conducted on WAG rats weighing 180-200 g, during which two groups were formed: group 1 (control group) included 12 WAG rats, which were not performed any manipulations; the rats of group 2 (investigation group) (n=12) for 30 days were exposed to a 70 kHz low- frequency alternating electric field (5th frequency range) daily from 9.00 to 12.00. To simulate a low-frequency 70 kHz alternating electric field, certified experimental equipment was used. The study material was the upper jaw tissue. Histological and histochemical staining methods were used. Morphometric study was conducted.

RESULTS: Complex morphological study on the experimental material allowed identifying the damaging effect of low-frequency electromagnetic radiation on the structural components of tooth and periodontal tissues.

CONCLUSION: Our findings suggest that the workers who are exposed to occupational low-frequency electromagnetic radiation should be included in the risk group for developing diseases of the dentomandibular system in order to carry out timely therapeutic and preventive measures.

<https://www.ncbi.nlm.nih.gov/pubmed/31175771>

ARE INCREASES IN EMF IN THE HUMAN ENVIRONMENT INTERACTING WITH ENVIRONMENTAL POLLUTION THE TIPPING POINT FOR INCREASES IN NEUROLOGICAL DEATHS?

Pritchard C, Silk A, Hansen L. Are rises in Electro-Magnetic Field in the human environment, interacting with multiple environmental pollutions, the tipping point for increases in neurological deaths in the Western World? *Med Hypotheses*. 2019 Jun;127:76-83. doi: 10.1016/j.mehy.2019.03.018.

Abstract

Whilst humans evolved in the earth's Electro-Magnetic-Field (EMF) and sun-light, both being essential to life but too much sun and we burn. What happens if background EMF rise to critical levels, coinciding with increasing environmental pollutants? Two of the authors can look back over 50 clinical years and appreciate the profound changes in human morbidity across a range of disparate conditions - autoimmune diseases, asthma, earlier cancer incidence and reduced male sperm counts. In particular have been increased autism, dyslexia, Attention Deficit Hyperactivity Disorder and neurological diseases, such as Amyotrophic Lateral Sclerosis, Multiple Sclerosis, Parkinson's Disease, Early Onset Dementia, Multiple System Atrophy and Progressive Supranuclear Palsy. What might have caused these changes- whilst genetic factors are taken as given, multiple environmental pollutants are associated with neurological disease although the mechanisms are unclear. The pace of increased neurological deaths far exceeds any Gompertzian explanation - that because people are living longer they are more likely to develop more age-related problems such as neurological disease. Using WHO global mortality categories of Neurological Disease Deaths (NDD) and Alzheimer's and Dementia deaths (Alz), updated June 2018, together they constitute Total Neurological Mortality (TNM), to calculate mortality rates per million for people aged 55-74 and for the over-75's in twenty-one Western countries. Recent increases in American people aged over-75's rose 49% from 1989 to 2015 but US neurological deaths increased five-fold. In 1989 based on Age-Standardised-Deaths-Rates America USA was 17th at 324 pm but rising to 539 pm became second highest. Different environmental/occupational factors have been found to be associated with neuro-degenerative diseases, including background EMF. We briefly explore how levels of EMF interact upon the human body, which can be described as a natural antennae and provide new evidence that builds upon earlier research to propose the following hypothesis. Based upon recent and new evidence we hypothesise that a major contribution for the relative sudden upsurge in neurological morbidity in the Western world (1989-2015), is because of increased background EMF that has become the tipping point-

impacting upon any genetic predisposition, increasing multiple-interactive pollutants, such as rises in petro-chemicals, hormone disrupting chemicals, industrial, agricultural and domestic chemicals. The unprecedented neurological death rates, all within just twenty-five years, demand a re-examination of long-term EMF safety related to the increasing background EMF on human health. We do not wish to 'stop the modern world', only make it safer.

<https://www.ncbi.nlm.nih.gov/pubmed/31088653>

THE POSSIBLE GLOBAL HAZARD OF CELL PHONE RADIATION ON THYROID CELLS AND HORMONES: A SYSTEMATIC REVIEW

Asl JF, Larijani B, Zakerkish M, Rahim F, Shirbandi K, Akbari R. The possible global hazard of cell phone radiation on thyroid cells and hormones: a systematic review of evidences. Environ Sci Pollut Res Int. 2019 May 6. doi: 10.1007/s11356-019-05096-z.

Abstract

The aim of this review was to investigate the effects of possible harmful waves from either cell phone use or being within the range of the cell phone from 450 to 3800 MHz on the thyroid cells and hormones. Eight electronic datasets were systematically searched using MeSH terms, including "cell phone," "mobile phone," "GSM," "radio frequency," "smartphone," "triiodothyronine," "thyroxine," "thyroid-stimulating hormone," "T3," "T4," "TSH," and "morphological" and all possible combinations, to identify relevant studies published up to Dec 2018. We also manually searched the reference lists of potentially selected studies to identify further relevant publications. About 161 relevant studies were initially found. After screening titles and abstracts, 139 studies were excluded, and finally 22 studies (comprising 7182 cases) were included in the qualitative synthesis. Of the 22 included studies, 11 studies reported changes in T3 and T4 levels (six reported a decrease in T3 levels and one reported increase in it); moreover, five found decreased T4 levels and two studies an increased level. In other 10 studies, TSH alteration was reported. Of these, two studies reported a decrease in TSH level and one reported an increase in the hormone levels, while in the remaining studies non-significant changes were reported. Finally, seven studies examined histological changes in the thyroid gland follicles and showed that the volume of these cells was reduced. Based on the evidence discussed above, the reduction in diameter of thyroid follicles is potentially linked with cell phone radiation. Exposure may negatively influence the iodine uptake in the thyroid gland or increases temperature effect on the thyroid gland. However, further research are needed in order to show that the level of TSH and thyroid hormone suppression by microwave.

<https://www.ncbi.nlm.nih.gov/pubmed/31062236>

Also see: <https://www.saferemr.com/2014/07/is-mobile-phone-use-contributing-to.html>

EFFECT OF MOBILE PHONE RADIOFREQUENCY SIGNAL ON THE ALPHA RHYTHM OF HUMAN WAKING EEG: A REVIEW

Wallace J, Selmaoui B. Effect of mobile phone radiofrequency signal on the alpha rhythm of human waking EEG: A review. *Environmental Research*. Published online May 12, 2019. <https://doi.org/10.1016/j.envres.2019.05.016>

Abstract

In response to the exponential increase in mobile phone use and the resulting increase in exposure to radiofrequency electromagnetic fields (RF-EMF), there have been several studies to investigate via electroencephalography (EEG) whether RF-EMF exposure affects brain activity. Data in the literature have shown that exposure to radiofrequency signals modifies the waking EEG with the main effect on the alpha band frequency (8–13 Hz). However, some studies have reported an increase in alpha band power, while others have shown a decrease, and other studies showed no effect on EEG power. Given that changes in the alpha amplitude are associated with attention and some cognitive aspects of human behavior, researchers deemed necessary to look whether alpha rhythm was modulated under RF-EMF exposure. The present review aims at comparing and discussing the main findings obtained so far regarding RF-EMF effects on alpha rhythm of human waking spontaneous EEG, focusing on differences in protocols between studies, which might explain the observed discrepancies and inconclusive results.

Excerpts

Overview of 30 total selected studies which investigated the effect of the radiofrequency electromagnetic fields on human waking spontaneous EEG ... 47% of studies found a significant modification exclusively of the alpha band, the 30% found a significant modification of the alpha band and other frequency bands (delta, theta, beta and gamma), the 3% (only one study) found an effect on the gamma and beta band, without any effect on the alpha rhythm, the 20% reported no significant effect on the EEG.

... MP-RF [mobile phone - radio frequency] can affect normal brain physiology and that the most consistent effect observed is in the alpha frequency. This effect is also observed after RF-EMF exposure. Some studies on adolescents (two studies included 2G system and one study included 3G system) did not indicate a higher sensitivity of this age group compared to adults. Conversely, four studies with epileptic patients showed an effect on their brain's electrophysiology related to 2G exposure. Previous systematic reviews and meta-analyses indicated that acute MP exposures did not have any cognitive or psychomotor effects (Valentini et al., 2011), with a negligible impact on attention and working memory (Barth et al., 2007). <https://www.sciencedirect.com/science/article/pii/S0013935119302749>

MOBILE PHONES: A TRADE-OFF BETWEEN SPEECH INTELLIGIBILITY AND EXPOSURE TO NOISE LEVELS AND TO RADIO-FREQUENCY ELECTROMAGNETIC FIELDS

Thielens A, Bockstael A, Declerck S, Aminzadeh R, Aerts S, Botteldooren D, Martens L, Wout J. Mobile phones: A trade-off between speech intelligibility and exposure to noise levels and to radio-frequency electromagnetic field. *Environmental Research*. Published online May 8, 2019. <https://doi.org/10.1016/j.envres.2019.05.006>.

Highlights

- First time measurement of simultaneous head exposure to RF-EMF and sound pressure during smartphone usage.
- Three use cases are compared: smartphone use at the ear, in speaker mode, and with a headset.
- We demonstrate that exposure to RF-EMF and sound pressure is highest when a phone held at the ear during calls.
- Speech intelligibility is more favourable when the phone is held at the ear in different background noise conditions.
- We demonstrate that reductions in exposure might come at a cost of speech intelligibility during wireless phone calls.

Abstract

When making phone calls, cellphone and smartphone users are exposed to radio-frequency (RF) electromagnetic fields (EMFs) and sound pressure simultaneously. Speech intelligibility during mobile phone calls is related to the sound pressure level of speech relative to potential background sounds and also to the RF-EMF exposure, since the signal quality is correlated with the RF-EMF strength. Additionally, speech intelligibility, sound pressure level, and exposure to RF-EMFs are dependent on how the call is made (on speaker, held at the ear, or with headsets). The relationship between speech intelligibility, sound exposure, and exposure to RF-EMFs is determined in this study. To this aim, the transmitted RF-EMF power was recorded during phone calls made by 53 subjects in three different, controlled exposure scenarios: calling with the phone at the ear, calling in speaker-mode, and calling with a headset. This emitted power is directly proportional to the exposure to RF EMFs and is translated into specific absorption rate using numerical simulations. Simultaneously, sound pressure levels have been recorded and speech intelligibility has been assessed during each phone call. The results show that exposure to RF-EMFs, quantified as the specific absorption in the head, will be reduced when speaker-mode or a headset is used, in comparison to calling next to the ear. Additionally, personal exposure to sound pressure is also found to be highest in the condition where the phone is held next to the ear. On the other hand, speech perception is found to be the best when calling with a phone next to the ear in comparison to the other studied conditions, when background noise is present.

Excerpt

To our knowledge, this is the first study that reports SAR values and emitted powers obtained using actual phone calls made by several volunteers in controlled exposure conditions. In addition, it is also to the authors' best knowledge, the first paper studying the joint exposure to sound and RF-EMF....

Conclusions

In this study, the transmitted radio-frequency electromagnetic field (RF-EMF) power was recorded for 53 subjects who carried out phone calls in three controlled exposure scenarios: calling with the phone at the ear, calling in speaker-mode, and calling with a headset. Phone calls were carried out using the Wideband Code Division Multiple Access (WCDMA) and Global System for Mobile communication (GSM) technologies. For both communication technologies, the emitted power of the phone at the ear was higher than the emitted power in the two other exposure conditions. Moreover, Finite-Difference Time-Domain simulations for a fixed emitted power showed that the brain-averaged specific absorption rate (SAR_{brain}) was higher when the emitting antenna was located close to the ear than in speaker-mode and headset (94–350 times higher). The SAR_{brain} values were then rescaled using the measured powers emitted using GSM technology during the experiments in order to estimate the RF-EMF absorption in the three studied scenarios. It was concluded that the SAR_{brain} will be reduced by more than a factor 100 when either speaker-mode or a headset are used, in comparison to calling next to the ear. These results can be used as additional input for governmental institutions that issue guidelines on smart phone usage with the aim of lowering exposure. Furthermore, in conditions where background noise was present, speech perception was found to be the best when the phone was held at the ear in comparison to using the phone in speaker mode or with a headset. However, the exposure to sound pressure was also found to be the highest in the at-ear configuration, while it was lowest with the phone in speaker mode. Overall, the speaker-mode condition was found to be the configuration in which both exposures to RF-EMFs (in terms of SAR_{brain}) and sound pressure were lowest, although reducing exposure by changing to this configuration does come at a cost in terms of speech intelligibility, in particular in noisy environments. Using a wired headset, on the other hand, was found to significantly reduce SAR_{brain} while only reducing speech intelligibility by a small, yet significant in noisy conditions, amount in comparison to using the phone at the ear. These results are important for smartphone users that might be concerned about both exposure during their calls and about the quality of their calls.

<https://www.sciencedirect.com/science/article/pii/S0013935119302580>

EFFECTS OF SMARTPHONE OVERUSE ON HEADACHE, SLEEP AND QUALITY OF LIFE IN MIGRAINE PATIENTS

Demir YP, Sumer MM. *Neurosciences* (Riyadh). 2019 Apr;24(2):115-121. doi: 10.17712/nsj.2019.2.20180037.

Abstract

OBJECTIVE: To investigate the effects of smartphone overuse on headache, sleep quality, daytime sleepiness and quality of life in migraine patients.

METHODS: This study is a single-center, cross sectional comparative study. This study was conducted between July and September 2017 in the Neurology Clinic of a private hospital. Migraine disability assessment (MIDAS) questionnaire was used to evaluate the disability status, and Mobile Phone Problematic Use Scale (MPPUS) was used to evaluate smartphone use frequency. The Visual Analogue Scale (VAS), 24-h Migraine Quality of Life Questionnaire (24-h MQoLQ), Pittsburgh Sleep Quality Index (PSQI) and Epworth Sleepiness Scale (ESS) were

used to evaluate the pain intensity, quality of life, sleep quality and daytime sleepiness, respectively.

RESULTS: The study included a total of 123 patients. There was a significant difference between the groups in terms of pain intensity, frequency and duration as well as VAS, PSQI, 24-h MQoLQ and ESS (p less than 0.05) scores. There was a negative correlation between MPPUS and PSQI ($r=-0.367$, p less than 0.05); a strong positive correlation between MPPUS and ESS ($r=0.675$, p less than 0.05) and a negative correlation between MPPUS and 24-h MQoLQ ($r=-0.508$, p less than 0.05).

CONCLUSION: Smartphone use has been observed to increase headache duration and frequency in migraine patients. Its overuse in migraine patients is related to poor sleep quality and daytime sleepiness; furthermore, as the smartphone use increases, sleep quality decreases, daytime sleepiness increases and quality of life decreases.

<https://www.ncbi.nlm.nih.gov/pubmed/31056543>

ANALYSIS OF BIOLOGICAL EFFECTS OF CELL PHONE RADIATION ON HUMAN BODY USING SPECIFIC ABSORPTION RATE AND THERMOREGULATORY RESPONSE

Tanghid B. Rashid TB, Song HH. Analysis of biological effects of cell phone radiation on human body using specific absorption rate and thermoregulatory response. Microwave and Optical Technology Letters. 61(6):1482- 1490. 2019. <https://doi.org/10.1002/mop.31777>

Abstract

Health and science have reached a point of intersection which has never existed before. With the recent rapid increase in the use of cellular phones and long periods of usage of these devices near the human body, public concern regarding potential health hazards due to absorption of electromagnetic energy has been growing. To address these issues, this research evaluates the average Specific Absorption Rate in different human tissues by varying source to antenna distance and radiated power using the ANSYS 3D human body model. The Pennes bioheat transfer equation was solved analytically to calculate the longtime exposure effect and temperature rise. The results show that regardless of the frequency, if the antenna radiated power is low (less than 125 mW), temperature increase within the human tissues is low; however if the antenna operates at high radiated power (1 W), temperature tends to increase eight and a half times.

Excerpts

The simulation was performed for five different frequencies (850 MHz, 900 MHz, 2.1 GHz, 2.6 GHz, and 5.1 GHz). To obtain the average SAR values on different scenarios, at each frequency antenna radiated power were varied four different times (0.125 W, 1 W, 1.5 W, and 2 W) and head to antenna distance varied three different times (0 mm, 10 mm, and 20 mm).

In head tissues, at higher frequencies (2.1 GHz, 2.6 GHz, and 5.1 GHz) at 125 mW radiated and when there is no distance between head and antenna, average SAR values are higher in all tissues except fat tissues as shown in Table 3-5. Maximum average SAR values are found in CSF, dura, brain, skin, and bone tissues at 5.1 GHz frequency, which are 11.4 W/kg, 10.89 W/kg, 10.77 W/kg, 10.51 W/kg, and 9.3 W/kg, respectively, as shown in Table 4.

Average SAR values are high at higher frequencies because tissues have relatively high conductivity. In high frequency at high radiated power of 1 W, average SAR values in all tissues are very high. The maximum average SAR value found in CSF tissue was 91.2 W/kg. This means if the antenna is operating at a high power level, there is a high chance of tissues being affected.

The above discussion proves that there is an inversely proportional relationship between SAR and the distance between the body model and the excitation source. For instance, increasing the distance between the source and the head model from 0 mm to 10 mm causes the SAR to decrease by approximately three times at lower frequency, and it decreases approximately five and a half times at higher frequency.

The research concludes, for the long time exposure, and even for the worst possible radiated power level, the temperature rise caused in the human tissues is not close to the dangerous [thermal] limit [42 degrees centigrade].

<https://onlinelibrary.wiley.com/doi/abs/10.1002/mop.31777>

TRENDS IN THE INCIDENCE OF PRIMARY BRAIN, CENTRAL NERVOUS SYSTEM AND INTRACRANIAL TUMORS IN ISRAEL, 1990-2015

Keinan-Boker L, Friedman E, Silverman BG. Trends in the incidence of primary brain, central nervous system and intracranial tumors in Israel, 1990-2015. *Cancer Epidemiol.* 2018 Oct;56:6-13. doi: 10.1016/j.canep.2018.07.003.

Highlights

- Exponential growth in cellphone use fueled concerns regarding brain and CNS tumors.
- Results so far are inconsistent. Studying cancer incidence trends may thus be informative.
- We studied brain tumor trends from 1990 to 2015 in Israel, when cellphone use dramatically increased.
- Results do not support a substantial role for cellphone use; smaller risks in special subgroups may exist.
- Future research is needed; implementation of the precautionary principle is prudent.

Abstract

BACKGROUND: The association between cellphone technology and brain, central nervous system (CNS) and intracranial tumors is unclear. Analysis of trends in incidence of such tumors for periods during which cellphone use increased dramatically may add relevant information. Herein we describe secular trends in the incidence of primary tumors of the brain and CNS from 1990 to 2015 in Israel, a period during which cellphone technology became extremely prevalent in Israel.

METHODS: All cases of primary brain, CNS and intracranial tumors (excluding lymphomas) diagnosed in Israel from 1990 to 2015 were identified in the Israel National Cancer Registry database and categorized by behavior (malignant; benign/uncertain behavior) and histologic type. Annual age-standardized incidence rates by sex and population group (Jews; Arabs)

were computed, and the annual percent changes and 95% confidence intervals per category were calculated using Joinpoint software.

RESULTS: Over 26 years (1990-2015) no significant changes in the incidence of malignant brain, CNS and intracranial tumors were observed, except for an increase in malignant glioma incidence in Jewish women up to 2008 and Arab men up to 2001, which levelled off in both subgroups thereafter. The incidence of benign/uncertain behavior brain, CNS and intracranial tumors increased in most population groups up to the mid-2000s, a trend mostly driven by changes in the incidence of meningioma, but either significantly decreased (Jews) or stabilized (Arabs) thereafter.

CONCLUSIONS: Our findings are not consistent with a discernable effect of cellphone use patterns in Israel on incidence trends of brain, CNS and intracranial tumors.

<https://www.ncbi.nlm.nih.gov/pubmed/30015055>

Excerpts

"When cancer occurrence rates referred to glioblastomas only, Joinpoint analysis of incidence trends was restricted to the period from 1995 to 2015 due to small numbers of cases in the Arab population prior to 1995. Stable incidence trends were noted, with non-significant APCs, in all population subgroups: APC1995–2015 for Jewish men was +0.6% (95%CI -0.4%,+1.6%); APC1995–2015 for Jewish women was +0.6% (95%CI -0.1%,+1.6%); APC1995–2015 for Arab men was -1.6% (95%CI -3.9%,+0.8%); APC1995–2015 for Arab women was +0.4% (95%CI -2.9%,+3.8%).

Analysis of time trends by age groups disclosed stable trends in most population- age- and sex groups, except for a mild increase in Jewish males aged 65 and over (APC1990–2015 +1.2%, $p < 0.05$) and in Arab males aged 20–64 (APC1990–2015 +1.5%, $p < 0.05$). In the population of Arab females, lack of cases in the age groups of 20–64 and 65+ in certain years prevented an analysis of trends."

"However, ecologic studies, of which ours is an example, may be insensitive to excess in risk which is restricted to certain groups (for example, heavy users or subjects exposed from very young ages) or to certain tumor types (e.g., tumors that are very rare, that involve specific anatomical sites, or that have unusually long latency periods) [34]. Little et al. [35] also commented that the predicted rates of glioma based on data derived from the small proportion of highly exposed people in the Interphone study, could be consistent with the observed rates in their study [35]. Therefore, although a substantial risk is not very plausible, smaller risks cannot be ruled out and future research should address specific exposure groups, and tumor types and sites, and should allow for longer follow up periods."

INCIDENCE TRENDS OF ADULT MALIGNANT BRAIN TUMORS IN FINLAND, 1990-2016

Natukka T, Raitanen J, Haapasalo H, Auvinen A. Acta Oncol. 2019 Apr 15:1-7. doi: 10.1080/0284186X.2019.1603396.

Abstract

BACKGROUND: Several studies have reported increased incidence trends of malignant gliomas in the late 1900s with a plateau in the 2000s, but also some recent increases have been reported. The purpose of our study was to analyze incidence trends of malignant gliomas in Finland by morphology and tumor location.

MATERIAL AND METHODS: Data on 4730 malignant glioma patients were obtained from case notifications to the nationwide, population-based Finnish Cancer Registry (FCR), and less detailed data on 3590 patients up to 2016. Age-standardized incidence rates (ASR) and average annual percent changes (APCs) in the incidence rates were calculated by histological subtype and tumor location.

RESULTS: The incidence rate of gliomas was 7.7/100,000 in 1990-2006 and 7.3 in 2007-2016. The incidence of all gliomas combined was stable during both study periods, with no departure from linearity. In an analysis by age group, increasing incidence was found only for ages 80 years and older (1990-2006). During both study periods, incidence rates were increasing in glioblastoma and decreasing in unspecified brain tumors. In 1990-2006, rates were also increasing for anaplastic oligodendroglioma, oligoastrocytoma and unspecified malignant glioma, while decreasing for astrocytoma. As for tumor location, incidence in 1990-2006 was increasing for frontal lobe and brainstem tumors, as well as those with an unspecified location, but decreasing for the parietal lobes, cerebrum and ventricles.

CONCLUSIONS: No increasing incidence trend was observed for malignant gliomas overall. An increasing incidence trend of malignant gliomas was found in the oldest age group during 1990-2006.

<https://www.ncbi.nlm.nih.gov/pubmed/30985227>

THE PREVALENCE OF PEOPLE WITH RESTRICTED ACCESS TO WORK IN MAN-MADE ELECTROMAGNETIC ENVIRONMENTS

Bevington M. The Prevalence of People With Restricted Access to Work in Man-Made Electromagnetic Environments. Journal of Environment and Health Science. Published online Jan 18, 2019.

Abstract

Some surveys have identified people who have restricted access to work in environments with man-made electromagnetic exposures. This study attempts to determine their prevalence, an aspect not previously investigated in its own right. It is based on analyses of the two different types of surveys of people with Idiopathic Environmental Intolerance attributed to Electromagnetic Fields (IEI-EMF), or Electromagnetic Hyper- Sensitivity (EHS), either of the general population or of people with IEI-EMF/EHS. In addition, there are different definitions

of IEI-EMF/EHS, with a range of subconscious, mild, moderate or severe symptoms, potentially leading in three stages to hyper-sensitivity. The current evidence is assessed as indicating that, in addition to subconscious sensitivity, the prevalence of IEI-EMF/EHS is between about 5.0 and 30 per cent of the general population for mild cases, 1.5 and 5.0 per cent for moderate cases and < 1.5 per cent for severe cases. The prevalence of people restricted in their access to work in a man-made electromagnetic environment is estimated at 0.65 per cent of the general population, at about 18% of the general population with moderate IEI- EMF/EHS. The estimate of 0.65% equates to 435,500 people in the UK's population of 67 million. Some reasons for possible under-reporting are discussed. Adjustments can enable some people with this disability to remain in employment, suggesting that rates of restriction in access to work may fall as employers become aware of what adjustments are needed.

Open access paper: <https://www.ommegaonline.org/article-details/The-Prevalence-of-People-With-Restricted-Access-to-Work-in-Man-Made-Electromagnetic-Environments/2402>

DISTURBANCE IN HAEMATOLOGICAL PARAMETERS INDUCED BY EMF EXPOSURE: REVIEW PAPER

Jbirea JM, Azab AE, Elsayed ASI. Disturbance in haematological parameters induced by exposure to electromagnetic fields. Hematology & Transfusion International Journal. 6(6):242-251. 2018.

Abstract

Background: The use of mobile phones, wireless, and electrical devices has gradually increased throughout the last century, and scientists have suggested that electromagnetic fields (EMFs) generated by such devices may have harmful effects on living creatures. Many studies revealed that the EMFs might produce a variety of adverse effects on human health as headaches, chronic fatigue, heart problems, stress, nausea, chest pain, and also some bad effects on central nervous, endocrine and immune systems. Exposure to EMF result in deterioration of RBCs function and metabolic activity, it was expected that, the increase of toxicity in specific organs was a result of the RBCs functional failure. The mechanisms by which the electromagnetic fields cause their bad effects may be by causing deterioration in cellular large molecules, imbalance in ionic equilibrium and generation of reactive oxygen species (ROS). These reactive oxygen species can damage cellular components such as proteins, lipids and DNA. Measurements of blood parameters are of the most important diagnostic methods by which we can determine the health status of human and animals for certain diseases as anemia, leukemia and also detect the presence of the inflammations.

Objectives: This study aimed to present an overview on the previous works from 1997 to 2018 on the varying effects of electromagnetic fields on haematological data in human and different species of experimental models by using different frequencies, intensities, and different sources of electromagnetic fields for different periods. The hematological parameters are fluctuating across the exposure period to the EMFs suggesting the possible induction of hazardous biological effects during the exposure to magnetic field.

Conclusion: It can be concluded that exposure of human and experimental animals to EMFs cause harmful effects on blood cells. These effects were disturbance in haematological

parameters depending on species, the sources of EMFs, frequencies, intensities and duration of exposure.

Open access paper: <https://medcraveonline.com/HTIJ/HTIJ-06-00193.pdf>

CONFLICTS OF INTEREST AND MISLEADING STATEMENTS IN OFFICIAL REPORTS ABOUT THE HEALTH CONSEQUENCES OF RADIOFREQUENCY RADIATION AND SOME NEW MEASUREMENTS OF EXPOSURE LEVELS

Pockett S. Conflicts of Interest and Misleading Statements in Official Reports about the Health Consequences of Radiofrequency Radiation and Some New Measurements of Exposure Levels. *Magnetochemistry* 2019, 5(2), 31;
<https://doi.org/10.3390/magnetochemistry5020031>

Abstract

Official reports to governments throughout the Western world attempt to allay public concern about the increasing inescapability of the microwaves (also known as radiofrequency radiation or RF) emitted by “smart” technologies, by repeating the dogma that the only proven biological effect of RF is acute tissue heating, and assuring us that the levels of radiation to which the public are exposed are significantly less than those needed to cause acute tissue heating. The present paper first shows the origin of this “thermal-only” dogma in the military paranoia of the 1950s. It then reveals how financial conflict of interest and intentionally misleading statements have been powerful factors in preserving that dogma in the face of now overwhelming evidence that it is false, using one 2018 report to ministers of the New Zealand government as an example. Lastly, some new pilot measurements of ambient RF power densities in Auckland city are reported and compared with levels reported in other cities, various international exposure limits, and levels shown scientifically to cause biological harm. It is concluded that politicians in the Western world should stop accepting soothing reports from individuals with blatant conflicts of interest and start taking the health and safety of their communities seriously.

Conclusions

It is time to stop believing ICNIRP spin. Tissue heating is not the only biological effect of radiofrequency radiation. The thermal-only exposure limit is not safe. Like tobacco smoke, low intensity radiofrequency radiation has multiple harmful effects on human health. Unlike secondhand smoke, secondhand radiation is fast becoming inescapable. The present situation is thus worse than Big Tobacco redux. Elected politicians should stop accepting biased reports from individuals with blatant conflicts of interest and start taking seriously the health and safety of their constituents; or at least of their own children and grandchildren. The unchecked expansion of Big Wireless permitted by ICNIRP’s thermal-only guidelines is actively harmful to all biological inhabitants of planet Earth. Further expansion to 5G technology will inevitably involve yet more radiation exposure. The fact that this exposure will not breach the ludicrously high ICNIRP-based standard is no defense at all.

Open access paper: <https://www.mdpi.com/2312-7481/5/2/31/htm>

SPATIAL AND TEMPORAL VARIABILITY OF RF-EMF EXPOSURE LEVELS IN URBAN ENVIRONMENTS IN FLANDERS, BELGIUM

Velghe M, Wout J, Debouvere S, Aminzadeh R, Martens L, Thielens A. Characterisation of spatial and temporal variability of Rf-Emf exposure levels in urban environments in Flanders, Belgium. *Environmental Research*. Published online May 22, 2019. <https://doi.org/10.1016/j.envres.2019.05.027> Get rights and content

Highlights

- Comparison of population exposure to RF-EMF in 5 densely populated cities with similar characteristics within Flanders, Belgium.
- The first findings that indicate the effects of regulations on exposure levels.
- Repeatability and representativeness of the used method are shown, which is important for future research.
- Application of this method outside of office hours renders new insights in daily behaviour of exposure.
- On-body calibration of the measurement device allowed us to, in contrast to most other similar studies, quantify the on-body measurement uncertainty.

Abstract

Personal exposure to Radio-Frequency Electromagnetic Fields (RF-EMFs) was studied using personal measurements in five different microenvironments in each of five cities (Brussels, Antwerp, Ghent, Bruges and Hasselt) in Flanders, Belgium. These measurements were carried out by two researchers using on-body calibrated personal exposimeters. In three out of the five studied cities (Brussels, Ghent and Bruges), temporal aspects of personal exposure to RF-EMFs were studied as well. Measurements during and outside of rush hours (7:00–9:15 and 16:30–19:00) were compared. Likewise, measurements were executed during night time and compared to the ones measured during working hours. Representativeness and repeatability of the measurement method was studied as well.

The highest mean total exposure was found in Brussels (2.63 mW/m²), the most densely populated city in this study. However, we measured higher downlink exposure in Antwerp than in Brussels, which might be an effect of the stronger legislation on base stations in Brussels. The measurements and used protocol were found to be both repeatable over time ($r = 0.95$ for median total exposure) and representative for the studied microenvironments in terms of path selection ($r = 0.88$ for median total exposure). Finally, in 10 out of the 13 on-body calibrated frequency bands we found that the measurement devices underestimate the intensity of the incident RF-EMFs with median underestimations up to 68%.

Conclusions

Personal exposure to RF-EMFs was studied using microenvironmental measurements in five cities in Flanders and the Brussels Capital Region. Highest total exposure values were found in Brussels (2.63 mW/m² averaged over five microenvironments). Our analysis showed that the amount of RF-EMF radiation in a certain environment was dependent on the population density within that environment. A higher average downlink exposure was measured in Antwerp in comparison to Brussels whilst having a lower population density. This

might be an effect of the stronger legislation on base stations in Brussels. Downlink was the largest contributor to total exposure. The total RF-EMF exposure was significantly higher during rush than during non-rush hours. Furthermore, the total exposure was highest at night compared to other timeslots. The selected paths showed to be representative for exposure in their respective microenvironments. The results were also found to be repeatable. The used measurement devices were calibrated on the body of the researchers that wore them during measurements. These calibrations showed that the devices underestimate the personal exposure since median underestimations were measured in a majority of the studied frequency bands on the bodies of the two individual researchers, respectively.

<https://www.sciencedirect.com/science/article/pii/S0013935119302853?via%3Dihub>

EVALUATION OF TEMPERATURE ELEVATION IN HUMAN OCULAR TISSUES DUE TO WIRELESS EYEWEAR DEVICES

Lan J, Du G. Evaluation of temperature elevation in human ocular tissues due to wireless eyewear devices. *ACES Journal*. 34(1):17-24. 2019.

Abstract

In this paper, a numerical study is proposed to evaluate the temperature variation in the human ocular tissues during the electromagnetic radiation exposure from wireless eyewear device. The results show that the temperature in the whole eyeball increases gradually as the exposure time goes on and could reach the thermal steady state at about 30 minutes. During this process, the temperature increments in different ocular tissues are between 1.1°C and 1.7°C. The results also show the maximal ratio of temperature increments in the initial 5 and 10 minutes to that of the whole steady state could reach to 42.9% and 69.2%, respectively. Therefore, we believe that electromagnetic radiation from wireless eyewear device might pose a threat on the health of the human eyes. People should decrease the talk time as soon as possible to protect their eyes from the possible health hazards. Finally, attention is paid to evaluate the relationship between the maximal SAR and the temperature increments. The results show the temperature increments do not increase in direct proportion to the maximal SAR, which indicates that the maximal SAR and the temperature increments should be taken into account simultaneously while evaluating the biological effect of microwave on the ocular tissues.

Conclusions

Based on the results evaluated in this paper, we find that the temperature in the whole eyeball increases gradually and reaches the thermal steady state at about 30 minutes during the EM exposure of wireless eyewear device. The temperature increments in different ocular tissues are from 1°C to 1.7°C. We, therefore, believe EM exposure from wireless eyewear device may pose a threat on the health of the eyes, especially for the lens which suffer from the maximal temperature increments. Meanwhile, the results also show that the maximal ratio of temperature increments in the initial 5 and 10 minutes exposure time to that of the complete thermal steady state could reach to 42.9% and 69.2%, respectively. Hence, wireless eyewear device users should shorten the usage time as soon as possible to protect their eyes from the possible health hazards. Finally, we evaluate the relationship between the maximal SAR and the temperature increments in the ocular tissues. We find that the temperature increments do not increase in direct proportion to the maximal SAR. Therefore, we believe

the maximal SAR and the temperature increments should be taken into account simultaneously while evaluating the biological effect of microwave on the ocular tissues. This paper could provide valuable data for the establishment of related safety standards and future researches in the biological effect of microwave and human eyes. However, limited by the experimental condition, the experiment is not included. Therefore, conclusions presented in this paper are just indicative but not definitive.

Open access paper:

<http://www.acesociety.org/includes/downloadpaper.php?of=ACES Journal January 2019 Paper 3&nf=19-1-3>

MILLIMETER WAVE RADIATION ACTIVATES LEECH NOCICEPTORS VIA TRPV1-LIKE RECEPTOR SENSITIZATION

Romanenko S, Harvey AR, Hool L, Fan S, Wallace VP. Millimeter Wave Radiation Activates Leech Nociceptors via TRPV1-Like Receptor Sensitization. *Biophys J*. 2019 Apr 25. pii: S0006-3495(19)30340-6. doi: 10.1016/j.bpj.2019.04.021.

Abstract

There is evidence that millimeter waves (MMWs) can have an impact on cellular function, including neurons. Earlier in vitro studies have shown that exposure levels well below the recommended safe limit of 1 mW/cm² cause changes in the action potential (AP) firing rate, resting potential, and AP pulse shape of sensory neurons in leech preparations as well as alter neuronal properties in rat cortical brain slices; these effects differ from changes induced by direct heating. In this article, we compare the responses of thermosensitive primary nociceptors of the medicinal leech under thermal heating and MMW irradiation (80-170 mW/cm² at 60 GHz). The results show that MMW exposure causes an almost twofold decrease in the threshold for activation of the AP compared with thermal heating (3.9 ± 0.4 vs. 8.3 ± 0.4 mV, respectively). Our analysis suggests that MMWs-mediated threshold alterations are not caused by the enhancement of voltage-gated sodium and potassium conductance. We propose that the reduction in AP threshold can be attributed to the sensitization of the transient receptor potential vanilloid 1-like receptor in the leech nociceptor. In silico modeling supported our experimental findings. Our results provide evidence that MMW exposure stimulates specific receptor responses that differ from direct thermal heating, fostering the need for additional studies.

<https://www.ncbi.nlm.nih.gov/pubmed/31103236>

CAN LOW-LEVEL RF EXPOSURE AFFECT COGNITIVE BEHAVIOUR IN LAB ANIMALS? LITERATURE REVIEW OF SPATIAL LEARNING AND PLACE MEMORY

Sienkiewicz Z, van Rongen E. Can Low-Level Exposure to Radiofrequency Fields Effect Cognitive Behaviour in Laboratory Animals? A Systematic Review of the Literature Related to Spatial Learning and Place Memory. *Int J Environ Res Public Health*. 2019 May 8;16(9). pii: E1607. doi: 10.3390/ijerph16091607.

Abstract

This review considers whether exposure to low-level radiofrequency (RF) fields, mostly associated with mobile phone technology, can influence cognitive behaviour of laboratory animals. Studies were nominated for inclusion using an a priori defined protocol with preselected criteria, and studies were excluded from analysis if they did not include sufficient details about the exposure, dosimetry or experimental protocol, or if they lacked a sham-exposed group. Overall, 62 studies were identified that have investigated the effects of RF fields on spatial memory and place learning and have been published since 1993. Of these, 17 studies were excluded, 20 studies reported no significant field-related effects, 21 studies reported significant impairments or deficits, and four studies reported beneficial consequences. The data do not suggest whether these outcomes are related to specific differences in exposure or testing conditions, or simply represent chance. However, some studies have suggested possible molecular mechanisms for the observed effects, but none of these has been substantiated through independent replication. Further behavioural studies could prove useful to resolve this situation, and it is suggested that these studies should use a consistent animal model with standardized exposure and testing protocols, and with detailed dosimetry provided by heterogeneous, anatomically-realistic animal models.

Open access paper: <https://www.mdpi.com/1660-4601/16/9/1607>

PROTECTIVE ROLE OF SPERMINE AGAINST MALE REPRODUCTIVE ABERRATIONS INDUCED BY EMF EXPOSURE IN THE RAT

Shahin NN, El-Nabarawy NA, Gouda AS, Megarbane B. *Toxicology and Applied Pharmacology*. 370:117-130. May, 2019. DOI: 10.1016/j.taap.2019.03.009

Highlights

- Exposure to electromagnetic field (EMF) impairs spermatogenesis and steroidogenesis.
- EMF toxicity is mediated by oxidative, inflammatory, apoptotic and DNA perturbations.
- Spermine exhibits protective effects against EMF-induced alteration in male fertility.
- Protection is at least in part due to anti-oxidative and anti-apoptotic effects.

Abstract

The exponentially increasing use of electromagnetic field (EMF)-emitting devices imposes substantial health burden on modern societies with particular concerns of male infertility. Limited studies have addressed the modulation of this risk by protective agents. We investigated the hazardous effects of rat exposure to EMF (900 MHz, 2 h/day for 8 weeks) on

male fertility and evaluated the possible protective effect of the polyamine, spermine, against EMF-induced alterations. Exposure to EMF significantly decreased sperm count, viability and motility, and increased sperm deformities. EMF-exposed rats exhibited significant reductions in serum inhibin B and testosterone along with elevated activin A, follicle-stimulating hormone, luteinizing hormone and estradiol concentrations. Testicular steroidogenic acute regulatory protein (StAR), c-kit mRNA expression and testicular activities of the key androgenic enzymes 3 beta- and 17 beta-hydroxysteroid dehydrogenases were significantly attenuated following exposure to EMF. Exposure led to testicular lipid peroxidation, decreased catalase and glutathione peroxidase activities and triggered nuclear factor-kappa B p65, inducible nitric oxide synthase, cyclooxygenase-2 and caspase-3 overexpression. EMF-exposed rats showed testicular DNA damage as indicated by elevated comet parameters. Spermine administration (2.5 mg/Kg/day intraperitoneally for 8 weeks) prevented EMF-induced alterations in the sperm and hormone profiles, StAR and c-kit expression and androgenic enzyme activities. Spermine hampered EMF-induced oxidative, inflammatory, apoptotic and DNA perturbations. Histological and histomorphometric analysis of the testes supported all biochemical findings. In conclusion, rat exposure to EMF disrupts sperm and hormone profiles with underlying impairment of steroidogenesis and spermatogenesis. Spermine confers protection against EMF-associated testicular and reproductive aberrations, at least in part, via antioxidant, anti-inflammatory and anti-apoptotic mechanisms.

Excerpt

Rats were exposed to the EMF at 900 MHz frequency and 0.02 mW/cm² power density during 2 h/day over a period of eight consecutive weeks, as previously described (Kesari et al., 2011). The average specific absorption rate was 1.075 W/Kg, as calculated by the Finite-Difference-Time-Domain. Non-exposed rats were placed in the same device with exposure off, used in similar environmental conditions.

<https://www.sciencedirect.com/science/article/pii/S0041008X19300912>

INTERACTION OF LOW FREQUENCY EXTERNAL ELECTRIC FIELDS AND PANCREATIC B-CELL: A MATHEMATICAL MODELING APPROACH TO IDENTIFY THE INFLUENCE OF EXCITATION PARAMETERS

Farashi S, Sasanpour P, Rafii-Tabar H. Interaction of low frequency external electric fields and pancreatic β -cell: a mathematical modeling approach to identify the influence of excitation parameters. *Int J Radiat Biol.* 2018 Nov;94(11):1038-1048. doi: 10.1080/09553002.2018.1478162.

Abstract

PURPOSE: Although the effect of electromagnetic fields on biological systems has attracted attraction in recent years, there has not been any conclusive result concerning the effects of interaction and the underlying mechanisms involved. Besides the complexity of biological systems, the parameters of the applied electromagnetic field have not been estimated in most of the experiments.

MATERIALS AND METHODS: In this study, we have used computational approach in order to find the excitation parameters of an external electric field which produces sensible effects in the function of insulin secretory machinery, whose failure triggers the diabetes disease. A

mathematical model of the human β -cell has been used and the effects of external electric fields with different amplitudes, frequencies and wave shapes have been studied.

RESULTS: The results from our simulations show that the external electric field can influence the membrane electrical activity and perhaps the insulin secretion when its amplitude exceeds a threshold value. Furthermore, our simulations reveal that different waveforms have distinct effects on the β -cell membrane electrical activity and the characteristic features of the excitation like frequency would change the interaction mechanism.

CONCLUSION: The results could help the researchers to investigate the possible role of the environmental electromagnetic fields on the promotion of diabetes disease.

<https://www.ncbi.nlm.nih.gov/pubmed/29792541>

SAFETY MANAGEMENT OF ELECTROMAGNETIC FIELDS IN THE WORK ENVIRONMENT

Koppel T. Safety Management of Electromagnetic Fields in the Work Environment. Ph.D. Thesis. Tallinn, Estonia: Tallinn University of Technology. Nov 2019.

Abstract

Occupational exposure to electromagnetic fields is a known risk factor and considered the most complicated physical hazard in the workplace. The legislation requires measures to be taken to reduce exposure and to mitigate risks in order to guarantee worker safety. Electromagnetic fields are considered a new and emerging risk factor. Assessing risks in the electromagnetic domain is a challenge as whole extent of the health implications of different types and forms of exposure is unknown.

EMFs were studied using both quantitative and qualitative approaches, including measurements, questionnaires, interviews and in-situ workplace observations. The research addressed current practices and rules of managing safety from electromagnetic fields. Safety compliance analyses were conducted with regard to legislative requirements. This endeavor was guided by the new requirements for health and safety with regard to electromagnetic fields.

This study was intended to help improve management's safety knowledge of this risk factor, by encompassing scientifically reasonable approaches in designing EMF safety. The study included analysis of the exposure levels of workers, and development of methods to reduce exposure, with respect to the new occupational EMF legislation. The author analyzed the EMF exposure in different settings, including means of work, encompassing industrial, office, and public settings. The EMF safety compliance of companies was investigated. New, safer ways to work when exposed to electromagnetic fields were proposed.

The author proposed and tested methods of EMF exposure reduction, which can be used by employers to demonstrate compliance with the occupational exposure norms, and public safety norms. As a result, a model was developed introducing a system for managing EMF

safety. The model prescribes a set of hierarchical steps to mitigate risks from the workers' exposure to EMFs.

The research improved the scientific understanding of consequences from exposure to electromagnetic fields (EMF). There are long term health effects from occupational exposure to extremely low frequency (ELF) electromagnetic fields that are not currently covered by safety legislation.

Significantly elevated radiofrequency (RF) EMF hotspots were measured in open spaces resulting from poor set up of RF antennas. Investigations also revealed that industrial workers are exposed to high levels of magnetic radiation from production devices that to a large extent is unnecessary. By following the technical and administrative intervention solutions developed by the author, the workers' exposure could be drastically reduced.

Contributing to safety education of both the workers and the working environment specialists will have a positive effect on safety compliance and other related safety issues within the company. Working environments specialists reported higher compliance with EMF safety arrangements compared to the workers, but overall, safety management practices were still poor relative to the legislative requirements. In comparison to workers, working environment specialists also reported better addressing the needs of workers in risk groups.

There are several steps the worker can take to control his/her overall exposure without significant additional effort or expense. Rearrangement of devices and adoption of new operational habits can reduce exposure to the EMFs even by orders of magnitude. Intervention measures may include increasing the distance from the source of the EMF and shielding the EMF source. The best reduction of EMF exposure will be achieved when several measures are implemented simultaneously.

In managing EMF safety, the author advises the employer to proceed step by step. The hierarchical process starts with the employer informing the worker about EMF conditions. Secondly, the employer should educate the worker how to reduce his/her exposure. Thirdly, the employer should motivate the worker to follow the EMF safety management procedures. And lastly, the employer should conduct regular reviews on the implementation and operational effectiveness of the EMF safety management system. "

<https://digi.lib.ttu.ee/i/?11585>

TOP 100 CITED NONINVASIVE NEUROMODULATION CLINICAL TRIALS

Lucena MFG, Teixeira PEP, Bonin Pinto C, Fregni F. Top 100 cited noninvasive neuromodulation clinical trials. *Expert Rev Med Devices*. 2019 May 16. doi: 10.1080/17434440.2019.1615440.

Abstract

Transcranial direct current stimulation (tDCS) and transcranial magnetic stimulation (TMS) are noninvasive neuromodulation techniques used as therapeutic and research tools for several neuropsychiatric conditions. Given the exponential scientific growth of this field we aimed to systematically review the most cited clinical trials using TMS or tDCS. Areas covered: A de-novo keyword search strategy identified and characterized the 100 most-cited trials. Total citation count for the most cited trials was 13,204. Articles were published between 2008 and 2014 in 50 different journals with a median impact factor of 6.52 (IQR 3.37). Almost half of the top cited papers were investigating mechanisms of action in healthy subjects. Most studies were feasibility trials and only 5 were pivotal trials, including the ones used for recent FDA approval. Seven articles were interlinked with another article by at least 25 citations and eight authors had collaborated with at least one other author. Expert Commentary: Although there has been a significant increase in interest for rTMS and tDCS, most of the cited clinical trials are still small feasibility studies, what reinforced the need for more robust clinical trials (larger samples sizes and effects sizes) to better define clinical effectiveness.

<https://www.ncbi.nlm.nih.gov/pubmed/31092060>

2100 MHZ MOBILE PHONE RADIATION DAMAGES DNA IN ONION ROOTS

Chandel S, Kaur S, Issa M, Singh HP, Batish DR, Kohli RK. Appraisal of immediate and late effects of mobile phone radiations at 2100 MHz on mitotic activity and DNA integrity in root meristems of *Allium cepa*. *Protoplasma*. 2019 May 21. doi: 10.1007/s00709-019-01386-y.

Abstract

The present study evaluated the potential of 2100 MHz radiofrequency radiations to act as cytotoxic and genotoxic agent. Fresh onion (*Allium cepa* L.) roots were exposed to electromagnetic field radiations (EMF-r) for different durations (1 h and 4 h) and evaluated for mitotic index (MI), phase index, chromosomal aberrations, and DNA damage. DNA damage was investigated with the help of the comet assay by assessing various parameters like % head DNA (HDNA), % tail DNA (TDNA), tail moment (TM), and olive tail moment (OTM).

Effects of EMF-r exposure were also compared with that of methyl methanesulfonate (MMS; 90 μ M), which acted as a positive control. The post-exposure effects of EMF-r after providing the test plants with an acclimatization period of 24 h were also evaluated. Compared to the control, a significant increase in the MI and aberration percentage was recorded upon 4 h of exposure. However, no specific trend of phase index in response to exposure was detected. EMF-r exposure incited DNA damage with a significant decrease in HDNA accompanied by an increase in TDNA upon exposure of 4 h. However, TM and OTM did not change significantly upon exposure as compared to that of control. Analysis of the post-exposure effects of EMF-

r did not show any significant change/recovery. Our data, thus, suggest the potential cytotoxic and genotoxic nature of 2100 MHz EMF-r. Our study bears great significance in view of the swiftly emergent EMF-r in the surrounding environment and their potential for inciting aberrations at the chromosomal level, thus posing a genetic hazard.

<https://www.ncbi.nlm.nih.gov/pubmed/31115694>

Conclusions

It is apparent from the present study that radiofrequency radiations at 2100 MHz have a potential for inciting cytotoxic and genotoxic effects in *A. cepa* root meristems. The observed biological effects were dependent on the duration of exposure, and the maximum alterations were found upon 4 h of exposure. As the concentration of EMF waves by man-made devices like mobile phones is increasing in the environment at a very fast rate, we cannot afford to ignore the biological effects of these radiations. Our study holds great significance in view of this rapidly emergent EMF-r in the surrounding environment and their potential for inciting aberrations and damage at the chromosomal level, thus posing a genetic hazard. The study calls for a proper risk assessment in terms of impacts on the environment and public health of the increasing electromagnetic smog and development of strategies to reduce EMF-r pollution in the natural environment.

EFFECTS OF 50 HZ MAGNETIC FIELD-EXPOSED CELL CULTURE MEDIUM ON CELLULAR FUNCTIONS IN HUMAN AMNIOTIC EPITHELIAL CELLS

Fei Y, Su L, Lou H, Zhao C, Wang Y, Chen G. The effects of 50 Hz magnetic field-exposed cell culture medium on cellular functions in FL cells. *J Radiat Res.* 2019 May 21. pii: rrz020. doi: 10.1093/jrr/rrz020.

Abstract

Although extremely low frequency magnetic fields (ELF-MFs) have been classified as a possible carcinogen for humans by the International Agency for Research on Cancer (IARC), their biological effects and underlying mechanisms are still unclear. Our previous study indicated that ELF-MF exposure influenced the relative permittivity of the saline solution, suggesting that the MF exposure altered physical properties of the solution. To explore the biophysical mechanism of ELF-MF-induced biological effects, this study examined the effects of 50 Hz sinusoidal MF at 0-4.0 mT on the permittivity of culture medium with phase-interrogation surface plasmon resonance (SPR) sensing. Then, the biological effects of MF pre-exposed culture medium on cell viability, the mitogen-activated protein kinase (MAPK) signaling pathways, oxidative stress, and genetic stabilities were analyzed using Cell Counting Kit-8, western blot, flow cytometry, γ H2AX foci formation, and comet assay. The results showed that SPR signals were decreased under MF exposure in a time- and dose- dependent manner, and the decreased SPR signals were reversible when the exposure was drawn off. However, MF pre-exposed culture medium did not significantly change cell viability, intracellular reactive oxygen species level, activation of the MARK signaling pathways, or genetic stabilities in human amniotic epithelial cells (FL

cells). In conclusion, our data suggest that the relative permittivity of culture medium was influenced by 50 Hz MF exposure, but this change did not affect the biological processes in FL cells.

<https://www.ncbi.nlm.nih.gov/pubmed/31111909>

MATERNAL CELL PHONE USE DURING PREGNANCY, PREGNANCY DURATION AND FETAL GROWTH IN FOUR BIRTH COHORTS

Tsarna E, Reedijk M, Birks LE, Guxens M, Ballester F, Ha M, Jiménez-Zabala A, Kheifets L, Lertxundi A, Lim HR, Olsen J, Safont LG, Sudan M, Cardis E, Vrijheid M, Vrijkotte T, Huss A, Vermeulen R. Maternal Cell Phone Use During Pregnancy, Pregnancy Duration And Fetal Growth In Four Birth Cohorts. *Am J Epidemiol*. 2019 Apr 17. pii: kwz092. doi: 10.1093/aje/kwz092.

Abstract

Previous studies evaluating potential effects of prenatal exposure to radiofrequency fields from cell phones on birth outcomes are inconsistent. We explored if maternal cell phone use was associated with pregnancy duration and fetal growth. We used information from 55,507 pregnant women and their children from Denmark (1996-2002), the Netherlands (2003-2004), Spain (2003-2008) and Korea (2006-2011). Based on self-reported number of cell phone calls per day, exposure was grouped as none, low (reference level), intermediate, and high. We examined pregnancy duration (gestational age at birth, preterm/postterm birth), fetal growth (birth weight ratio, small/large for gestational age), and birth weight, low and high birth weight, and meta-analyzed cohort specific estimates. The intermediate exposure group had higher risk of giving birth at lower gestational age (Hazard Ratio=1.04, 95%CI 1.01, 1.07), and exposure-response relationships were found for shorter pregnancy duration ($P<0.001$) and preterm birth ($P=0.003$). We observed no association with fetal growth or birth weight. In conclusion, maternal cell phone use during pregnancy may be associated with shorter pregnancy duration and increased risk for preterm birth. Results should be interpreted with caution, as they may reflect stress during pregnancy or other residual confounding, rather than direct effect of cell phone exposure.

<https://www.ncbi.nlm.nih.gov/pubmed/30995291>

MOTHER'S EXPOSURE TO ELECTROMAGNETIC FIELDS BEFORE AND DURING PREGNANCY IS ASSOCIATED WITH RISK OF SPEECH PROBLEMS IN OFFSPRING

Zarei S, Vahab M, Oryadi-Zanjani MM, Alighanbari N, Mortazavi SM. Mother's Exposure to Electromagnetic Fields before and during Pregnancy is Associated with Risk of Speech Problems in Offspring. *J Biomed Phys Eng*. 2019 Feb 1;9(1):61-68.

Abstract

BACKGROUND: Rapid advances in technology, especially in the field of telecommunication, have led to extraordinary levels of mothers' exposures to radiofrequency electromagnetic fields (RF-EMFs) prior to or during pregnancy.

OBJECTIVE: The main goal of this study was to answer this question whether exposure of women to common sources of RF-EMFs either prior to or during pregnancy is related to speech problems in the offspring.

MATERIALS AND METHODS: In this study, mothers of 110 three-to-seven-year-old children with speech problems and 75 healthy children (control group) were interviewed. These mothers were asked whether they had exposure to different sources of EMFs such as mobile phones, mobile base stations, Wi-Fi, cordless phones, laptops and power lines. Chi square test was used to analyze the differences observed between the control and exposed groups.

RESULTS: Statistically significant associations were found between the use of cordless phone and offspring speech problems for both before pregnancy and during pregnancy maternal exposures ($P=0.005$ and $P=0.014$, respectively). However, due to high rate of mobile phone use in both groups, this study failed to show any link between mobile phone use and speech problems in offspring. Furthermore, significant associations were observed between living in the vicinity of power lines and speech problems again for both before pregnancy and during pregnancy maternal exposures ($P=0.003$ and $P=0.002$, respectively). However, exposure to other sources of non-ionizing radiation was not linked to speech problems. Moreover, exposure to ionizing radiation (e.g. radiography before and during pregnancy) was not associated with the occurrence of speech problems.

CONCLUSION: Although this study has some limitations, it leads us to this conclusion that higher-than-ever levels of maternal exposure to electromagnetic fields could be linked to offspring speech problems.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6409372/>

MATERNAL PROXIMITY TO EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS AND RISK OF BIRTH DEFECTS

Auger N, Arbour L, Luo W, Lee GE, Bilodeau-Bertrand M, Kosatsky T. Maternal proximity to extremely low frequency electromagnetic fields and risk of birth defects. *Eur J Epidemiol.* 2019 Apr 11. doi: 10.1007/s10654-019-00518-1.

Abstract

Causes of birth defects are unclear, and the association with electromagnetic fields is inconclusive. We assessed the relationship between residential proximity to extremely low frequency electromagnetic fields from power grids and risk of birth defects. We analyzed a population-based sample of 2,164,246 infants born in Quebec, Canada between 1989 and 2016. We geocoded the maternal residential postal code at delivery and computed the distance to the nearest high voltage electrical transmission line or transformer station. We used log-binomial regression to estimate risk ratios (RR) and 95% confidence intervals (CI) for the association of residential proximity to transmission lines and transformer stations with birth defects, adjusting for maternal and infant characteristics. The prevalence of birth defects within 200 m of a transmission line (579.4 per 10,000 per live births) was only slightly higher compared with distances further away (568.7 per 10,000). A similar trend was seen for transformer stations. Compared with 200 m, a distance of 50 m was not associated with the risk of birth defects for transmission lines (RR 1.00, 95% CI 1.00-1.01) and transformer stations (RR 1.01, 95% CI 1.00-1.03).

There was no consistent association when we examined birth defects in different organ systems. We found no compelling evidence that residential proximity to extremely low frequency electromagnetic fields from electrical power grids increases the risk of birth defects. Women residing near electrical grids can be reassured that an effect on the risk of birth defects is unlikely.

<https://www.ncbi.nlm.nih.gov/pubmed/30977029>

MICROWAVE EMISSIONS FROM CELL PHONES EXCEED SAFETY LIMITS IN EUROPE AND THE US WHEN TOUCHING THE BODY

Gandhi OP. Microwave Emissions From Cell Phones Exceed Safety Limits in Europe and the US When Touching the Body. IEEE Access. 7:47050-47052. Apr 11, 2019. DOI: 10.1109/ACCESS.2019.2906017

Abstract

In our publications, we have shown both from measurements and computer modeling that the specific absorption rate (SAR) reduces by 10%–15% for every millimeter separation of the cell phone on account of rapidly diminishing EM fields in the near-field region of the cell phone antenna. This rapid reduction of SAR depending on the antenna and its location on the handset has been shown, both computationally and experimentally, regardless of the phantom model such as a flat phantom suggested for SAR compliance testing of devices in contact with the body, for a sphere phantom, and for head-shaped models used for SAR compliance testing of cell phones. Unfortunately, our observations in the past were based on SARs of only three cell phones. Expecting that the SARs for cell phones may exceed the safety limits for body contact, cell phone manufacturers have started to recommend that the devices can be used at 5–25 mm from the body even though it is difficult to see how to maintain this distance correctly under mobile conditions. The National Agency ANFR of France recently released the cell phone SAR test data for 450 cell phones that measure 10-g SARs reducing by 10%–30% for each millimeter distal placement from the planar body phantom. Their data corroborate our findings that most cell phones will exceed the safety guidelines when held against the body by factors of 1.6–3.7 times for the European/ICNIRP standard or by factors as high as 11 if 1-g SAR values were to be measured as required by the U.S. FCC.

Open access paper: <https://ieeexplore.ieee.org/document/8688629>

ON MEASURING ELECTROMAGNETIC FIELDS IN 5G TECHNOLOGY

Pawlak R, Krawiec P, Żurek J. On Measuring Electromagnetic Fields in 5G Technology. IEEE Access. 7: 29826- 29835. March 5, 2019. DOI: 10.1109/ACCESS.2019.2902481

Abstract

At the awakening of the new 5G network as the network of services, issues related to electromagnetic fields (EMFs) will become one of the key aspects for the cost-effective establishment of the 5G infrastructure. The new 5G services will meet the rigorous demand for bandwidth through the implementation of a large number of densely located base stations operating in the millimeter-wave range. Introduction of new emission sources, working in

parallel with already existing 2G/3G/4G mobile technologies, raises concerns about exceeding the admissible EMF exposure limits. This paper analyzes issues and challenges related to EMF measurements in 5G technology, which are crucial for the assessment of EMF compliance with regulatory limits. We point out that the existing methodologies, dedicated to EMF measurements in 2G, 3G, and 4G networks, are not suitable for 5G. The reason is the use of new techniques, such as massive MIMO and precise beamforming together with higher frequency bands so that the existing measurement methods can lead to significantly overestimated

results when they will be applied to 5G networks. Such results, in conjunction with the restrictive legislation on the EMF limits that apply in some countries, may have the negative impact on 5G network deployment, making it difficult to achieve the intended 5G network capabilities. We also propose an alternative method of EMF exposure assessment that is based on calculations and simulations and allows obtaining an accurate estimation of the EMF distribution in the 5G environment.

Open access paper: <https://ieeexplore.ieee.org/document/8660395>

ON THE ASSESSMENT OF HUMAN EXPOSURE TO ELECTROMAGNETIC FIELDS TRANSMITTED BY 5G BASE STATIONS

Keller H. On the assessment of human exposure to electromagnetic fields transmitted by 5G NR base stations. Health Phys. 2019 Apr 23. doi: 10.1097/HP.0000000000001089.

Abstract

The fifth-generation new radio cellular network will be rolled out within the next few years. Several assessment methods of human exposure to electromagnetic fields transmitted by fifth-generation new radio base stations are discussed. Currently no method exists that allows extrapolation to the maximum theoretical exposure. Thus two new extrapolation methods are proposed. A 95th percentile exposure can be derived from the maximum theoretical exposure by an agreed-upon reduction factor if a more realistic exposure assessment is required.

<https://www.ncbi.nlm.nih.gov/pubmed/31022013>

ELECTROMAGNETIC FIELD MEASUREMENT FOR PUBLIC SAFETY EXPOSURE LEVEL

Khan ZI, Razak AZA, Zakaria NA, Rashid NEA, Othman, KA. Electromagnetic field (EMF) Measurement for Public Safety Exposure Level. 2018 International Conference on Radar, Antenna, Microwave, Electronics, and Telecommunications (ICRAMET). 1-2 Nov. 2018. Serpong, Indonesia. Added to IEEE Xplore: 09 April 2019. pp. 66-69.

Abstract

This paper presents the level of Radio Frequency electromagnetic fields from Global System for Mobile communications (GSM) and Long Term Evolution (LTE) base station antennas. The exposure of Electromagnetic field towards public is being discuss widely due to the fact that it effects the human lives that is surrounded by these communication developments. Certain area was investigated earlier in order to obtain the strongest point of exposure. The location chosen in this paper was based on the red zone detected in the earlier drive test

measurement. The measurement was conducted during morning, afternoon and night for 3 days. Data was collected using isotropic antenna and spectrum analyzer. The E-field exposure levels were found to be lower than the maximum level set by international commission on Non-Ionizing radiation protection (ICNIRP) for the general public.

Conclusion

Overall LTE 2.6 GHz has a highest maximum E-field value compare to the other frequency. The high value of Efield could be related to the mobile traffic and also the higher power need for transmitting higher frequency. Lower frequency like GSM900 can travel further even though it requires less power because the properties of the wave itself. Higher frequencies require more power to travel longer distances. Based on all the data and analyzation done, all of the value gain are below the limit set by ICNIRP.

<https://ieeexplore.ieee.org/document/8683911>

A MULTI-BAND BODY-WORN DISTRIBUTED EXPOSURE METER FOR PERSONAL RADIO-FREQUENCY DOSIMETRY IN DIFFUSE INDOOR ENVIRONMENTS

Aminzadeh R, Thielens A, ..., Wout J. (19 authors). A multi-band body-worn distributed exposure meter for personal radio-frequency dosimetry in diffuse indoor environments. IEEE Sensors Journal. April 29, 2019. DOI: 10.1109/JSEN.2019.2913309

Abstract

A multi-band body-worn distributed exposure meter (BWDM) is designed and calibrated for diffuse fields in a reverberation chamber (RC) for personal exposure assessment in indoor environments. The BWDM uses 22 nodes distributed over the torso and measures the incident power density (Sinc) on body for 11 telecommunication bands in the frequency range 790-5513 MHz. In order to calibrate the measurement device in diffuse fields, a protocol is proposed for on-body calibration of the BWDM. This protocol is applicable to wearable personal exposure meters in general. The BWDM and the proposed calibration protocol are validated in five indoor locations and five frequency bands (the downlink bands at 800, 900, 1800 and 2100 MHz and WiFi 2 GHz) using a tri-axial broadband antenna and a spectrum analyzer (SA). The calibration shows that the BWDM has a relatively low measurement uncertainty with a 68% confidence interval on its antenna apertures, in the range 3.4-5.5 dB. A maximum difference of 0.9 dB is obtained for the total exposure in the test areas between the measurements of the BWDM and SA, which is an excellent agreement.

<https://ieeexplore.ieee.org/document/8701577>

A SYSTEMATIC REVIEW OF IN VITRO AND IN VIVO RADIO FREQUENCY EXPOSURE METHODS

Hansen JW, Swartz EM, Cleveland JD, Asif SM, Brooks B, Braaten BD, Ewert D. A systematic review of in vitro and in vivo radio frequency exposure methods. IEEE Rev Biomed Eng. 2019 Apr 18. doi: 10.1109/RBME.2019.2912023.

Abstract

The interests in the effects of radio frequency (RF) on biological systems has increased. This interest has increased partially due to the advancements and increase implementations of RF into technology. As research in the area has progressed, the reliability and reproducibility of those experiments has not crossed multidisciplinary boundaries. Therefore, as researchers, it is imperative to understand the various exposure systems available as well as the aspects, both electromagnetic and biological, needed to produce a sound exposure experiment. This systematic review examines common radio frequency exposure methods for both in vitro and in vivo studies. For in vitro studies, discussion of possible biological limitations to consider were also emphasized. The validity of the examined methods, for both in vitro and in vivo, were analyzed by discussing the advantages and disadvantages of each. This review offers guidance for researchers to assist in the development of an RF exposure experiment that crosses current multidisciplinary boundaries.

<https://www.ncbi.nlm.nih.gov/pubmed/30998481>

Conclusion

In a field that continues to struggle with reproducible results, the use of detailed, rigorous, reproducible, and transparent methodologies are critical moving forward. This detail needs to be thoroughly recorded for both the electromagnetic and the biological components of these exposure studies in order for the results to be reliable. Biological conditions and controls need to be considered as well in order to produce a reliable and reproducible experiment. Consideration of both the electromagnetic and biological components of the study should be detailed within these methodologies in order to provide reproducibility to the field. In addition, the realization that researchers are investigating a complex adaptive system is important in determining the impact of comparisons made between study and methods due to the difficulty in determining if the result is due to test exposure or because of the nature of the system. This review provides a systematic overview of common exposure methods in both in vitro and in vivo exposures, as well as providing advantages and disadvantages of each method. The goal of this being that researchers have a better understanding of methods they decide to use, and conclusions made given the results of studies which share similar scopes.

DIRECT AND INDIRECT EFFECTS OF EXPOSURE TO 900 MHZ GSM RF EMF ON CHO CELL LINE: EVIDENCE OF BYSTANDER EFFECT BY NON-IONIZING RADIATION

Jooyan N, Goliaei B, Bigdeli B, Faraji-Dana R, Zamani A, Entezami M, Mortazavi SMJ. Direct and indirect effects of exposure to 900 MHz GSM radiofrequency electromagnetic fields on CHO cell line: Evidence of bystander effect by non-ionizing radiation. *Environ Res.* 2019 Apr 1. pii: S0013-9351(19)30197-5. doi: 10.1016/j.envres.2019.03.063.

Highlights

- Short-term exposure to radiofrequency radiation (RFR) emitted from mobile phones may cause genotoxic effects.
- RFR has both targeted and non-targeted effects on cells.
- RFR-induced non-targeted effects include bystander effect.
- The biological effects of RFR are possibly mediated by oxidative stress.
- Extracellular ROS can trigger molecular signals in non-targeted cells.

Abstract

INTRODUCTION: The rapid rise in global concerns about the adverse health effects of exposure to radiofrequency radiation (RFR) generated by common devices such as mobile phones has prompted scientists to further investigate the biological effects of these environmental exposures. Non-targeted effects (NTEs) are responses which do not need a direct exposure to be expressed and are particularly significant at low energy radiations. Although NTEs of ionizing radiation are well documented, there are scarcely any studies on non-targeted responses such as bystander effect (BE) after exposure to non-ionizing radiation. The main goal of this research is to study possible RFR-induced BE.

MATERIAL AND METHODS: Chinese hamster ovary cells were exposed to 900 MHz GSM RFR at an average specific absorption rate (SAR) of 2 W/kg for 4, 12 and 24 hours (h). To generate a uniformly distributed electromagnetic field and avoid extraneous RF exposures a cavity was designed and used. Cell membrane permeability, cell redox activity, metabolic and mitotic cell death and DNA damages were analyzed. Then the most effective exposure durations and statistically significant altered parameters were chosen to assess the induction of BE through medium transfer procedure. Furthermore, intra and extra cellular reactive oxygen species (ROS) levels were measured to assess the molecular mechanism of BE induced by non-ionizing radiation.

RESULTS: No statistically significant alteration was found in cell membrane permeability, cell redox activity, metabolic cell activity and micronuclei (MN) frequency in the cells directly exposed to RFR for 4, 12, or 24 h. However, RFR exposure for 24 h caused a statistically significant decrease in clonogenic ability as well as a statistically significant increase in olive moment in both directly exposed and bystander cells which received media from RFR-exposed cells (conditioned culture medium; CCM). Exposure to RFR also statistically significant elevated both intra and extra cellular levels of ROS.

CONCLUSION: Our observation clearly indicated the induction of BE in cells treated with CCM. To our knowledge, this is the first report that a non-ionizing radiation (900 MHz GSM RFR) can induce bystander effect. As reported for ionizing radiation, our results proposed that ROS can

be a potential molecule in indirect effect of RFR. On the other hand, we found the importance of ROS in direct effect of RFR but in different ways.

<https://www.ncbi.nlm.nih.gov/pubmed/31036329>

EFFECTS OF MOBILE PHONE EMF ON β -AMYLOID-INDUCED OXIDATIVE STRESS IN HUMAN AND RAT PRIMARY ASTROCYTES

Tsoy A, Saliev T, Abzhanova E, Turgambayeva A, Kaiyrylykzy A, Akishev M, Saparbayev S, Umbayev B, Askarova

S. The Effects of Mobile Phone Radiofrequency Electromagnetic Fields on β -Amyloid-Induced Oxidative Stress in Human and Rat Primary Astrocytes. *Neuroscience*. Published online Apr 3, 2019. <https://doi.org/10.1016/j.neuroscience.2019.03.058>

Highlights

- EMF of 918 MHz decreases A β ₄₂- induced cellular and mitochondrial ROS in human and rat primary astrocytes.
- EMF of 918 MHz increases mitochondrial membrane potential in rat primary astrocytes.
- EMF of 918 MHz suppresses induced by A β ₄₂ activation of NADPH oxidase in rat primary astrocytes.
- EMF of 918 MHz suppresses H₂O₂-induced phosphorylation of p38MAPK and ERK 1/2 in rat primary astrocytes.

Abstract

Amyloid beta peptide (A β) is implicated in the development of pathological reactions associated with Alzheimer's disease (AD), such as oxidative stress, neuro-inflammation and death of brain cells. Current pharmacological approaches to treat AD are not able to control the deposition of A β and suppression of A β - induced cellular response. There is a growing body of evidence that exposure to radiofrequency electromagnetic field (RF-EMF) causes a decrease of beta-amyloid deposition in the brains and provides cognitive benefits to Alzheimer's Tg mice. Herein, we investigated the effects of mobile phone radiofrequency EMF of 918 MHz on reactive oxygen species (ROS) formation, mitochondrial membrane potential (MMP), activity of NADPH-oxidase, and phosphorylation of p38MAPK and ERK1/2 kinases in human and rat primary astrocytes in the presence of A β ₄₂ and H₂O₂. Our data demonstrate that EMF is able to reduce A β ₄₂- and H₂O₂-induced cellular ROS, abrogate A β ₄₂-induced production of mitochondrial ROS and the co-localization between the cytosolic (p47- phox) and membrane (gp91-phox) subunits of NADPH oxidase, while increasing MMP, and inhibiting H₂O₂- induced phosphorylation of p38MAPK and ERK1/2 in primary astrocytes. Yet, EMF was not able to modulate alterations in the phosphorylation state of the MAPKs triggered by A β ₄₂. Our findings provide an insight into the mechanisms of cellular and molecular responses of astrocytes on RF-EMF exposure and indicate the therapeutic potential of RF-EMF for the treatment of Alzheimer's disease.

Excerpt

In summary, our data showed that EMF treatment of brain cells with parameters similar to irradiation from the ordinary mobile phone (918 MHz; GSM) was capable of suppressing oxidative stress triggered by A β ₄₂ and H₂O₂, thus indicating its possible therapeutic benefit.

Our data conform to the previous reports on beneficial impact of EMF that can be employed for the treatment of neurodegenerative disorders such as Alzheimer's disease. However, further studies are needed to validate the effectiveness and safety of EMF application in AD patients. <https://www.sciencedirect.com/science/article/abs/pii/S0306452219302337>

RADIOPHYSICAL MICROWAVE INSTALLATION FOR INVESTIGATING BIOLOGICAL EFFECTS IN MICE WITH TUMOR

Kryukova OV, Pyankov VF, Salomatov YP, Kopylov AF. Radiophysical microwave installation for investigating biological effects in mice with tumor. 2019 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering (EIConRus). 28-31 Jan. 2019. DOI: 10.1109/EIConRus.2019.8657031.

Abstract

Designing radiophysical devices for investigating the effect of microwave radiation on biological objects is one of the main directions in applied modern radio-electronics. An installation for investigating the radiophysical microwave radiation effects on laboratory animals has been developed, with the frequency being 915 MHz, power of electromagnetic radiation being 10 $\mu\text{W}/\text{cm}^2$. The results obtained demonstrate the survival rate of mice with tumor under the influence of electromagnetic field.

Excerpts

The laboratory animals were exposed to microwave EMR at a frequency of 915 MHz, with the energy flux density being 10 $\mu\text{W} / \text{cm}^2$ and 100 $\mu\text{W} / \text{cm}^2$ As a model tumor, Ehrlich ascites carcinoma was used. Ehrlich ascites carcinoma is one of the most common tumors used as a model in scientific research....

After the tumor transplantation the animals were divided into three groups: the control and two experimental ones. (EMR group exposed to 10 $\mu\text{W}/\text{cm}^2$ and EMR group exposed to 100 $\mu\text{W}/\text{cm}^2$). The animals of the experimental groups were daily subjected to electromagnetic radiation for 1 hour during 10 days. The control group was kept under the same conditions without the influence of the electromagnetic radiation. In the course of the experiment the mortality of the animals was recorded during 45 days after the beginning of the tumor transplantation.

Thus, independently on the power, the impact of microwave radiation changes the lifetime of the animals with Ehrlich ascites carcinoma. In this case, using the power of 10 $\mu\text{W} / \text{cm}^2$ slows down the animal death and the power of 100 $\mu\text{W}/\text{cm}^2$ decreases the lifetime of the animals. However, in the group exposed to 100 $\mu\text{W}/\text{cm}^2$ no tumor developed after the transplantation. Using the mathematical methods of analysis the author [10], [11] show that there is a connection between the development of cancer diseases among the population and the main factors of the electromagnetic load due to EMR when using MRT as a carcinogenic factor or a factor contributing to cancer genesis. Moreover, some researchers suggest that radiofrequency fields can act as cancer promoters [12]. Thus, it is important to study the impact of electromagnetic microwave radiation on the growth dynamics of tumor cells and their functional condition, for example, in order to estimate the degree of risk of tumor progressing. Consequently, it is necessary to develop a method of estimating the carcinogenic risk under the impact of microwave radiation, in particular to improve the suggested and

implemented measures for minimizing unfavorable and harmful effects. It is dangerous to underestimate as well as to overestimate the risk of the impact for the given widely spread factor.

<https://ieeexplore.ieee.org/document/8657031>

LONG-TERM EXPOSURE OF 2450 MHZ ELECTROMAGNETIC RADIATION INDUCES STRESS AND ANXIETY LIKE BEHAVIOR IN RATS

Gupta SK, Patel SK, Tomar MS, Singh SK, Mesharam MK, Krishnamurthy S. Long-term exposure of 2450 MHz electromagnetic radiation induces stress and anxiety like behavior in rats. *Neurochemistry International*. Publ. online Apr 4, 2019.

Highlights

- EMR-2450 MHz induces stress and aggravates anxiety-like symptoms in rats.
- Exposure of EMR-2450 MHz increases plasma corticosterone level and, expression of CRH-2 and GR in amygdala.
- Increased expression of cytochrome-C and caspase-9 indicating mitochondrial dysfunction and activation of apoptosis.
- Change in expression of mitochondrial Bax: Bcl2 ratio indicating modulation of apoptosis.
- EMR-2450 MHz exposure causes both amygdalar necrotic and apoptotic cell death.

Abstract

Long term exposure of electromagnetic radiations (EMR) from cell phones and Wi-Fi hold greater propensity to cause anxiety disorders. However, the studies investigating the effects of chronic exposure of EMR are limited. Therefore, we investigated the effects of repeated exposure of discrete frequency of EMR in experimental animals. Male rats were exposed to EMR (900, 1800 and 2450 MHz) for 28 (1 h/day) days. Long term exposure of EMR (2450 MHz) induced anxiety like behavior. It deregulated the hypothalamic pituitary adrenal (HPA) axis in rats as observed by increase in plasma corticosterone levels apart from decreased corticotrophin releasing hormone-2 (CRH-2) and Glucocorticoid receptor (GR) expression in amygdala. Further, it impaired mitochondrial function and integrity. The expression of Bcl2 showed significant decrease while Bax and ratio of Bax: Bcl2 were increased in the mitochondria and vice versa in cytoplasm indicating altered regulation of apoptosis. EMR exposure caused release of cytochrome-c and expression of caspase-9 ensuing activation of apoptotic cell death. Additional set of experiments performed to estimate the pattern of cell death showed necrotic and apoptotic amygdalar cell death after EMR exposure. Histopathological studies also revealed a significant decrease in neuronal cells in amygdala. The above findings indicate that long-term exposure of EMR radiation (2450 MHz) acts as a stressor and induces anxiety-like behaviors with concomitant pathophysiological changes in EMR subjected rats.

Excerpts

The average power density was 0.1227 W/m². The whole body SAR values was found in between the 0.025– 0.070 W/kg range, representing an average SAR value to be approximately 0.042 W/kg. The value of SAR in head region was found to be 0.131 W/kg (900,

1800 and 2450 MHz) with a value of power density 0.1227 W/m².... All the rats were distributed into four different groups of six each. They were designated as control, EMR-900, EMR-1800 and EMR-2450. The groups, EMR-900 MHz, EMR-1800 MHz and EMR-2450 MHz were continuously exposed to electromagnetic radiations between 10 a.m. and 1 p.m. for 1 h for 28 days beginning from D-1. After 15 min of EMR exposure on D-1 to D-28 at 7 day interval, behavioral assessments were performed....

In this study, we have shown that rats sub-chronically exposed to EMR at a frequency of 2450 MHz exhibited anxiety-like symptoms. Repeated EMR-2450 MHz exposure caused an increase in corticosterone levels while the expression of CRH-2 and GR expression were significantly reduced in amygdala. EMR exposed animals showed alterations in the mitochondrial function and integrity. It also induced apoptotic factors leading to decrease of neuronal cells in the amygdalar region....

<https://www.ncbi.nlm.nih.gov/pubmed/30954502>

Note: This was not Wi-Fi because the signals were not modulated.

EFFECTS OF 220 MHZ PULSED MODULATED RADIOFREQUENCY FIELD ON THE SPERM QUALITY IN RATS

Guo L, Lin JJ, Xue YZ, An GZ, Zhang JP, Zhang KY, He W, Wang H, Li W, Ding GR. Effects of 220 MHz Pulsed Modulated Radiofrequency Field on the Sperm Quality in Rats. *Int J Environ Res Public Health*. 2019 Apr 10;16(7). pii: E1286. doi: 10.3390/ijerph16071286.

Abstract

Under some occupational conditions, workers are inevitably exposed to high-intensity radiofrequency (RF) fields. In this study, we investigated the effects of one-month exposure to a 220 MHz pulsed modulated RF field at the power density of 50 W/m² on the sperm quality in male adult rats. The sperm quality was evaluated by measuring the number, abnormality and survival rate of sperm cells. The morphology of testis was examined by hematoxylin-eosin (HE) staining. The levels of secreting factors by Sertoli cells (SCs) and Leydig cells (LCs) were determined by enzyme linked immunosorbent assay (ELISA). The level of cleaved caspase 3 in the testis was detected by immunofluorescence staining. Finally, the expression levels of the apoptosis-related protein (caspase 3, BAX and BCL2) in the testis were assessed by Western blotting. Compared with the sham group, the sperm quality in the RF group decreased significantly. The levels of secreting factors of SCs and the morphology of the testis showed an obvious change after RF exposure. The level of the secreting factor of LCs decreased significantly after RF exposure. The levels of cleaved caspase 3, caspase 3, and the BAX/BCL2 ratio in the testis increased markedly after RF exposure. These data collectively suggested that under the present experimental conditions, 220 MHz pulsed modulated RF exposure could impair sperm quality in rats, and the disruption of the secreting function of LCs and increased apoptosis of testis cells induced by the RF field might be accounted for by this damaging effect.

<https://www.ncbi.nlm.nih.gov/pubmed/30977029>

ASSESSMENT OF THE EFFECTS OF RADIOFREQUENCY RADIATION ON HUMAN COLON EPITHELIUM CELLS

Tomruk A, Terzi YK, Guler GO. Assessment of the effects of radiofrequency radiation on human colon epithelium cells. Bratisl Lek Listy. 2019;120(4):299-308. doi: 10.4149/BLL_2019_050.

Abstract

OBJECTIVES: The aim of the study was to investigate the possible effects of radiofrequency radiation (RFR) at different frequencies for different exposure durations on caspase-dependent apoptosis pathways in human colon adenocarcinoma (HT-29).

METHODS: HT-29 cells were exposed to 1800 MHz; 2100 MHz and 2600 MHz RFR for 3 h cont., 6 h int. and 6 h cont.. Cell viability measurements were performed by Trypan Blue exclusion assay and the gene expressions of CASP8, CASP9, CASP3 and CASP12 were analyzed using qRT-PCR.

RESULTS: Exposure to 2100 MHz RFR for all 3 durations of exposures was more effective for the ratio of the number of viable HT-29 cells w.r.t 1800 MHz RFR and 2600 MHz RFR exposures. After 2100 MHz RFR exposure, caspase activation increased significantly (for 3h cont. and 6 h int. exposures CASP8 and CASP9 levels; for 6 h cont. exposure CASP3 levels) (p 0.05).

CONCLUSION: Decreases in the cell viability of HT-29 cells for certain frequencies and also durations are consistent with significant increases in caspase activations. The results of caspase activation after 1800 MHz or 2600 MHz RFR exposures can be interpreted as the activation of different types of cell death pathway by caspase signaling cascades (Fig. 15, Ref. 56).

<https://www.ncbi.nlm.nih.gov/pubmed/31023054>

EFFECT OF CELL PHONE RADIATION ON NEUTROPHIL OF MICE

Pei Y, Gao H, Li L, An X, Tian Q. Effect of cell phone radiation on neutrophil of mice. Int J Radiat Biol. 2019 Apr 23:1-22. doi: 10.1080/09553002.2019.1607605.

Abstract

Purpose The present study aims to evaluate the effect of cell phone radiation on neutrophil of mice.

Materials and methods 40 male BALB/C mice were randomly broken up into 4 groups as control, blank control, TD-CDMA and LTE-Advanced groups respectively. Mice were exposed to cell phone radiation for a period of 6 weeks. Then numbers of neutrophil were detected by fully automatic haematology analyzer. Soft agar diffusion method was performed to assess the chemotaxis of neutrophils while the phagocytosis of neutrophils was determined by measuring the staphylococcus albus phagocytosis percentage. Apoptosis was analyzed by flow cytometry.

Results No significant differences were observed among the control and exposure groups regarding the numbers of neutrophils after 2 weeks' exposure to cell phone radiation, while the numbers of neutrophils in TD-SCDMA and LTE-Advanced groups were seen to rise after an exposure of 4 or 6 weeks. No effect was observed on chemotaxis of neutrophils due to phone radiation. The phagocytosis of neutrophils was decreased while the apoptosis were increased both in TD-SCDMA and LTE-Advanced groups after 6 weeks exposure.

Conclusions Mobile phone radiation could give rise to increase of neutrophil numbers yet with no effect whatever on neutrophils chemotaxis, and the radiation was likely to cause decrease of phagocytosis and induced apoptosis of neutrophils.

<https://www.ncbi.nlm.nih.gov/pubmed/31012799>

EFFECTS OF 50 HZ MAGNETIC FIELDS ON CIRCADIAN RHYTHM CONTROL IN MICE

Lundberg L, Sienkiewicz Z, Anthony DC, Broom KA. Effects of 50 Hz magnetic fields on circadian rhythm control in mice. Bioelectromagnetics. 2019 Apr 4. doi: 10.1002/bem.22188.

Abstract

Artificial light and power frequency magnetic fields are ubiquitous in the built environment. Light is a potent zeitgeber but it is unclear whether power frequency magnetic fields can influence circadian rhythm control. To study this possibility, 8-12-week-old male C57BL/6J mice were exposed for 30 min starting at zeitgeber time 14 (ZT14, 2 h into the dark period of the day) to 50 Hz magnetic fields at 580 μ T using a pair of Helmholtz coils and/or a blue LED light at 700 lux or neither. Our experiments revealed an acute adrenal response to blue light, in terms of increased adrenal per1 gene expression, increased serum corticosterone levels, increased time spent sleeping, and decreased locomotor activity (in all cases, $P < 0.0001$) compared to an unexposed control group.

There appeared to be no modulating effect of the magnetic fields on the response to light, and there was also no effect of the magnetic fields alone (in both cases, $P > 0.05$) except for a decrease in locomotor activity ($P < 0.03$). Gene expression of the cryptochromes cry1 and cry2 in the adrenals, liver, and hippocampus was also not affected by exposures (in all cases, $P > 0.05$). In conclusion, these results suggest that 50 Hz magnetic fields do not significantly affect the acute light response to a degree that can be detected in the adrenal response.

<https://www.ncbi.nlm.nih.gov/pubmed/30945762>

THE CELLULAR EFFECTS OF PULSED ELECTROMAGNETIC FIELDS ON OSTEOBLASTS: A REVIEW

Galli C, Pedrazzi G, Guizzardi S. The cellular effects of Pulsed Electromagnetic Fields on osteoblasts: A review. Bioelectromagnetics. 2019 Mar 25. doi: 10.1002/bem.22187.

Abstract

Electromagnetic fields (EMFs) have long been known to interact with living organisms and their cells and to bear the potential for therapeutic use. Among the most extensively investigated applications, the use of Pulsed EMFs (PEMFs) has proven effective to ameliorate bone healing in several studies, although the evidence is still inconclusive. This is due in part to our still-poor understanding of the mechanisms by which PEMFs act on cells and affect their functions and to an ongoing lack of consensus on the most effective parameters for specific clinical applications. The present review has compared in vitro studies on PEMFs on

different osteoblast models, which elucidate potential mechanisms of action for PEMFs, up to the most recent insights into the role of primary cilia, and highlight the critical issues underlying at least some of the inconsistent results in the available literature <https://www.ncbi.nlm.nih.gov/pubmed/30908726>

Excerpt

Two main stimulation regimes possess the most evidence supporting their biological action: a 75 Hz, 1.5–2.5 mT PEMF stimulation with trapezoidal waves and a 0.3–1.8 mT, 15 Hz PRF PEMF stimulation with carrier frequency of about 4 kHz, which correspond to the most common, commercially available clinical stimulation devices. These choices appear to be rooted in habit or equipment availability rather than a systematic screening, which is still needed in the osteoblast field.

Taken together, the literature on in vitro studies on osteoblasts seem to solidly support an effect of PEMFs on osteoblastic differentiation, and several works have reported a modulation of the RANKL/OPG axis [Chang et al., 2005; Borsje et al., 2010; Jansen et al., 2010; He et al., 2018; Wang et al., 2018], which is central to bone homeostasis. Moreover, there is robust and consistent evidence that BMP-2 [Bodamyali et al., 1998; Patterson et al., 2006; Selvamurugan et al., 2007; Yan et al., 2015; Wang et al., 2019], TGF- β [Lohmann et al., 2000; Patterson et al., 2006; Selvamurugan et al., 2017], and Wnt [Lin et al., 2015; Zhou et al., 2015; Zhai et al., 2016] signaling are modulated in osteoblasts by PEMFs.

It has been long known that cell membrane appears at the center of the effects of PEMFs because of their action on ion channels, most noticeably calcium channels, and the release of bioactive factors and membrane trafficking. Most recently, primary cilia have been reported to play a role in transducing PEMF signaling to cells [Yan et al., 2015; Xie et al., 2016; Wang et al., 2018] and could provide a unifying theory to explain differences in cell responsiveness depending on their differentiation stage and the involvement of signaling pathways that could all be regulated at the receptor level by an effect on membrane trafficking. Besides biochemical signaling, therefore, a closer attention to morphology is probably needed in any new study on osteoblasts and PEMFs.

Reports of morphological effects of PEMFs on cells are sporadic but consistent [Noriega-Luna et al., 2011; Wang et al., 2018], and they might be central to a more correct interpretation of the latest data to better understand the cellular targets of PEMFs and therefore improve their clinical use.

RADIOFREQUENCY ELECTROMAGNETIC FIELD EXPOSURE AND THE RESTING EEG: EXPLORING THE THERMAL MECHANISM HYPOTHESIS

Loughran SP, Verrender A, Dalecki A, Burdon CA, Tagami K, Park J, Taylor NAS, Croft RJ. Radiofrequency Electromagnetic Field Exposure and the Resting EEG: Exploring the Thermal Mechanism Hypothesis. *Int J Environ Res Public Health*. 2019 Apr 28;16(9). pii: E1505. doi: 10.3390/ijerph16091505.

Abstract

There is now strong evidence that radiofrequency electromagnetic field (RF-EMF) exposure influences the human electroencephalogram (EEG). While effects on the alpha band of the resting EEG have been repeatedly shown, the mechanisms underlying that effect have not been established. The current study used well- controlled methods to assess the RF-EMF exposure effect on the EEG and determine whether that effect might be thermally mediated. Thirty-six healthy adults participated in a randomized, double-blind, counterbalanced provocation study. A water-perfusion suit (34 C) was worn throughout the study to negate environmental influences and stabilize skin temperature. Participants attended the laboratory on four occasions, the first being a calibration session and the three subsequent ones being exposure sessions. During each exposure session, EEG and skin temperature (8 sites) were recorded continuously during a baseline phase, and then during a 30 min exposure to a 920 MHz GSM-like signal (Sham, Low RF-EMF (1 W/kg) and High RF-EMF (2 W/kg)). Consistent with previous research, alpha EEG activity increased during the High exposure condition compared to the Sham condition. As a measure of thermoregulatory activation, finger temperature was found to be higher during both exposure conditions compared to the Sham condition, indicating for the first time that the effect on the EEG is accompanied by thermoregulatory changes and suggesting that the effect of RF-EMF on the EEG is consistent with a thermal mechanism.

Open access paper: <https://www.mdpi.com/1660-4601/16/9/1505>

ION CYCLOTRON RESONANCE: GEOMAGNETIC STRATEGY FOR LIVING SYSTEMS?

Liboff AR. ION cyclotron resonance: Geomagnetic strategy for living systems? *Electromagn Biol Med*. 2019 Apr 27;1-6. doi: 10.1080/15368378.2019.1608234.

Abstract

Except for relatively few polarity reversals the magnitude of the magnetic dipole moment of the earth has remained constant since life first began, allowing evolutionary processes to integrate the geomagnetic field (GMF) into several biological functions. One of these, bearing the classical signature of an ion cyclotron resonance (ICR)-like interaction, results in biological change associated with enhanced proton transport. The wide range of cation masses over which this effect is found suggest a fundamental biological dependence on the GMF, one that functions equally well for electric as well as magnetic fields. Such generalization of ICR requires two things: transparency of tissues to the GMF and suitably tuned ELF resonant magnetic or electric fields. To complement the widely reported ICR responses to applied AC magnetic fields, we hypothesize the existence of weak endogenous ICR electric field oscillations within the cell. This equivalence implies that even in the absence of applied AC magnetic fields, biological systems will exhibit intrinsic GMF-dependent ion cyclotron resonance intracellular interactions. Many ICR effects that have been reported appear as

antagonist pairs suggesting that the characteristics of the GMF have not only been incorporated into the genome but also appear to function in an endocrine-like manner.

<https://www.ncbi.nlm.nih.gov/pubmed/31017814>

CARDIOVASCULAR RESPONSE AS A MARKER OF ENVIRONMENTAL STRESS CAUSED BY VARIATIONS IN GEOMAGNETIC FIELD AND LOCAL WEATHER

Pishchalnikova RY, Gurfinkel YI, Sarimov RM, Vasin AL, Sasonko ML, Matveeva TA, Binhi VN, Baranov MB. Cardiovascular response as a marker of environmental stress caused by variations in geomagnetic field and local weather. Biomedical Signal Processing and Control . 51:401-410. May 2019. <https://doi.org/10.1016/j.bspc.2019.03.005>

Highlights

- A Helmholtz-like magnetic field exposure system adapted for long-term experiments.
- Three modes of magnetic field exposure including geomagnetic storm have been used.
- Correlations of heart rate with magnetic field are criterion of cardiovascular response.
- Maximum cardiovascular response has been detected for the storm mode of exposure.
- Time-frequency representation of heart rate for each subject has individual character.

Abstract

We report the results of a physiological study that include ECG analysis, capillary blood velocity (CBV) data, and blood pressure (BP) measurements obtained under conditions of modified external magnetic field (MF). Each of eight volunteers was sequentially exposed to MFs of three different types for 22 h. A Helmholtz-like MF exposure system was used. The system was specially designed for long-term exposures of human beings to static and low frequency MFs. The MF of the first type reproduced an initially recorded geomagnetic storm (GS). The MF inductions of the other two types were about 55 and 49 μ T, which corresponded to the natural local magnetic background and a slightly decreased MF, respectively. In all three cases, the environmental magnetic fluctuations were suppressed by the active Helmholtz system. The variability of RR intervals[the time elapsed between two successive R-waves of the QRS signal on the electrocardiogram] was considered as a key indicator of cardiovascular response to the MFs and weather conditions. A time-frequency representation (TFR) and a frequency-frequency representation (FFR) were used for processing of the time series of RR intervals. It turned out that the transformation to TFR makes it possible to obtain the characteristic matrix of RR intervals; such a matrix can be used as a subject identifier. FFR was used to calculate correlations of RR intervals with the components of the MFs. The averaged correlation coefficients of RR intervals with the Bx and By components appeared significantly higher ($p < 0.001$) during the Storm mode in comparison with control. Thus, it is shown that artificial geomagnetic storm can cause a detectable cardiovascular response.

<https://www.sciencedirect.com/science/article/abs/pii/S1746809419300795>

EVALUATION OF IN VIVO EXPOSURE TO ELF MAGNETIC FIELDS ON PLASMA LEVELS OF PRO-INFLAMMATORY CYTOKINES IN RATS

Wyszkowska J, Jędrzejewski T, Piotrowski J, Wojciechowska A, Stankiewicz M, Kozak W. Evaluation of the influence of in vivo exposure to extremely low-frequency magnetic fields on the plasma levels of pro-inflammatory cytokines in rats. *Int J Radiat Biol.* 2018 Oct;94(10):909-917. doi: 10.1080/09553002.2018.1503428.

Abstract

PURPOSE: Epidemiological data suggest that there is a link between exposure to extremely low-frequency magnetic fields (ELF-MFs), immune response, and the occurrence of neurodegenerative diseases. The exact nature of this phenomenon remains speculative and requires detailed laboratory investigation. In the present study, we evaluate changes in plasma concentration of pro-inflammatory and regulatory cytokines as well as alternations of the hematological parameters in rats exposed to an ELF-MF.

MATERIALS AND METHODS: Male Wistar rats were repeatedly exposed for either 1 h/day for 7 days, or continuously for 24 h, to a sinusoidal ELF-MF (50 Hz, 7 mT). Control groups were sham exposed for either 1 h/day for 7 days, or continuously for 24 h, respectively. The levels of cytokines: interleukin (IL)-1 β , IL-2, IL-6, and IL-10 in plasma obtained from blood samples were determined using enzyme-linked immunosorbent assay (ELISA). The changes in blood parameters were determined using an automatic hematology analyzer in whole blood samples immediately after collection.

RESULTS: We found that a single continuous (lasting 24 h) exposure provoked a significant increase of the plasma IL-1 β , IL-6, and IL-2 levels, and caused an elevation in blood parameters, such as white blood cells, lymphocytes, hemoglobin, and hematocrit levels. In contrast, however, repetitive exposure of rats to an ELF-MF for 1 h/day for 7 days did not lead to any changes in plasma levels of cytokines and hematological counts.

CONCLUSIONS: Based on these data we conclude that exposure duration (dose-response) plays a significant role in the immune response, specifically at the cellular level. While single 24 h-lasting exposure provoked changes that indicate an immune alarm stimulation, under the conditions which are typical for therapeutic use of ELF-MFs (repeated short daily exposure) the immune potentially harmful response has not been observed.

<https://www.ncbi.nlm.nih.gov/pubmed/30028649>

EFFECTS OF ELF EMF ON C-MAF, STAT6, AND ROR α EXPRESSIONS IN SPLEEN AND THYMUS OF RAT

Mahaki H, Jabarivasal N, Sardarian K, Zamani A. The effects of extremely low-frequency electromagnetic fields on c-Maf, STAT6, and ROR α expressions in spleen and thymus of rat. *Electromagn Biol Med.* 2019 Apr 24:1-7. doi: 10.1080/15368378.2019.1608832.

Abstract

The study investigated the effect of extremely low-frequency electromagnetic fields (ELF-EMFs) exposure at different magnetic flux densities on genes expression of transcription factor Maf (c-Maf), signal transducer and activator of transcription 6 (STAT6), and retinoid-related orphan receptor alpha (ROR α) in the spleen and

thymus of rats. Eighty adult male rats were separated into four ELF-EMFs exposed and were exposed to magnetic flux densities of 1, 100, 500, and 2000 μ T at a frequency of 50 Hz for 2 h daily for up to 60 d. All rats were intraperitoneally immunized on d 31, 44, and 58 of exposure. The experimental results showed that the expression levels of c-Maf, STAT6, and ROR α in the thymus were not significantly changed at different magnetic flux densities. The expression levels of ROR α and c-Maf were significantly downregulated at the densities of 1 and 100 μ T, while the expression of STAT6 was only significantly decreased at the density of 100 μ T. In conclusion, low magnetic flux densities of ELF-EMFs may reduce the expression levels of c-Maf, STAT6, and ROR α genes in the spleen.

<https://www.ncbi.nlm.nih.gov/pubmed/31017814>

EFFECTS OF CONTINUOUS EXPOSURE TO POWER FREQUENCY ELECTRIC FIELDS ON SOYBEAN GLYCINE MAX

Li X, Liu X, Wan B, Li X, Li M, Zhu H, Hua H. Effects of continuous exposure to power frequency electric fields on soybean Glycine max. *J Environ Radioact.* 2019 Apr 5;204:35-41. doi: 10.1016/j.jenvrad.2019.03.026.

Abstract

With the increasing density of high voltage transmission systems, the potential risks and hazards of environmental electric fields (EFs) generated by these systems to surrounding organisms is becoming a source of public concern. To evaluate the effect of environmental EFs on plants, we used soybean as a model and systematically evaluated the effect of continuous exposure to different intensities (0 kV/m, 2 kV/m, and 10 kV/m) of power frequency EFs on agronomic characters, yield, nutrient contents, protective enzyme activities, and gene transcription. We found that the effects on soybean were more pronounced when plants were exposed to EF during development (especially at the seedling stage) than when they were exposed at maturity. The functional leaf number, stem diameter, plant dry weight, and pod number were largely unaffected by EF, while the germination rate and protective enzyme activities increased with increasing EF intensity. In plants exposed to low-intensity EF (2 kV/m), some agronomic characters, including chlorophyll content, plant height, and bean dry weight, as well as the soluble sugar and total protein contents, were significantly higher than those of plants exposed to high-intensity EF (10 kV/m) and control plants (0 kV/m). Through transcriptome analysis, we found that 2,977 genes were significantly up-regulated and 1,462 genes were down-regulated when plants were exposed to EF. These differentially expressed genes mainly encode ribosome proteins and related enzymes involved in carbon metabolism pathway, providing a novel perspective for understanding molecular mechanisms underpinning the responses to EF stress in soybean.

<https://www.ncbi.nlm.nih.gov/pubmed/30959328>

The "Moscow signal" epidemiological study, 40 years on

Martinez JA. The "Moscow signal" epidemiological study, 40 years on. *Reviews on Environmental Research*. 34(1):13-24. Mar 2019. doi: 10.1515/reveh-2018-0061.

Abstract

Between 1953 and 1979, the USSR irradiated the United States embassy in Moscow with microwaves. This episode, a classic Cold War affair, has acquired enormous importance in the discussions on the effect of non- ionizing radiation on people's health. In 2011, the International Agency for Research on Cancer (IARC) classified radiofrequency electromagnetic fields as being a possible human carcinogen (Group 2B), but the results of recent laboratory and epidemiological studies have led some researchers to conclude that radiofrequency electromagnetic fields should be reclassified as a human carcinogen instead of merely a possible human carcinogen. In 1978, the "Moscow signal" case was officially closed after the publication of the epidemiological study of (Lilienfeld AM, Tonascia J, Tonascia S, Libauer CA, Cauthen GM. Foreign Service health status study.

Evaluation of health status of foreign service and other employees from selected Eastern European posts. Report on Foreign Service Health Status Study, U.S. Department of State 6025-619073, 1978), showing no apparent evidence of increased mortality rates and limited evidence regarding general health status. However, several loose ends still remain with respect to this epidemiological study, as well as the affair as a whole. In this paper, we summarize the available evidence concerning this case, paying special attention to the epidemiological study of Lilienfeld et al. After reviewing the available literature (including declassified documents), and after some additional statistical analyses, we provide new insights which do not complete the puzzle, but which may help to better understand it.

<https://www.ncbi.nlm.nih.gov/pubmed/30676008>

Conclusions

This event was just one of many that took place during the Cold War, and must therefore be assessed in the context of manipulation, political interests and classified information typical of the time. With the data in hand, with what we have been able to gather and what we have shown in this article, we can approach the truth, possibly even guess it, but not reveal it in its total dimension. And we will probably never be able to do so.

Those who, in the published results we have mentioned, use this event to deny the harmful effects of microwave radiation do not have enough evidence to support their position. There are too many loose ends, unanalyzed information, methodological flaws, and debatable interpretations.

However, on the opposite side of the debate, those who take this case as incontestable evidence of the harmful effects of microwaves on humans at low intensities, must also admit that there is a lack of statistical consistency in the results. There is still too much imprecision.

A global vision of the whole event, including the nuances and details that we have explained in this article, show the latter to be closer to the truth than the former, even more so when we consider non-carcinogenic effects linked to what is now associated with electrohypersensitivity. However, it must be recognized that the methodology used by

Lilienfeld et al. (1) also casts doubt on this claim, as the health status symptom questionnaires were filled in after the case was made public (nocebo effect). In addition, the results of our simulations are also partially dependent of the quality of data of Lilienfeld et al. (1), which were not complete, having a different degree of potential bias regarding mortality, cancer incidence and health status. Further research on the personnel of the Havana embassy who were recently subjected to a similar attack, could indirectly help to better understand what happened in Moscow more than 40 years ago.

Power densities measured at the Moscow embassy were higher than the average levels typically found nowadays in homes, schools and urban areas, and were of the same order of magnitude as the more extreme case of living just a few meters from a base station (see (19)). This means that exposure at the embassy could have been high in terms of today's typical levels of exposure. Nevertheless, the exposure was several orders of magnitude lower than those suggested by the ICNIRP guidelines, adopted by many countries as legal limits. As Hardell et al. (19) indicated, the BioInitiative Report (49) with updated references defined the scientific benchmark for possible health risks as 0.000003–0.000006 mW/cm². Consequently, the exposure at the Moscow embassy was from 3 to 4 orders of magnitude higher than this safety benchmark, but 3 orders of magnitude lower than the legal limits of many countries.

In any case, and as Frentzle-Beyme (50) stated, “The level of proof required to justify action for health protection should be less than that required to constitute causality as a scientific principle”. The “Moscow signal” remains a “signal”; let us not reject it, but listen to it instead.

RADIO FREQUENCY ELECTROMAGNETIC FIELD EXPOSURE ASSESSMENT FOR FUTURE 5G NETWORKS

Persia S, Carciofi C, Barbiroli M, Volta C, Bontempelli D, Anania G. Radio frequency electromagnetic field exposure assessment for future 5G networks. IEEE 29th Annual International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), 2018. IEEE, 2018. doi:10.1109/PIMRC.2018.8580919

Abstract

The fifth generation of mobile network (5G) will rely not only on the expansion of existing fourth (4G) Long Term Evolution (LTE) network, but thanks to the introduction of new radio access in the millimetre wave bands will allow to meet new requirements in terms of connectivity and capacity. Specifically, 5G network will be characterized by the use of new spectrum at higher frequencies with a very large number of antenna elements deployment. As a consequence, the RF EMF (Radio Frequency Electromagnetic Field) compliance assessments with the regulatory requirements for human exposure for the installation permission needs to be revised accordingly. In this work, a Country case (Italy), where a more restrictive regulatory framework than the ICNIRP Guidelines is applied, has been analysed to investigate the impact of the restrictive approach on the future 5G mobile networks roll-out.

Conclusions

The EMF evaluations of existing cellular networks has been analysed in this work in order to highlight how restrictive regulatory framework than International Guidelines can affect 5G and future network deployment. Italy case study is considered as an example, due to its restrictive regulation to verify if it can permit an efficient 5G roll-out. This consideration has

been confirmed by evaluations of the trend of saturated sites from 2010 to 2017 in Italy. Simulations demonstrate that in Italy the strong development expected for the evolution of 4G networks and, in the perspective of 5G systems, can be threatened with the stringent constraints imposed by the current regulatory framework for exposure to electromagnetic fields.

<https://ieeexplore.ieee.org/document/8580919>

Radio Frequency Electromagnetic Fields Exposure Assessment in Indoor Environments: A Review

Chiaromello E, Bonato M, Fiocchi S, Tognola G, Parazzini M, Ravazzani P, Wiart J. Radio Frequency Electromagnetic Fields Exposure Assessment in Indoor Environments: A Review. *Int J Environ Res Public Health*. 2019 Mar 17;16(6). pii: E955. doi: 10.3390/ijerph16060955.

Abstract

Exposure to radiofrequency (RF) electromagnetic fields (EMFs) in indoor environments depends on both outdoor sources such as radio, television and mobile phone antennas and indoor sources, such as mobile phones and wireless communications applications. Establishing the levels of exposure 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 ten years research efforts about RF EMF exposure in indoor environments, considering different RF-EMF sources found to cause exposure in indoor environments, different indoor environments and different approaches used to assess the exposure. The highest maximum mean levels of the exposure considering the whole RF-EMF frequency band was found in offices (1.14 V/m) and in public transports (0.97 V/m), while the lowest levels of exposure were observed in homes and apartments, with mean values in the range 0.13 - 0.43 V/m. The contribution of different RF-EMF sources to the total level of exposure was found to show slightly different patterns among the indoor environments, but this finding has to be considered as a time-dependent picture of the continuous evolving exposure to RF-EMF.

Open access paper: <https://www.mdpi.com/1660-4601/16/6/955>

ASSESSMENT OF RF EMF EXPOSURE FROM PERSONAL MEASUREMENTS CONSIDERING THE BODY SHADOWING EFFECT IN KOREAN CHILDREN AND PARENTS

Choi J, Hwang JH, Lim H, Joo H, Yang HS, Lee YH, Eeftens M, Struchen B, Rösli M, Lee AK, Choi HD, Kwon JH, HaM. Assessment of radiofrequency electromagnetic field exposure from personal measurements considering the body shadowing effect in Korean children and parents. *Sci Total Environ*. 2018 Jun 15;627:1544-1551. doi: 10.1016/j.scitotenv.2018.01.318.

Abstract

We aimed to assess the personal radiofrequency electromagnetic field (RF-EMF) exposure levels of children and adults through their activities, with consideration to the body shadowing effect. We recruited 50 child-adult pairs, living in Seoul, Cheonan, and Ulsan, South Korea. RF-EMF measurements were performed between September and December 2016, using a portable exposure meter tailored to capture 14 Korean radiofrequency (RF) bands ranging from 87.5 to 5875MHz. The participants carried the device for 48h and kept a time-activity diary using a smartphone application in flight mode. To enhance accuracy of the exposure assessment, the body shadowing effect was compensated during the statistical analysis with the measured RF-EMF exposure. The compensation was conducted using the

hybrid model that represents the decrease of the exposure level due to the body shadowing effect. A generalized linear mixed model was used to compare the RF-EMF exposure levels by subjects and activities. The arithmetic (geometric) means of the total power density were 174.9 (36.6) $\mu\text{W}/\text{m}^2$ for all participants, 226.9 (44.6) for fathers, 245.4 (44.8) for mothers, and 116.2 (30.1) for children. By compensating for the body shadowing effect, the total RF-EMF exposure increased marginally, approximately 1.4 times. Each frequency band contribution to total RF-EMF exposure consisted of 76.7%, 2.4%, 9.9%, 5.0%, 3.3%, and 2.6% for downlink, uplink, WiFi, FM Radio, TV, and WiBro bands, respectively. Among the three regions, total RF-EMF exposure was highest in Seoul, and among the activities, it was highest in the metro, followed by foot/bicycle, bus/car, and outside. The contribution of base-station exposure to total RF-EMF exposure was the highest both in parents and children. Total and base-station RF-EMF exposure levels in Korea were higher than those reported in European countries.

<https://www.ncbi.nlm.nih.gov/pubmed/30857115>

EMISSIONS FROM SMART METERS AND OTHER RESIDENTIAL RADIOFREQUENCY SOURCES

Aerts S, Verloock L, Van den Bossche M, Martens L, Vergara X, Joseph W. Emissions from smart meters and other residential radiofrequency sources. *Health Phys.* 2019 Mar 15. doi: 10.1097/HP.0000000000001032.

Abstract

The advent of the Internet of things comes with a huge increase in wirelessly communicating devices in our environment. For example, smart energy-consumption meters are being widely deployed in residences from which they communicate their state using radiofrequency networks. Accurate characterization of the radiofrequency emissions from emerging residential wireless solutions is important to inform the public about the potential impact on their exposure to radiofrequency electromagnetic fields. A new measurement procedure to determine the exposure from residential radiofrequency devices is proposed by assessing the peak emitted fields at various distances and the proportion of time they transmit (duty cycle). Radiofrequency emissions from 55 residential devices were measured in 10 residences (Belgium and France) and compared to environmental levels, emissions from 41 mobile phones, and international standards. Overall, residential levels of radiofrequency electromagnetic field exposure are low. In addition to the continuous environmental exposure, wireless access points (due to frequent use) and especially mobile phones and other personal communication devices (due to their use close to the body) continue to represent the bulk of the radiofrequency electromagnetic field exposure in the smart home. However, some residential devices can significantly increase the exposure if their duty cycles are high enough (>10%), especially when held or used close to the body. Individual smart meters, on the other hand, will contribute only little in general, despite emissions of up to 20 V per m at 50 cm, due to their low duty cycles (maximum 1%) and locations.

<https://www.ncbi.nlm.nih.gov/pubmed/30883437>

Conclusion

Overall, low to very low emissions were measured for nearly all of the devices, and it is concluded that, in addition to the continuous exposure due to environmental sources, when used, wireless access points and especially mobile phones and other personal communication devices (e.g., DECT cordless phones, walkie-talkies) will continue to represent the bulk of our exposure to radiofrequency electromagnetic fields in the smart home, due to their typically

high emissions and use close to the body. However, RF-emitting devices with high duty cycles (e.g., in this sample, motion sensor, baby monitor, and an IoT toothbrush) may significantly increase the potential for exposure, especially when used or located close to the body. The potential impact on the exposure due to individual smart meters, on the other hand, and in particular due to the communications modules wirelessly linked to a utility company's central network, is small, regardless of their emissions of up to 20 volts per meter at 0.2 m, given their rare transmissions and usual deployment away from the residents.

NOT IN MY NEIGHBORHOOD: A USER EQUIPMENT PERSPECTIVE OF CELLULAR PLANNING UNDER RESTRICTIVE EMF LIMITS

Chiaraviglio L, Galán-Jiménez J, Fiore M, Blefari-Melazzi N. Not in my neighborhood: A user equipment perspective of cellular planning under restrictive EMF limits. IEEE Access. 7:6161-6185. 20 December 2018. Updated 16 January 2019. DOI: 10.1109/ACCESS.2018.2888916

Abstract

The installation of base station (BS) sites is regulated by a variety of laws at international, national, and local levels. While international regulations are already severe, the national and local laws applied in many countries and regions follow precautionary principles and enforce electromagnetic field (EMF) constraints that are even more restrictive. This legal environment results in substantial constraints affecting the planning of cellular networks, as requests for new BS site installation are easily denied by national or local authorities. In this paper, we consider the problem of cellular planning under restrictive EMF limits from the user equipment (UE) viewpoint. We focus on outdoor urban areas and first evaluate the impact of the current, non-optimal network planning at the UE side through a quantitative measurement-driven analysis of the quality of service (QoS) observed by users in heterogeneous, large-scale urban scenarios. We then perform a qualitative assessment of the perceived QoS and generated EMF levels at one UE transferring data from/to a BS based on its position with respect to the serving BS. Finally, we run a what-if analysis by comparing the existing planning with the one where new BS sites can be installed, thanks to a relaxation of the restrictive EMF constraints. Our results clearly show that a cellular planning driven by restrictive EMF constraints forces UE to experience large distances from the serving BS, frequent non-line-of-sight conditions, and poor received signal. In turn, this entails a very negative combination of high electric field activity (EFA) levels generated by the UE and low QoS perceived by the user. We show that, by relaxing the restrictive EMF constraints, the problem could be sensibly mitigated with a positive impact on the UE channel conditions and consequently on the perceived QoS and the UE EFA.

Open access paper: <https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8584448>

BECOMING ELECTRO-HYPERSENSITIVE: A REPLICATION STUDY

Dieudonné M. Becoming electro-hypersensitive: A replication study. Bioelectromagnetics. 2019 Apr;40(3):188- 200. doi: 10.1002/bem.22180.

Abstract

Idiopathic Environmental Intolerance attributed to Electromagnetic Fields (IEI-EMF) is an emerging environmental illness that is characterized by the attribution of various symptoms to electromagnetic fields (EMF). To date, research has not succeeded in objectifying the illness' semiology or etiology. IEI-EMF remains impossible to define other than in terms of the

attributions of the persons affected. Yet, the genesis of these attributions is still not well understood. This study's objective is to replicate previous results relating to them, while correcting their limitations. Sixteen electro-hypersensitive (EHS) subjects lent themselves to both a sociological interview and a medical interview, and completed a set of standardized questionnaires. Three distinct types of biographical trajectories leading to persons becoming convinced of their hypersensitivity were identified, which were called the Reticent Attribution model, the Prior Attribution model, and the By Proxy Attribution model. These three models of EHS attribution process do not appear to lead to clinically distinct forms of IEI-EMF. What distinguishes them is the way in which the initial suspicion of the electromagnetic environment emerges. They demonstrate a diversification of the pathways to IEI-EMF. Nonetheless, in each model, the learning process that enables the EHS attribution to be materialized and operationalized is identical. The ability to establish causation between the electromagnetic environment and their condition is therefore the result of EHS subjects' trajectories, rather than their starting point. This observation is not congruent with models attributing IEI-EMF to nocebo reactions, which raises the question of these models' ecological validity.

<https://www.ncbi.nlm.nih.gov/pubmed/30920673>

A CRITICAL REVIEW ON WIRELESS CHARGING FOR ELECTRIC VEHICLES

Machura P, Li Q. A critical review on wireless charging for electric vehicles. Renewable and Sustainable Energy Reviews. 104:209-234. Apr 2019. <https://doi.org/10.1016/j.rser.2019.01.027>.

Highlights

- The paper timely presents a thorough review on wireless charging technology for electric vehicles.
- Following the previous review papers, the paper includes the most recent developments.
- The paper shows future directions for wireless charging from both commercial and research perspective.
- The paper has reviewed the health and safety aspect of wireless charging technology, as well as relevant standards published recently.
- The paper covers the economic aspect of wireless charging systems, and presents a detailed comparison on cost.

Abstract

Electric vehicles (EVs) have recently been significantly developed in terms of both performance and drive range. There already are various models commercially available, and the number of EVs on road increases rapidly.

Although most existing EVs are charged by electric cables, companies like Tesla, BMW and Nissan have started to develop wireless charged EVs that don't require bulky cables. Rather than physical cable connection, the wireless (inductive) link effectively avoids sparking over plugging/unplugging. Furthermore, wireless charging opens new possibilities for dynamic charging – charging while driving. Once realised, EVs will no longer be limited by their electric drive range and the requirement for battery capacity will be greatly reduced. This has been prioritised and promoted worldwide, particularly in UK, Germany and Korea. This paper

presents a thorough literature review on the wireless charging technology for EVs. The key technical components of wireless charging are summarised and compared, such as compensation topologies, coil design and communication. To enhance the charging power, an innovative approach towards the use of superconducting material in coil designs is investigated and their potential impact on wireless charging is discussed. In addition, health and safety concerns about wireless charging are addressed, as well as their relevant standards.

Economically, the costs of a wide range of wireless charging systems has also been summarised and compared.

<https://www.sciencedirect.com/science/article/pii/S1364032119300383>

EFFECTS OF A BRAIN TUMOR IN A HUMAN HEAD ON SAR AND TEMPERATURE RISE DUE TO RF SOURCES AT 4G AND 5G FREQUENCIES

Kaburcuk F. Effects of a brain tumor in a dispersive human head on SAR and temperature rise distributions due to RF sources at 4G and 5G frequencies. *Electromagn Biol Med*. 2019 Mar 20:1-9. doi: 10.1080/15368378.2019.1591441.

Abstract

In this paper, effects of a brain tumor located in a dispersive human head model on specific absorption rate (SAR) and temperature rise distributions due to different types of RF sources at 4G and 5G cellular frequencies are investigated with the use of a multiphysics model. This multiphysics model analyzes the dispersive human head with the brain tumor and provides the SAR and temperature rise distributions in the head due to the RF source operated at 4G and 5G cellular frequencies in a single finite-difference time-domain simulation. An adjacent antenna operated at 4G and 5G cellular frequencies to the human head is considered as the RF source for near-field exposure, while a plane wave field radiated by base stations operated at 4G and 5G cellular frequencies is considered as the RF source for far-field exposure. Numerical results show that the brain tumor in the head slightly affects the SAR and temperature rise distributions due to different RF sources at 4G and 5G cellular frequencies.

<https://www.ncbi.nlm.nih.gov/pubmed/30889978>

Conclusion

The effects of the brain tumor in the dispersive human head on the SAR_{1g} and temperature rise distributions due to the near-field and far-field exposures are investigated at 4G and 5G cellular frequencies with the aid of multiphysics model. In the multiphysics model, these distributions in the head are calculated at 2.1 and 3.6 GHz in a single simulation. Numerical results show that the SAR_{1g} and temperature rise distributions are slightly affected by the presence of the brain tumor in the head. The calculated SAR_{1g} values and temperature rise in the area of the brain tumor are higher than those calculated in the same area of the healthy head because the EM and thermal parameters of the brain tumor are different from those of the healthy tissues in the same area of the head. Moreover, it has been realized that the distributions are affected by the frequencies and type of the RF sources

COMPARING DNA DAMAGE INDUCED BY MOBILE TELEPHONY AND OTHER TYPES OF MAN-MADE ELECTROMAGNETIC FIELDS

Panagopoulos DJ. Comparing DNA damage induced by mobile telephony and other types of man-made electromagnetic fields. *Mutation Research/Reviews in Mutation Research*. Published online Mar 11, 2019. <https://doi.org/10.1016/j.mrrev.2019.03.003>.

Abstract

The number of studies showing adverse effects on living organisms induced by different types of man-made Electromagnetic Fields (EMFs) has increased tremendously. Hundreds of peer reviewed published studies show a variety of effects, the most important being DNA damage which is linked to cancer, neurodegenerative diseases, reproductive declines etc. Those studies that are far more effective in showing effects employ real-life Mobile Telephony (MT) exposures emitted by commercially available mobile phones. The present review - of results published by my group from 2006 until 2016 - compares DNA fragmentation induced by six different EMFs on the same biological system - the oogenesis of *Drosophila melanogaster* - under identical conditions and procedures. Such a direct comparison between different EMFs - especially those employed in daily life - on the same biological endpoint, is very useful for drawing conclusions on their bioactivity, and novel. It shows that real MT EMFs are far more damaging than 50 Hz alternating magnetic field (MF) - similar or much stronger to those of power lines - or a pulsed electric field (PEF) found before to increase fertility. The MT EMFs were significantly more bioactive even for much shorter exposure durations than the other EMFs. Moreover, they were more damaging than previously tested cytotoxic agents like certain chemicals, starvation, dehydration. Individual parameters of the real MT EMFs like intensity, frequency, exposure duration, polarization, pulsing, modulation, are discussed in terms of their role in bioactivity. The crucial parameter for the intense bioactivity seems to be the extreme variability of the polarized MT signals, mainly due to the large unpredictable intensity changes.

Excerpts

Thus, the present study makes the point that once a specific EMF is polarized (and coherent), includes ELF, and has adequate intensity, then variability in its parameters (especially in its intensity) is of decisive importance in terms of its bioactivity. In the present study this was shown, a) by the direct comparison between six different EMFs in terms of their ability to induce DNA fragmentation in my studies, b) by indirect comparison between the effects of real MT EMFs in my studies and simulated MT EMFs in other studies, both directly compared with corresponding effects of a 50 Hz alternating MF, and c) by the large difference in bioactivity between simulated MT signals with invariable parameters and real MT (highly variable) ones from a great number of reviewed studies. This important point in terms of biological activity and public health protection should be further confirmed experimentally by direct comparison of effects between simulated and real MT EMFs of the same average parameters.

The importance of exposure variability shown in the present study implies the need to define EMF-exposures not only by frequency components and average intensity values, but by reporting maximum and minimum intensity as well, frequency variations, pulsing or continuous wave, modulation, and - of course - polarization. Moreover, in published reviews of experimental studies employing MT and other types of microwave telecommunication

EMFs such as DECT phones, Wi-Fi etc, it must be explicitly reported whether the exposures were real from commercially available devices or simulated from generators, test phones, etc.

The present study further confirms my previous results and conclusions that experiments should employ real-life and not simulated EMFs, and human/animal exposure to microwave telecommunication EMFs should be drastically reduced by prudent use, and establishment of much stringer exposure limits by the responsible health authorities.

<https://www.sciencedirect.com/science/article/pii/S1383574218300991>

RADIOFREQUENCY ELECTROMAGNETIC FIELD EXPOSURE AND RISK PERCEPTION: A PILOT EXPERIMENTAL STUDY

Berihun M., Zeleke BM, Bhatt CR, Brzozek C, Abramson MJ, Freudenstein F, Croft RJ, Wiedemann P, Benke G. Radiofrequency electromagnetic field exposure and risk perception: A pilot experimental study. *Environmental Research*. 170:493-499. March 2019. <https://doi.org/10.1016/j.envres.2018.12.058>

Highlights

- People may get concerned about radiofrequency electromagnetic fields exposures.
- We examined people's risk perceptions to RF-EMF from mobile phone base stations.
- Personal RF-EMF exposure measurement and provision did not affect risk perception.
- Personal exposure knowledge improves confidence in self-protection from RF-EMF.

Abstract

Background Exposure to far-field radiofrequency electromagnetic fields (RF-EMF) has raised public concerns in recent decades. However, it is not known if individuals' perception towards the health risks of RF-EMF is dependent on their knowledge of the objectively measured personal RF-EMF exposure levels.

Objectives This pilot study aimed to demonstrate the feasibility of objectively measuring personal RF-EMF exposure from mobile phone base stations (MPBS) and to determine if the risk perception of people to the potential health risk of exposure to RF-EMF from MPBS is dependent on their knowledge of personal RF-EMF exposure levels.

Design An experimental study was conducted in 383 adults, recruited in Melbourne, Australia. Participants were randomized to one of the three groups: 1) basic information group who were provided with basic information about RF-EMF to read prior to completing a risk perception assessment questionnaire; 2) precautionary group who were provided with an information pack which included precautionary messages; and 3) personal exposure measurement group who were provided with a summary of their quantitative RF-EMF exposure from MPBS. The same basic information about RF-EMF was also given to the precautionary and personal exposure measurement groups.

Results Participants had a mean ($\pm$ SD) age of 36.9 ± 12.5 years; 66.7% were women. Overall, 44.1% had noticed an MPBS in their neighbourhood. The mean (SD) values (from 1 to 7) for risk perceptions to RF-EMF from MPBS were 4.02 (1.67) for basic information, 3.82 (1.62) for precautionary messages, and 3.97 (1.72) for the personal exposure measurement groups.

These differences were not statistically significant. Nevertheless, the personal exposure measurement group were more confident that they could protect themselves from RF-EMF than the precautionary or basic information groups.

Conclusion Our findings suggest that providing people with personal RF-EMF exposure measurements may not affect their perceived risk from MPBS, but increase their confidence in protecting themselves.

Conclusions

In conclusion, our study demonstrated that, compared to those provided with precautionary messages and basic information, people provided with personal RF-EMF exposure data did not have significantly different scores for their exposure or risk perception towards RF-EMF in general or that from MPBS, but had greater confidence in being able to protecting themselves from RF-EMF. As a strategy, providing software apps on mobile phones that measure actual exposure could be implemented with the intention of providing realistic exposure information. This may 'demystify' the relatively abstract notion of personal RF-EMF exposure, and ultimately boost confidence in protection. Future research, preferably from a larger and more diverse sample, should aim to investigate the impact of provision of objectively measured exposure information and the knowledge of personal, as well as environmental RF-EMF exposures from both near-field and far-field sources on peoples' risk perception and risk communication vis-a-vis telecommunication technologies.

<https://www.sciencedirect.com/science/article/pii/S001393511830255X>

EFFECTS OF EXPOSURE TO 5.8 GHZ EMF ON MICRONUCLEUS FORMATION, DNA STRAND BREAKS & HEAT SHOCK PROTEIN EXPRESSIONS IN HUMAN EYE CELLS

Miyakoshi J, Tonomura H, Koyama S, Narita E, Shinohara N. Effects of Exposure to 5.8 GHz Electromagnetic Field on Micronucleus Formation, DNA strand breaks, and Heat Shock Protein Expressions in Cells Derived from Human Eye. IEEE Trans Nanobioscience. 2019 Mar 15. doi: 10.1109/TNB.2019.2905491.

Abstract

In the near future, electrification will be introduced to heavy-duty vehicles and passenger cars. However, wireless power transfer (WPT) requires high energy levels, and the suitability of various types of WPT systems must be assessed. This paper describes a method for solving technical and safety issues associated with this technology. We exposed human corneal epithelial (HCE-T) cells derived from the human eye to 5.8-GHz electromagnetic fields for 24 h. We observed no statistically significant increase in micronucleus (MN) frequency in cells exposed to a 5.8-GHz field at 1 mW/cm² (the general public level in ICNIRP) relative to sham-exposed or incubator controls. Similarly, DNA strand breaks, and expression of heat shock protein (Hsp) Hsp27, Hsp70, and Hsp90 α exhibited no statistically significant effects as a result of exposure. These results indicate that exposure to 5.8-GHz electromagnetic fields at 1 mW/cm² for 24 h has little or no effect on micronucleus formation, DNA strand breaks, and Hsp expression in human eye cells.

<https://www.ncbi.nlm.nih.gov/pubmed/30892224>

THE CARCINOGENIC POTENTIAL OF NON-IONIZING RADIATIONS: THE CASES OF S-50 HZ MF AND 1.8 GHZ GSM RADIOFREQUENCY RADIATION

Soffritti M, Giuliani L. The carcinogenic potential of non-ionizing radiations: The cases of S-50 Hz MF and 1.8 GHz GSM radiofrequency radiation. *Basic Clin Pharmacol Toxicol*. 2019 Feb 24. doi: 10.1111/bcpt.13215.

Abstract

Epidemiological studies have suggested that human exposure to extremely low-frequency electromagnetic fields from the electric power and to mobile phone radiofrequency electromagnetic fields induce an increased risk of developing malignant tumours. However, no adequate laboratory data, in particular long-term carcinogenicity bioassays to support the epidemiological evidence, have yet been available. This motivated the Ramazzini Institute to embark on a first project of four large life-span carcinogenic bioassays conducted on over 7000 Sprague Dawley rats exposed from prenatal life until natural death to S-50 Hz MF alone or combined with gamma radiation or formaldehyde or aflatoxin B1. Results now available from these studies, which started concurrently, have shown that exposure to Sinusoidal-50 Hz Magnetic Field (S-50 Hz MF) combined with acute exposure to gamma radiation or to chronic administration of formaldehyde in drinking water induces a significantly increased incidence of malignant tumours in males and females. A second project of two large life-span carcinogenic bioassays was conducted on over 3000 Sprague Dawley rats exposed from prenatal life until natural death to 1.8 GHz GSM of mobile phone radio base station, alone or combined with acute exposure to gamma radiation. Early results from the experiment on 1.8 GHz GSM alone show a statistically significant increase in the incidence of heart malignant schwannoma among males exposed at the highest dose.

<https://www.ncbi.nlm.nih.gov/pubmed/30801980>

MONITORING OF MICE HEALTH, INVESTIGATION OF BEHAVIOR, HEMATOLOGICAL PARAMETERS UNDER THE EFFECT OF AN ELECTROMAGNETIC FIELD

Zymantiene, J, Zelvyte, R, Juozaitiene, V, Oberauskas, V, Noreika, A, Juodziukyniene, N, Aniuliene, A. Monitoring of BALB/C strain mice health, investigation of behavior, hematological parameters under the effect of an electromagnetic field. *Weterynary JNA-Veterinary Medicine-Science and Practice*. 75(3):158-163. Mar 2019.

Abstract

The aim of this study was to investigate the effect of electromagnetic fields on BALB/c strain mice on their health, body weight, behavior characteristics, hematological parameters and histopathological findings in the brain. The mice of the experimental groups were exposed to electromagnetic waves by using Nokia 230 and Samsung 19300 Galaxy S III mobile phones situated at 2 cm from the cages. In the present study, it can be concluded that the exposure of mice to mobile phone radiation had an effect on the structure of the brain, behavior and body weight. The waves of mobile phones increased activity characteristics and changed some behavioral categories of mice and also decreased their body weight. Histopathological examination revealed mild edema of neutrophils and degeneration of some neurons and glial cells in the brains of experimental mice. The results of the present study showed that a using mobile phone had an influence on in vivo systems.

Open access paper:

<http://www.medycynawet.edu.pl/images/stories/pdf/pdf2019/032019/2019036194.pdf>

OXIDATIVE STRESS-MEDIATED ALTERATIONS ON SPERM PARAMETERS IN MALE WISTAR RATS EXPOSED TO 3G MOBILE PHONE RADIATION

Gautam R, Singh KV, Nirala J, Murmu NN, Meena R, Rajamani P. Oxidative stress-mediated alterations on sperm parameters in male Wistar rats exposed to 3G mobile phone radiation. *Andrologia*. 2019 Apr;51(3):e13201. doi: 10.1111/and.13201.

Abstract

In recent years, there has been significant increase in mobile phone users. With this, health concerns associated with the exposure to electromagnetic radiation are also increasing. Continuous exposure to electromagnetic (EM) radiation generated from mobile phone is one of the probable reasons behind increasing male infertility.

EM radiations induce oxidative stress that leads to numerous changes in reproductive parameters. With this hypothesis, we studied the effect of 3G mobile phone radiations on the reproductive system of male Wistar rats. Adult rats were divided into two groups: control and radio frequency-exposed. The animals were exposed to 3G mobile phone radiation for 45 days (2 hr/day) in specially designed exposure setup under standard conditions.

Various biochemical and physiological parameters such as sperm count, sperm morphology, mitochondrial activity, lipid peroxidation, reactive oxygen species level and histopathological analysis were studied.

Histopathological examination revealed a reduction in spermatogenic cells and alterations in sperm membrane. Significant increase in ROS and lipid peroxidation level with simultaneously decrease in sperm count, alterations in sperm tail morphology were observed in the exposed group. In conclusion, exposure to mobile phone radiations induces oxidative stress in male Wistar rats which may lead to alteration in sperm parameters and affects their fertility.

<https://www.ncbi.nlm.nih.gov/pubmed/30461041>

EXPOSURE TO NON-IONIZING ELECTROMAGNETIC RADIATION OF PUBLIC RISK PREVENTION INSTRUMENTS THREATENS THE QUALITY OF SPERMATOZOIDS

Tirpak F, Slanina T, Tomka M, Zidek R, Halo M Jr, Ivanic P, Gren A, Formicki G, Stachanczyk K, Lukac N, Massanyi P. Exposure to non-ionizing electromagnetic radiation of public risk prevention instruments threatens the quality of spermatozooids. *Reprod Domest Anim*. 2019 Feb;54(2):150-159. doi: 10.1111/rda.13338.

Abstract

The use of artificial insemination in cattle breeding has evolved to global extent, and insemination doses are often shipped via air transport which requires strict radiation-based examinations. For the determination of effect of non-ionizing radiation (NIR), to which are beings frequently exposed due to protection of airport or cultural event security, freshly ejaculated and cryopreserved bovine spermatozoa were used as experimental model. Following radiation with hand-held metal detector in various exposition times (0, 10 s, 15, 30 and 60 min-groups FR, FR10, FR15, FR30 and FR60) the spermatozoa underwent motility and DNA fragmentation analyses. Study on cryoconserved semen treated with NIR was performed in time intervals 0, 10 s, 1 and 5 min (insemination doses radiated before cryoconservation-CB, CB10, CB1, CB5; samples radiated after freezing-CA, CA10, CA1 and CA5). Fresh semen and insemination doses radiated after cryoconservation showed significantly lower total and progressive motility. No effect on motility parameters was detected in semen extended with

cryopreservative medium and radiated prior to freezing. Surprisingly, NIR showed a potential to stimulate spermatozoa velocity; however, the effect was modulated throughout the post-thawing incubation. Based on the DNA fragmentation assay, sperm DNA stayed intact. Present study underlines the potential harm of NIR, which is frequently used in everyday life, with overall adverse impact on human and animal reproduction. Current study also points out on interesting short-term spermatozoa stimulation induced by NIR.
<https://www.ncbi.nlm.nih.gov/pubmed/30192989>

EFFECT OF 1800-2100 MHZ ELECTROMAGNETIC RADIATION ON LEARNING-MEMORY AND HIPPOCAMPAL MORPHOLOGY IN SWISS ALBINO MICE

Kishore, GK, Venkateshu, KV, Sridevi, NS. Effect of 1800-2100 MHz electromagnetic radiation on learning- memory and hippocampal morphology in Swiss albino mice. J Clinical and Diagnostic Research. 13(2); Feb 2019. DOI: 10.7860/JCDR/2019/39681.12630

Abstract

Introduction: With advancing technology the mobile phone with multiple features is used as a multipurpose device and attract people of all age groups. Increased usage of mobile phone raises the question of possible adverse effects on health.

Aim: To assess the 1800-2100 MHz radiation effect on learning-memory and microscopic anatomy of hippocampal Cornu Ammonis (CA3) neurons in mice.

Materials and Methods: A total of 18 albino mice were divided into 3 groups (6 Mice per group). Group-I: Control Group, Group-II: Exposed to Radio frequency-Electromagnetic radiation (RF-EMR) for 30 minutes/day for 3 months, Group-III: Exposed to RF-EMR for 60 minutes/day for 3 months. Followed by the exposure, learning memory was assessed by using Hebb-Williams maze in all the groups. The mice were then sacrificed, brains were dissected out and sections were taken at the level of hippocampus and then stained with Haematoxylin and Eosin The results were expressed in Mean +/- SD and analysed by using one-way (analysis of variance) ANOVA followed by LSD (Least Square Difference) test for paired wise data. The p-value<0.05 was considered as statistically significant.

Results: The time taken by the animal to reach the target chamber was significantly increased in Group-III (exposed 60 minutes/day for 3 months), whereas group-II (exposed 30 minutes/day for 3 months) showed no significant changes when compared to Group-I (control group). Microscopic anatomy of hippocampal CA3 neurons in exposed group shows less number of pyramidal cells with darkened nuclei, cytoplasm was vacuolated and cells were scattered.

Conclusion: Exposure to 1800-2100 MHz radiation leads to damage and decrease of neurons in hippocampal region, which alters the learning and memory.

Open access paper:
[https://www.jcdr.net/articles/PDF/12630/39681_CE\[Ra1\]_F\(AC\)_PF1\(PC_SL\)_PFA\(PC_KM\)_PN\(SL\).pdf](https://www.jcdr.net/articles/PDF/12630/39681_CE[Ra1]_F(AC)_PF1(PC_SL)_PFA(PC_KM)_PN(SL).pdf)

CELL PHONE RADIATION EFFECT ON BONE-TO-IMPLANT OSSEointegration: A PRELIMINARY HISTOLOGIC EVALUATION IN RABBITS

Kavyashree M, Harish PV, Mishra SK, Chowdhary R. Cell phone radiation wffect on bone-to-implant osseointegration: A preliminary histologic evaluation in rabbits. *Int J Oral Maxillofac Implants*. 2019 Feb 19. doi: 10.11607/jomi.7024.

Abstract

BACKGROUND AND PURPOSE: The increased use of cell phones has raised many questions as to whether their use is safe for patients with dental implants. This study aimed to assess the consequences of cell phone-emitted radiation on bone-to-implant osseointegration during the healing phase.

MATERIALS AND METHODS: Twelve rabbits were grouped into three groups of four. Group 1 (control) was not exposed to electromagnetic radiation; group 2 (test) was exposed for 8 hours/day in speech mode and 16 hours/day in standby mode; and group 3 (test) was exposed for 24 hours continuously in standby mode for 3 months. Forty-eight implants were placed in tibia and femur bone of rabbits, and after 90 days the rabbits were sacrificed and bone surrounding the implant was retrieved. Histopathologic evaluations of the specimens were done using transmitted light microscope. The differences among the three groups were statistically analyzed with analysis of variance (ANOVA) and pairwise comparisons via Fisher's exact test.

RESULTS: Significantly less bone-to-implant contact and bone area surrounding implant threads were found in the test groups compared to the control group. There was a significant difference in regular bone formation ($P < .001$) among the three groups.

CONCLUSION: Implants exposed to cell phone radiation showed more inflammatory reaction when compared to the nonexposed implants, thus indicating that cellular phone overuse could affect the maturation of bone and thus delay osseointegration.

<https://www.ncbi.nlm.nih.gov/pubmed/30892289>

EFFECT OF MOBILE TOWER RADIATION ON MICROBIAL DIVERSITY IN SOIL AND ANTIBIOTIC RESISTANCE

Sharma AB, Lamba OS; Sharma L, Sharma A. Effect of mobile tower radiation on microbial diversity in soil and antibiotic resistance. 2018 International Conference on Power Energy, Environment and Intelligent Control (PEEIC). April 13-14, 2018. DOI: 10.1109/PEEIC.2018.8665432

Abstract

A substantial increase in the number of mobile phone base stations (MPBS) has been demonstrated in the world. This development has raised concerns with biological systems due to electromagnetic field and radiations. Antibiotic resistance is referred as "the silent tsunami facing modern medicine". The aim of this in vitro study was to demonstrate the impact of these radiations transmitted by Mobile tower stations on microbial diversity in soil and antibiotic resistance pattern. Soil samples were taken from near four different base

stations located in Dausa city, while control samples were taken far from stations. Isolation and identification of microorganisms was done using biochemical reactions and antibiotic resistance was observed. Chi-square test with Yates correction was applied to compare the pattern of antibiotic resistance. *Stenotrophomonas maltophilia*, *Chryseobacterium Gleum*, *Kocuria Rosea* were isolated and identified in soil samples collected near radiation exposed zone. Greater antibiotic resistance was observed in microbes present in soil near base stations compared to control. A statistical significant difference in pattern of antibiotic resistance was found with Nalidixic acid, and cefixime when used as antimicrobial agents. (P-value less than 0.05). Our findings suggest that mobile tower radiations can significantly alter the vital systems in microbes and turn them multidrug resistant (MDR) which is most important current threat to public health.

<https://ieeexplore.ieee.org/document/8665432>

EFFECTS OF ELF EMF ON B16F10 CANCER CELLS

Tang JY, Yeh TW, Huang YT, Wang MH, Jang LS. Effects of extremely low-frequency electromagnetic fields on B16F10 cancer cells. *Electromagn Biol Med*. 2019 Mar 20;1-9. doi: 10.1080/15368378.2019.1591438.

Abstract

This paper presents a method to inhibit B16F10 cancer cells using extremely low-frequency electromagnetic fields (ELF-EMFs) and to evaluate cell viability using MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide) assay. The study examined the effect of a natural EMF resonance frequency (7.83 Hz) and a power line frequency (60 Hz) on B16F10 cancer cells for 24 and 48 h. The B16F10 cancer cells were also exposed to sweep frequencies in several sweep intervals to quantitatively analyze the viability of cancer cells. The results yielded a 17% inhibition rate under 7.83 Hz compared with that of the control group. Moreover, sweep frequencies in narrow intervals (7.83 ± 0.1 Hz for the step 0.05 Hz) caused an inhibition rate of 26.4%, and inhibitory effects decreased as frequency sweep intervals increased. These results indicate that a Schumann resonance frequency of 7.83 Hz can inhibit the growth of cancer cells and that using a specific frequency type can lead to more effective growth inhibition.

<https://www.ncbi.nlm.nih.gov/pubmed/30889982>

LOW FREQUENCY PULSED EMF PROMOTES DIFFERENTIATION OF OLIGODENDROCYTE PRECURSOR CELLS THROUGH UPREGULATION OF MIR-219-5P IN VITRO

Yao F, Li Z, Cheng L, Zhang L, Zha X, Jing J. Low frequency pulsed electromagnetic field promotes differentiation of oligodendrocyte precursor cells through upregulation of miR-219-5p in vitro. *Life Sci*. 2019 Mar 15. pii: S0024-3205(19)30189-4. doi: 10.1016/j.lfs.2019.03.031.

Abstract

AIM: Spinal cord injury (SCI) is a common demyelinating disorder of the central nervous system. The differentiation of oligodendrocyte precursor cells (OPCs) into mature oligodendrocytes (OLs), which induce myelination, plays a critical role in the functional recovery following SCI. In this study, the effect of low frequency pulsed electromagnetic field (PEMF) on the differentiation of OPCs and the potential underlying mechanisms were investigated.

MAIN METHODS: OPCs were randomly divided into the PEMF and non-PEMF (NPEMF) groups. qRT-PCR and western blot assays were performed to assess the expression levels of OLs stage-specific markers after 3, 7, 14, and 21 days of PEMF exposure. qRT-PCR was used to further assess the expression levels of miR-219-5p, miR-338, miR-138, and miR-9, which are associated with OPCs differentiation, and the expression levels of genes associated with miR-219-5p. Finally, following PEMF or NPEMF exposure, qRT-PCR and western blot assays were performed to explore the relationship between miR-219-5p and Lingo1 and between miR-219-5p and PEMF in promoting OPCs differentiation.

KEY FINDINGS: PEMF promoted the differentiation of OPCs. PEMF upregulated the expression level of miR-219-5p and downregulated the expression level of Lingo1 during the differentiation of OPCs. Under PEMF exposure, miR-219-5p targeted Lingo1 and reversed the inhibitory effect of miR-219-5p inhibitor on OPCs differentiation. In addition, PEMF synergized with miR-219-5p to promote OPCs differentiation.

SIGNIFICANCE: Our results, for the first time, indicated that PEMF promoted OPCs differentiation by regulating miR-219-5p activity in vitro.

<https://www.ncbi.nlm.nih.gov/pubmed/30885522>

EFFECTS OF PULSED EMF ON LEARNING AND MEMORY ABILITIES OF STZ-INDUCED DEMENTIA RATS

Li Y, Zhang Y, Wang W, Zhang Y, Yu Y, Cheing GL, Pan W. Effects of pulsed electromagnetic fields on learning and memory abilities of STZ-induced dementia rats. *Electromagn Biol Med*. 2019 Mar 17:1-8. doi: 10.1080/15368378.2019.1591437.

Abstract

INTRODUCTION: Recent studies have shown that pulsed electromagnetic field (EMF) has therapeutic potential for dementia, but the associated neurobiological effects are unclear. This study aimed to determine the effects of pulsed EMF on Streptozotocin (STZ)-induced dementia rats.

METHODS: Forty Sprague-Dawley rats were randomly allocated to one of the four groups: (i) control, (ii) normal saline injection (sham group), (iii) STZ injection (STZ group) and (iv) STZ injection with pulsed EMF exposure (PEMF, 10 mT at 20 Hz) (STZ + MF group). Morris water maze was used to assess the learning and memory abilities. Insulin growth factors 1 and 2 (IGF-1 and IGF-2) gene expression were determined by quantitative PCR.

RESULTS: The results showed that the mean escape latency in STZ-induced dementia rats was reduced by 66% under the exposure of pulsed EMF. Compared with the STZ group, the swimming distance and the time for first crossing the platform decreased by 55 and 41.6% in STZ + MF group, respectively. Furthermore, the IGF-2 gene expression significantly increased compared to that of the STZ group.

CONCLUSIONS: Our findings indicate that the pulsed EMF exposure can improve the ability of learning and memory in STZ-induced dementia rats and this effect may be related to the process of IGF signal transduction, suggesting a potential role for the pulsed EMF for the amelioration of cognition impairment. <https://www.ncbi.nlm.nih.gov/pubmed/30880541>

COMPUTATIONAL SIMULATIONS OF THE PENETRATION OF 0.30 THZ RADIATION INTO THE HUMAN EAR

Vilagosh Z, Lajevardipour A, Wood A. Computational simulations of the penetration of 0.30 THz radiation into the human ear. *Biomed Opt Express*. 2019 Feb 28;10(3):1462-1468. doi: 10.1364/BOE.10.001462.

Abstract

There is an increasing interest in industrial and security applications and the establishment of wireless communication operating at frequencies of up to 0.30 THz. Soft tissue has a high coefficient of absorption at 0.30 THz and this limits effective penetration of the energy to a depth of 0.2 to 0.4 mm. The capacity of 0.30 THz radiation to access the deeper parts of the ear by diffusing through the ear canal and exposing the tympanic membrane (ear drum) to the radiation has not been studied. Simulations show that, with excitation parallel to the ear canal, the average power flux density within the central tympanic membrane region is 97% of the incident excitation. The structures of the outer ear are highly protective; less than 0.4% of the power flux density is directed at 45° from the parallel reached the same region. Given the sensitivity of the tympanic membrane to mechanical change, in-vivo assessment of the penetration of 0.3 THz into the ear canal is warranted to assess the suitability of the present radiation safety limits and to inform 0.3 THz emitting device design. <https://www.ncbi.nlm.nih.gov/pubmed/30891359>

INVOLVEMENT OF CALCIUM IN 50-HZ MAGNETIC FIELD-INDUCED ACTIVATION OF SPHINGOSINE KINASE 1 SIGNALING PATHWAY

Yang X, Ye A, Chen L, Xia Y, Jiang W, Sun. Involvement of calcium in 50-Hz magnetic field-induced activation of sphingosine kinase 1 signaling pathway. *Bioelectromagnetics*. 2019 Apr;40(3):180-187. doi: 10.1002/bem.22181.

Abstract

Previously, we found that exposure to a 50-Hz magnetic field (MF) could induce human amniotic epithelial (FL) cell proliferation and sphingosine kinase 1 (SK1) activation, but the mechanism was not clearly understood. In the present study, the possible signaling pathways which were involved in SK1 activation induced by 50-Hz MF exposure were investigated. Results showed that MF exposure increased intracellular Ca²⁺ which was dependent on the L-type calcium channel, and induced Ca²⁺-dependent phosphorylation of extracellular regulated protein kinase (ERK), SK1, and protein kinase C α (PKC α). Also, treatment with U0126, an inhibitor of ERK, could block MF-induced SK1 phosphorylation, but had no effect on PKC α phosphorylation. Also, the inhibitor of PKC α , Gö6976, had no effect on MF-induced SK1 activation in FL cells. In addition, the activation of ERK and PKC α could be abolished by SKI II, the inhibitor of SK1. In conclusion, the intracellular Ca²⁺ mediated the 50-Hz MF-induced SK1 activation which enhanced PKC α phosphorylation, and there might be a feedback mechanism between SK1 and ERK activation in responding to MF exposure in FL cells. <https://www.ncbi.nlm.nih.gov/pubmed/30920672>

TRANSDUCTION OF THE GEOMAGNETIC FIELD AS EVIDENCED FROM ALPHA-BAND ACTIVITY IN THE HUMAN BRAIN

Wang CX, Hilburn IA, Wu D-A, Mizuhara Y, Cousté CP, Abrahams JNH, Bernstein SE, Matani A, Shimojo S, Kirschvink JL. Transduction of the Geomagnetic Field as Evidenced from Alpha-band Activity in the Human Brain. *eNeuro* 18 March 2019, ENEURO.0483-18.2019; DOI: <https://doi.org/10.1523/ENEURO.0483-18.2019>

Abstract

Magnetoreception, the perception of the geomagnetic field, is a sensory modality well-established across all major groups of vertebrates and some invertebrates, but its presence in humans has been tested rarely, yielding inconclusive results. We report here a strong, specific human brain response to ecologically-relevant rotations of Earth-strength magnetic fields. Following geomagnetic stimulation, a drop in amplitude of EEG alpha oscillations (8-13 Hz) occurred in a repeatable manner. Termed alpha event-related desynchronization (alpha-ERD), such a response has been associated previously with sensory and cognitive processing of external stimuli including vision, auditory and somatosensory cues. Alpha-ERD in response to the geomagnetic field was triggered only by horizontal rotations when the static vertical magnetic field was directed downwards, as it is in the Northern Hemisphere; no brain responses were elicited by the same horizontal rotations when the static vertical component was directed upwards. This implicates a biological response tuned to the ecology of the local human population, rather than a generic physical effect. Biophysical tests showed that the neural response was sensitive to static components of the magnetic field. This rules out all forms of electrical induction (including artifacts from the electrodes) which are determined solely on dynamic components of the field. The neural response was also sensitive to the polarity of the magnetic field. This rules out free-radical 'quantum compass' mechanisms like the cryptochrome hypothesis, which can detect only axial alignment. Ferromagnetism remains a viable biophysical mechanism for sensory transduction and provides a basis to start the behavioral exploration of human magnetoreception.

Significance Statement

Although many migrating and homing animals are sensitive to Earth's magnetic field, most humans are not consciously aware of the geomagnetic stimuli that we encounter in everyday life. Either we have lost a shared, ancestral magnetosensory system, or the system lacks a conscious component with detectable neural activity but no apparent perceptual awareness by us. We found two classes of ecologically-relevant rotations of Earth-strength magnetic fields that produce strong, specific and repeatable effects on human brainwave activity in the EEG alpha band (8-13 Hz); EEG discriminates in response to different geomagnetic field stimuli. Biophysical tests rule out all except the presence of a ferromagnetic transduction element, such as biologically-precipitated crystals of magnetite (Fe₃O₄).

Conclusion

Our results indicate that at least some modern humans transduce changes in Earth-strength magnetic fields into an active neural response. We hope that this study provides a road-map for future studies aiming to replicate and extend research into human magnetoreception. Given the known presence of highly-evolved geomagnetic navigation systems in species across the animal kingdom, it is perhaps not surprising that we might retain at least some functioning neural components especially given the nomadic hunter/gatherer lifestyle of our not-too-distant ancestors. The full extent of this inheritance remains to be discovered. Open access paper: <http://www.eneuro.org/content/early/2019/03/18/ENEURO.0483-18.2019>

GEOMAGNETIC STORM UNDER LABORATORY CONDITIONS: RANDOMIZED EXPERIMENT

Oleg Grigoriev, Chairman of the Russian National Committee on Non-Ionizing Radiation Protection, sent me the following paper after I disseminated the study above: Gurfinkel YI, Vasin AL, Pishchalnikov RY, Sarimov RM, Sasonko ML, Matveeva TA. Geomagnetic storm under laboratory conditions: randomized experiment. *Int J Biometeorol*. 2018 Apr;62(4):501-512. doi: 10.1007/s00484- 017-1460-8.

Abstract

The influence of the previously recorded geomagnetic storm (GS) on human cardiovascular system and microcirculation has been studied under laboratory conditions. Healthy volunteers in lying position were exposed under two artificially created conditions: quiet (Q) and storm (S). The Q regime playbacks a noise-free magnetic field (MF) which is closed to the natural geomagnetic conditions on Moscow's latitude. The S regime playbacks the initially recorded 6-h geomagnetic storm which is repeated four times sequentially. The cardiovascular response to the GS impact was assessed by measuring capillary blood velocity (CBV) and blood pressure (BP) and by the analysis of the 24-h ECG recording. A storm-to-quiet ratio for the cardio intervals (CI) and the heart rate variability (HRV) was introduced in order to reveal the average over group significant differences of HRV. An individual sensitivity to the GS was estimated using the autocorrelation function analysis of the high-frequency (HF) part of the CI spectrum. The autocorrelation analysis allowed for detection a group of subjects of study which autocorrelation functions (ACF) react differently in the Q and S regimes of exposure.

<https://www.ncbi.nlm.nih.gov/pubmed/29030697>

REAL-WORLD CELL PHONE RADIOFREQUENCY ELECTROMAGNETIC FIELD EXPOSURES

Wall S, Wang ZM, Kendig T, Dobraca D, Lipsett M. Real-world cell phone radiofrequency electromagnetic field exposures. *Environ Res*. 2019 Apr;171:581-592. doi: 10.1016/j.envres.2018.09.015.

"Based in part on the results of this study, the California Department of Public Health published the following safety guidelines: "How to Reduce Exposure to Radiofrequency Energy from Cell Phones" (CDPH, 2017)."

Highlights

- Factors decreasing cell phone RF EMF exposures were strong signal strength, greater distance from phones, and Bluetooth use.
- Cell phone RF EMF exposures were one to four orders of magnitude higher in weak vs strong signal reception environments.
- At a typical texting distance, RF EMF exposures from phones with weak signal strength decreased by 90% over near-ear distance.
- Exposures from Bluetooth headsets were 10 to 400 times lower than direct near-ear exposures from the attached cell phones.

Abstract

In 2011 the International Agency for Research on Cancer classified radiofrequency electromagnetic fields (RF EMF) from cell phones as possibly carcinogenic to humans. The National Toxicology Program and the Ramazzini Institute have both reported that RF EMF exposures significantly increase gliomas and Schwannomas of the heart in rodent studies. Recent studies indicate that RF EMF exposures from cell phones have negative impacts on animal cells and cognitive and/or behavioral development in children. Case-control epidemiological studies have found evidence for cell phone use and increased risk for glioma and localization of the glioma associated with the consistent exposure site of regular cell phone use. Understanding the exposure level, or power density, from RF EMF emitted by cell phones under real-world usage and signal reception conditions, as distinct from the published measurements of maximum Specific Absorption Rate values, may help cell phone users decide whether to take behavioral steps to reduce RF EMF exposure.

Exposure measurements were conducted on phone models from four major mobile network operators (MNOs) in the USA for calls received under strong and weak reception signal conditions, near the phone face and at several distances up to 48 cm. RF EMF exposure from all phones was found to be greater under weak (1-2 display bars) than under strong (4-5 display bars) reception signal conditions by up to four orders of magnitude. Notably, RF EMF exposure levels under weak reception signal conditions at a distance of 48 cm from the phone were similar to or greater than those detected under strong reception signal conditions at a distance of 4 cm. Under weak reception signal conditions, power density reductions of up to 90% occurred at 16 cm typical for speaker phone or texting over the 4 cm near-ear exposure.

The results of this investigation of second-generation (2G) technology suggest that reduced and precautionary use of cell phones under weak signal conditions could lower a user's RF EMF exposure by up to several orders of magnitude. Bluetooth headset power density exposures were 10-400 times lower than those of the cell phones to which they were connected and dependent on the headset rather than the connected phone. The results of this study informed the development of public health guidance regarding cell phone use.

<https://www.ncbi.nlm.nih.gov/pubmed/30448205>

MOTHER'S EXPOSURE TO EMF BEFORE AND DURING PREGNANCY IS ASSOCIATED WITH RISK OF SPEECH PROBLEMS IN OFFSPRING

Zarei S, Vahab M, Oryadi-Zanjani MM, Alighanbari N, Mortazavi SM. Mother's Exposure to Electromagnetic Fields before and during Pregnancy is Associated with Risk of Speech Problems in Offspring. J Biomed Phys Eng. 2019 Feb 1;9(1):61-68.

Abstract

Background: Rapid advances in technology, especially in the field of telecommunication, have led to extraordinary levels of mothers' exposures to radiofrequency electromagnetic fields (RF-EMFs) prior to or during pregnancy.

Objective: The main goal of this study was to answer this question whether exposure of women to common sources of RF-EMFs either prior to or during pregnancy is related to speech problems in the offspring.

Materials and Methods: In this study, mothers of 110 three-to-seven-year-old children with speech problems and 75 healthy children (control group) were interviewed. These mothers were asked whether they had exposure to different sources of EMFs such as mobile phones, mobile base stations, Wi-Fi, cordless phones, laptops and power lines. Chi square test was used to analyze the differences observed between the control and exposed groups.

Results: Statistically significant associations were found between the use of cordless phone and offspring speech problems for both before pregnancy and during pregnancy maternal exposures ($P=0.005$ and $P=0.014$, respectively). However, due to high rate of mobile phone use in both groups, this study failed to show any link between mobile phone use and speech problems in offspring. Furthermore, significant associations were observed between living in the vicinity of power lines and speech problems again for both before pregnancy and during pregnancy maternal exposures ($P=0.003$ and $P=0.002$, respectively). However, exposure to other sources of non-ionizing radiation was not linked to speech problems. Moreover, exposure to ionizing radiation (e.g. radiography before and during pregnancy) was not associated with the occurrence of speech problems.

Conclusion: Although this study has some limitations, it leads us to this conclusion that higher-than-ever levels of maternal exposure to electromagnetic fields could be linked to offspring speech problems.

<https://www.ncbi.nlm.nih.gov/pubmed/30881935>

IMPACT OF ADOLESCENTS' SCREEN TIME & NOCTURNAL MOBILE PHONE-RELATED AWAKENINGS ON SLEEP & HEALTH SYMPTOMS

Foerster M, Henneke A, Chetty-Mhlana S, Rösli M. A prospective cohort study. *Int J Environ Res Public Health*. 2019 Feb 12;16(3). pii: E518. doi: 10.3390/ijerph16030518.

Abstract

Nocturnal media use has been linked to adolescents' sleeping problems in cross-sectional studies which do not address reverse causality. To prospectively assess the new occurrence of sleep problems or health symptoms in relation to electronic media use and nocturnal mobile phone use, we used data from the longitudinal Swiss HERMES (Health Effects Related to Mobile phone use in adolescents) cohort on 843 children from 7th to 9th grade. Logistic regression models were fitted and adjusted for relevant confounders. Adolescents reporting at baseline and follow-up at least one nocturnal awakenings from their own mobile phone per month were more likely to have developed restless sleep (Odds Ratio (OR): 5.66, 95% Confidence Interval: 2.24–14.26) and problems falling asleep (3.51, 1.05–11.74) within one year compared to adolescents without nocturnal awakenings. A similar pattern was observed for developing symptoms, although somewhat less pronounced in terms of the magnitude of the odds ratios. With respect to high screen time at baseline and follow-up, associations were observed for falling asleep (2.41, 1.41–4.13), exhaustibility (1.76, 1.02–3.03), lack of energy (1.76, 1.04–2.96) and lack of concentration (2.90, 1.55–5.42). Our results suggest a detrimental effect of screen time and mobile phone-related awakenings on sleep problems and related health symptoms. However, the results should be interpreted cautiously with respect to adolescents' natural changes in circadian rhythm, which may coincide with an increase in mobile phone and media use.

Open access paper: <https://www.mdpi.com/1660-4601/16/3/518>

MEMORY FUNCTION AND CELL PHONE MICROWAVE EXPOSURE IN YOUNGSTERS

Lin JC. Memory Function and Cell Phone Microwave Exposure in Youngsters [Health Matters]. IEEE Microwave Magazine. 20(2):16-20. Feb 2019.

Abstract

Cell phones, especially smartphones, have become such a popular phenomenon that marketing cell phones to youngsters is no longer the forbidden practice it once was. As a result of the increase of cell phone use among youngsters, France and other countries have banned the use of such phones in primary, junior, and middle schools, both inside classrooms and even outside on school playgrounds [1], [2].

Looking at the Data

The question of whether RF/microwave radiation emitted by cell phones during use could disturb brain activity in children and lead to impaired learning ability or behavioral problems has persisted for some time. To date, there remains a paucity of existing scientific data and relevant knowledge, including data on cognitive functions of adolescents. As a result, the question cannot be easily answered based on existing scientific evidence.

Reported results may lead to the conclusion that RF/microwave radiation emitted from GSM cell phones does not produce acute effects on an adolescent's cognitive or memory function. But available data suggest that significant decreases in figural memory were found to be consistently associated with cumulative exposure of the brain of adolescents to 1,000–4,000 mJ/kg per day over one year. Therefore, a cautious approach to risk management, especially in relation to children and adolescents, is warranted.

<https://ieeexplore.ieee.org/document/8608029>

SHIELDING METHODS AND PRODUCTS AGAINST MAN-MADE ELECTROMAGNETIC FIELDS: PROTECTION VERSUS RISK

Panagopoulos DJ, Chrousos GP. Shielding methods and products against man-made Electromagnetic Fields: Protection versus risk. Sci Total Environ. 2019 Feb 23;667:255-262. doi: 10.1016/j.scitotenv.2019.02.344.

Highlights

- Human exposure to man-made EMFs has increased with increasing health problems.
- Metal shielding is lately suggested by private companies/individuals as a way to reduce exposure.
- Metal shielding reduces both man-made and natural atmospheric EMFs.
- EHS symptom relapses and internal desynchronization are reported after shielding.
- An avoidance strategy of man-made EMFs should be preferable than metal shielding.

Abstract

Human exposure to man-made Electromagnetic Fields (EMFs) has increased to unprecedented levels, accompanied by increase in various health problems. A connection has been indicated by an increasing number of studies. Symptoms characterized as Electro-hypersensitivity (EHS) are frequently reported especially in urban environments. Lately, people are advised by private companies and individuals to protect themselves from man-made EMFs by metal shielding through various products, for which there are reasonable concerns about their protective efficacy and safety. Indeed, any metal shielding practice, even when correctly

applied, attenuates not only man-made totally polarized EMFs accused for the health problems, but also the natural non-polarized EMFs responsible for the biological rhythmicity and well-being of all animals. Strong evidence on this was provided by pioneering experiments in the 1960's and 1970's, with volunteers staying in a shielded underground apartment. We analyze the physical principles of EMF-shielding, the importance of natural atmospheric EMFs, and examine available shielding methods and suggested products, relying on science-based evidence. We suggest that an avoidance strategy is safer than shielding, and provide specific protection tips. We do not reject shielding in general, but describe ways to keep it at a minimum by intermittent use, as this is theoretically safer than extensive permanent shielding. We explain why metallic patches or "chips" or minerals claimed by sellers to be protective, do not seem to make sense and might even be risky. We finally suggest urgent research on the safety and efficacy of shielding methods combined with use of generators emitting weak pulses of similar frequency, intensity, and waveform with the natural atmospheric resonances.

<https://www.ncbi.nlm.nih.gov/pubmed/30831365>

SHORT-TERM RF EXPOSURE FROM NEW GENERATION MOBILE PHONES REDUCES EEG ALPHA POWER WITH NO EFFECTS ON COGNITIVE PERFORMANCE

Vecsei Z, Knakker B, Juhász P, Thuróczy G, Trunk A, Hernádi I. Short-term radiofrequency exposure from new generation mobile phones reduces EEG alpha power with no effects on cognitive performance. *Sci Rep.* 2018 Dec 20;8(1):18010. doi: 10.1038/s41598-018-36353-9.

Abstract

Although mobile phone (MP) use has been steadily increasing in the last decades and similar positive trends are expected for the near future, systematic investigations on neurophysiological and cognitive effects caused by recently developed technological standards for MPs are scarcely available. Here, we investigated the effects of radiofrequency (RF) fields emitted by new-generation mobile technologies, specifically, Universal Mobile Telecommunications System (UMTS) and Long-Term Evolution (LTE), on intrinsic scalp EEG activity in the alpha band (8-12 Hz) and cognitive performance in the Stroop test. The study involved 60 healthy, young-adult university students (34 for UMTS and 26 for LTE) with double-blind administration of Real and Sham exposure in separate sessions. EEG was recorded before, during and after RF exposure, and Stroop performance was assessed before and after EEG recording. Both RF exposure types caused a notable decrease in the alpha power over the whole scalp that persisted even after the cessation of the exposure, whereas no effects were found on any aspects of performance in the Stroop test. The results imply that the brain networks underlying global alpha oscillations might require minor reconfiguration to adapt to the local biophysical changes caused by focal RF exposure mimicking MP use.

Open access paper: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6301959/>

TOWARDS PREDICTING INTRACELLULAR RADIOFREQUENCY RADIATION EFFECTS

Nielsen C, Hui R, Lui WY, Solov'yov IA. Towards predicting intracellular radiofrequency radiation effects. PLoS One. 2019 Mar 14;14(3):e0213286. doi: 10.1371/journal.pone.0213286.

Abstract

Recent experiments have reported an effect of weak radiofrequency magnetic fields in the MHz-range on the concentrations of reactive oxygen species (ROS) in living cells. Since the energy that could possibly be deposited by the radiation is orders of magnitude smaller than the energy of molecular thermal motion, it was suggested that the effect was caused by the interaction of RF magnetic fields with transient radical pairs within the cells, affecting the ROS formation rates through the radical pair mechanism. It is, however, at present not entirely clear how to predict RF magnetic field effects at certain field frequency and intensity in nanoscale biomolecular systems. We suggest a possible recipe for interpreting the radiofrequency effects in cells by presenting a general workflow for calculation of the reactive perturbations inside a cell as a function of RF magnetic field strength and frequency. To justify the workflow, we discuss the effects of radiofrequency magnetic fields on generic spin systems to particularly illustrate how the reactive radicals could be affected by specific parameters of the experiment. We finally argue that the suggested workflow can be used to predict effects of radiofrequency magnetic fields on radical pairs in biological cells, which is specially important for wireless recharging technologies where one has to know of any harmful effects that exposure to such radiation might cause.

Open access paper:

<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0213286>

ANALYSIS OF BIOLOGICAL EFFECTS OF CELL PHONE RADIATION ON HUMAN BODY USING SAR

Rashid TB, Song HH. Analysis of biological effects of cell phone radiation on human body using specific absorption rate and thermoregulatory response. Microwave and Optical Technology Letters. First published: 15 March 2019.

Abstract

Health and science have reached a point of intersection which has never existed before. With the recent rapid increase in the use of cellular phones and long periods of usage of these devices near the human body, public concern regarding potential health hazards due to absorption of electromagnetic energy has been growing. To address these issues, this research evaluates the average Specific Absorption Rate in different human tissues by varying source to antenna distance and radiated power using the ANSYS 3D human body model. The Pennes bioheat transfer equation was solved analytically to calculate the longtime exposure effect and temperature rise. The results show that regardless of the frequency, if the antenna radiated power is low (less than 125 mW), temperature increase within the human tissues is low; however if the antenna operates at high radiated power (1 W), temperature tends to increase eight and a half times.

Excerpts

SAR values are lower than the FCC safety limit in all cases shown in Tables 1 and 2 in head tissues, when there is no distance between head and antenna, in a lower frequency (850 MHz, 900 MHz) and lower radiated power (125 mW). In the same cases, when antenna radiated power increases to 1 W, SAR values are higher than the FCC safety limit in all head tissues. The maximum SAR values are found in CSF [cerebrospinal fluid] and skin tissues.

In head tissues, at higher frequencies (2.1 GHz, 2.6 GHz, and 5.1 GHz) at 125 mW radiated and when there is no distance between head and antenna, average SAR values are higher in all tissues except fat tissues as shown in Table 3-5. Maximum average SAR values are found in CSF, dura, brain, skin, and bone tissues at 5.1 GHz frequency, which are 11.4 W/kg, 10.89 W/kg, 10.77 W/kg, 10.51 W/kg, and 9.3 W/kg, respectively, as shown in Table 4. Average SAR values are high at higher frequencies because tissues have relatively high conductivity (sic). In high frequency at high radiated power of 1 W, average SAR values in all tissues are very high. The maximum average SAR value found in CSF tissue was 91.2 W/kg. This means if the antenna is operating at a high power level, there is a high chance of tissues being affected.

... increasing the distance between the source and the head model from 0 mm to 10 mm causes the SAR to decrease by approximately three times at lower frequency, and it decreases approximately five and a half times at higher frequency.

The research concludes, for the long time exposure, and even for the worst possible radiated power level, the temperature rise caused in the human tissues is not close to the dangerous limit.

<https://onlinelibrary.wiley.com/doi/abs/10.1002/mop.31777>

MOBILE PHONE EMR AFFECTS AMYLOID PRECURSOR PROTEIN AND A-SYNUCLEIN METABOLISM IN SH-SY5Y CELLS

Stefi AL, Margaritis LH, Skouroliaiou AS, Vassilacopoulou D. Pathophysiology. Published online March 1, 2019. <https://doi.org/10.1016/j.pathophys.2019.02.004>.

Highlights

- GSM radiation applied to SH-SY5Y cells:
- Causes alternative APP metabolism.
- Shifts the equilibrium from multimeric to the monomeric form of α -synuclein.
- Induces oxidative stress and cytotoxicity.
- Contributes to the Alzheimer's and Parkinson's disease pathogenetic mechanisms.

Abstract

In this study, the effects of low-level, GSM emitted ElectroMagnetic Field (EMF) on Amyloid Precursor Protein (APP) and alpha-synuclein (α -syn) in human neuroblastoma cells was investigated. Our data indicated alterations on APP processing and cellular topology, following EMF exposure ($E = 10.51$ V/m, SAR = 0.23 W/kg, exposure time: 3 times, for 10 minutes, for 2 days). Furthermore, changes in monomeric α -syn accumulation and multimerization, as well as induction of oxidative stress and cell death, were documented.

The results presented here require further investigation to determine potential links of EMF with the molecular pathogenic mechanisms in Alzheimer's and Parkinson's Diseases.

Conclusions

To the best of our knowledge, the work presented here, seems to be the first report linking exposure to EMF emitted by a transmitting mobile phone, to altered metabolism of APP and α -syn in SH-SY5Y cells. The observed increase in monomeric α -syn along with the generation of novel amyloidogenic fragments possessing alternative cellular topology, in addition to the induction of cellular toxicity and oxidative stress, should be taken into consideration in future research aiming towards the understanding of the molecular mechanisms linking EMR to human health. It is possible that wireless communications, may represent a new factor affecting human health while exposure to these devices could be involved in pathogenic mechanisms leading to neurodegeneration.

<https://www.sciencedirect.com/science/article/pii/S0928468018303523>

PERSONAL EXPOSURE TO ENVIRONMENTAL RF EMF IN ALBACETE (SPAIN) AND RISK PERCEPTION

Ramirez-Vazquez R, Gonzalez-Rubio J, Arribas E, Najera A. Environ Res. 2019 Feb 12;172:109-116. doi: 10.1016/j.envres.2019.02.015.

Abstract

In the last decades, exposure to radiofrequency electromagnetic fields (RF-EMF) has substantially increased as new wireless technologies have been introduced. Society has become more concerned about the possible effects of RF-EMF on human health in parallel to the increase in their exposure. The appearance of personal exposimeters opens up wide-ranging research possibilities. Despite studies having characterised personal exposure to RF-EMF, part of the population is still worried, to the extent that psychogenic diseases ("nocebo" effect) appear, and patients suffer. It could be interesting to share personal exposure results with the population to better understand and promote public health. The main objective was to characterise personal exposure to environmental RF-EMF in Albacete (166,000 inhabitants, SE Spain), and assess the effect of sharing the results of the study on participants' risk perception. Measurements were taken by a personal Satimo EME SPY 140 exposimeter, which was programmed every 10 s for 24 h. To measure personal exposure to RF-EMF, we worked with 75 volunteers. Their personal exposure, 14 microenvironments in the city, e.g., home, outdoors, work, etc., and possible time differences were analysed. After participating in the study, 35 participants completed a questionnaire about their RF-EMF risk perception, which was also answered by a control sample to compare the results (N = 36). The total average exposure of 14 bands was 37.7 $\mu\text{W}/\text{m}^2$, and individual ranges fell between 0.2 $\mu\text{W}/\text{m}^2$, recorded in TV4&5, and a maximum of 264.7 $\mu\text{W}/\text{m}^2$ in DECT. For Friday, we recorded a mean of 53.9 $\mu\text{W}/\text{m}^2$ as opposed to 23.4 $\mu\text{W}/\text{m}^2$ obtained on Saturday. The recorded night-time value was 27.5 $\mu\text{W}/\text{m}^2$ versus 43.8 $\mu\text{W}/\text{m}^2$ recorded in the daytime. The mean personal exposure value also showed differences between weekdays and weekend days, with 39.7 $\mu\text{W}/\text{m}^2$ and 26.9 $\mu\text{W}/\text{m}^2$, respectively. The main source that contributed to the mean total personal exposure was enhanced cordless telecommunications (DECT) with 50.2%, followed by mobile phones with 18.4% and mobile stations with 11.0% (GSM, DCS and UMTS), while WiFi signals gave 12.5%. In the analysed microenvironments, the mean exposure of homes and workplaces was 34.3 $\mu\text{W}/\text{m}^2$ and 55.2 $\mu\text{W}/\text{m}^2$, respectively. Outdoors, the mean

value was 34.2 $\mu\text{W}/\text{m}^2$ and the main sources were DECT, WiFi and mobile phone stations, depending on the place. The risk perception analysis found that 54% of the participants perceived that RF-EMF were less dangerous than before participating in the study, while 43% reported no change in their perceptions. Only 9% of the volunteers who received information about their measurements after the study assessed the possible RF-EMF risk with a value over or equal to 4 (on a scale from 1 to 5) versus 39% of the non-participant controls. We conclude that personal exposure to RF-EMF fell well below the limits recommended by ICNIRP and showed wide temporal and spatial variability. The main exposure sources were DECT, followed by mobile phones and WiFi. Sharing exposure results with participants lowered their risk perception.

<https://www.ncbi.nlm.nih.gov/pubmed/30782530>

My Note: The case-control studies of wireless phone use and brain tumor risk typically failed to account for DECT phone radiation exposure to the head. The above study found that DECT phones contributed 50% to the overall personal RF radiation exposure as compared to only 18% for mobile phones. Thus, except for Hardell's research, case-control studies likely underestimate the effect of wireless phone use on brain tumor risk.

SIMULATION OF INCIDENCE OF MALIGNANT BRAIN TUMORS IN BIRTH COHORTS THAT STARTED USING MOBILE PHONES WHEN THEY FIRST BECAME POPULAR IN JAPAN

Sato Y, Kojimahara N, Yamaguchi N. Bioelectromagnetics. 2019 Mar 15. doi: 10.1002/bem.22176.

Abstract

Over 20 years have passed since the initial spread of mobile phones in Japan. Epidemiological studies of mobile phone use are currently being conducted around the world, but scientific evidence is inconclusive. The present study aimed to simulate the incidence of malignant brain tumors in cohorts that began using mobile phones when they first became popular in Japan. Mobile phone ownership data were collected through an Internet-based questionnaire survey of subjects born between 1960 and 1989. The proportion of mobile phone ownership between 1990 and 2012 was calculated by birth cohort (1960s, 1970s, and 1980s). Subsequently, using the ownership proportion, the incidence of malignant brain tumors was calculated under simulated risk conditions. When the relative risk was set to 1.4 for 1,640 h or more of cumulative mobile phone use and the mean daily call duration was 15 min, the incidence of malignant brain tumors in 2020 was 5.48 per 100,000 population for the 1960s birth cohort, 3.16 for the 1970s birth cohort, and 2.29 for the 1980s birth cohort. Under the modeled scenarios, an increase in the incidence of malignant brain tumors was shown to be observed around 2020.

Conclusion

Epidemiological studies on mobile phone use have mainly focused on malignant brain tumors as a health outcome. The present study revealed that under the modeled scenarios, an increase in the incidence of malignant brain tumors was shown to be observed around 2020. In future epidemiological studies on mobile phone use, we believe that it will be necessary to investigate whether or not the incidence of malignant brain tumors is actually increased in 1960s, 1970s, and 1980s birth cohorts.

<https://www.ncbi.nlm.nih.gov/pubmed/30875091>

NO EVIDENCE FOR INCREASED BRAIN TUMOR INCIDENCE IN THE SWEDISH NATIONAL CANCER REGISTER BETWEEN 1980-2012

Nilsson J, Järås J, Henriksson R, Holgersson G, Bergström S, Estenberg J, Augustsson T, Bergqvist M. No evidence for increased brain tumour incidence in the Swedish National Cancer Register between years 1980-2012. *Anticancer Res.* 2019 Feb;39(2):791-796. doi: 10.21873/anticancer.13176.

Abstract

BACKGROUND/AIM: The main objective of this study was to evaluate if there was an increased incidence of brain tumours between years 1980-2012, a time period when mobile phone usage has increased substantially.

MATERIALS AND METHODS: From the Swedish Cancer Registry, cases of meningiomas, low-grade gliomas (LGG) and high-grade gliomas (HGG) were identified in patients between 1980-2012. Direct age-standardised incidence rates were used to calculate incidence trends over time.

RESULTS: A total of 13,441 cases of meningiomas, 12,259 cases of high-grade gliomas and 4,555 cases of LGG were reported to the register during the study period. The results suggest that there may be a negative development in the trend for LGG of -0,016 cases per 100,000 and year, corresponding to a mean reduction of approximately 1% per year.

CONCLUSION: The present study was not able to demonstrate an increased incidence of glioma during the past 30 years in Sweden.

Excerpt:

" For HGG, there was a trend for slightly decreased incidence in the age group 0-39 years (incidence trend estimate=-0.004, 95% CI=-0.006--0.001; p=0.005) and a trend for mildly increased incidence in the age group 60-74 years (incidence trend estimate=0.006, 95% CI=0.001-0.012; p=0.029)."

Open access paper: <http://ar.iiarjournals.org/content/39/2/791.long>

Note: The title of this paper is misleading as the authors found an increased incidence of high-grade gliomas from 1980 to 2012 in the age group 60-74. The authors did not provide a justification for performing a linear regression on the age-standardized incidence rates. How likely is it that a linear model is appropriate to explain a 32-year trend? And even if a linear model were appropriate, since this is a time series where there is likely autocorrelation, the p-values from a linear regression are meaningless.

RISK COMMUNICATION STRATEGIES FOR POSSIBLE HEALTH RISKS FROM RF-EMF EMISSION BY TELECOM STRUCTURES

Fernandez PR, Ng KH, Kaur S. Risk Communication Strategies for Possible Health Risks From Radio-Frequency Electromagnetic Fields (RF-EMF) Emission by Telecommunication Structures. Health Phys. 2019 Mar 4. doi: 10.1097/HP.0000000000001037.

Abstract

There is widespread anxiety and speculation about RF-EMF emissions by telecommunication base stations and structures, as it is perceived by some to be unsafe and a threat to public health. Scientists, medical experts, politicians, journalists, and mobile telecommunication company specialists are involved in an active debate on whether people are immune to RF or if we are gambling with our future. Interviews with 31 individuals from 7 stakeholder groups in Malaysia reveal that the residents' main concerns are that the telecommunication companies do not follow guidelines and as a result the telecommunication structures are constructed close to their homes, which they perceive as a threat to public health. Some residents also do not want these structures because of cultural reasons, while some are jealous over rental income received by the landlords. Meanwhile, the authorities entrusted with safe-guarding public health are involved in a blame game as there is no agency that is clearly in charge. The interviews also highlight that the current risk communication initiatives are more reactive rather than proactive, and that the authorities do not speak in one voice. Based on the outcome of the interviews, eleven recommendations are formulated to improve risk communication initiatives in Malaysia. The recommendations stress on repairing, building, and strengthening trust, because trust in agencies, along with credibility, determines risk communication initiatives' effectiveness. These strategies can also be effectively replicated across regions to deal with contestations over RF-EMF emissions and the impact on health.

<https://www.ncbi.nlm.nih.gov/pubmed/30844902>

EVALUATING EXTREMELY LOW FREQUENCY MAGNETIC FIELDS IN THE REAR SEATS OF THE ELECTRIC VEHICLES

Lin J, Lu M, Wu T, Yang L, Wu TN. Evaluating extremely low frequency magnetic fields in the rear seats of the electric vehicles. Radiation Protection Dosimetry. 182(2):190-199. Dec 2018.

Abstract

In the electric vehicles (EVs), children can sit on a safety seat installed in the rear seats. Owing to their smaller physical dimensions, their heads, generally, are closer to the underfloor electrical systems where the magnetic field (MF) exposure is the greatest. In this study, the magnetic flux density (B) was measured in the rear seats of 10 different EVs, for different driving sessions. We used the measurement results from different heights corresponding to the locations of the heads of an adult and an infant to calculate the induced electric field (E-field) strength using anatomical human models. The results revealed that measured B fields in the rear seats were far below the reference levels by the International Commission on Non-Ionizing Radiation Protection. Although small children may be exposed to higher MF strength, induced E-field strengths were much lower than that of adults due to their particular physical dimensions.

<https://www.ncbi.nlm.nih.gov/pubmed/29584925>

ALUMINIUM FOIL DAMPENED THE ADVERSE EFFECT OF 2100 MHZ MOBILE PHONE-INDUCED RADIATION ON THE BLOOD PARAMETERS AND MYOCARDIUM IN RATS

Kalanjati VP, Purwantari KE, Prasetiowati L. Aluminium foil dampened the adverse effect of 2100 MHz mobile phone-induced radiation on the blood parameters and myocardium in rats. *Environ Sci Pollut Res Int.* 2019 Feb 26. doi: 10.1007/s11356-019-04601-8.

Abstract

Mobile phones emit a radiofrequency radiation (RFR) that might have adverse health effects. We aimed to investigate the possible protective effects of aluminium foil (AF) as a physical shield against the RFR from mobile phones on the blood parameters and the myocardium in rats. The effects of whole body 2100 MHz with 0.84-1.86 W/kg of SAR, 4 h/day for 30 days Global System for Mobile Communications (GSM)-RFR exposure for 4 h/day for 30 days on blood parameters (i.e. haemoglobin, leucocytes, thrombocytes, erythrocyte sedimentation rate, white blood cell differential count, corticosterone, CKMB), and the histology of myocardium were investigated. Three-month-old male rats (n = 32) were studied and randomised equally in the following four groups: K1 (non-AF non-RFR control), K2 (AF non-RFR control), P1 (non-AF RFR-exposed), P2 (AF RFR-exposed). Data were analysed with level of significance of $p < 0.05$. In P1, lower leucocytes and neutrophils counts with high corticosterone levels were found compared with the control groups, whilst a significantly higher CKMB was observed compared with P2 ($p = 0.034$). Lower cardiomyocyte counts congruent to the area fraction of the non-fibrotic myocardium were observed in P1 compared with the other groups ($p < 0.01$). AF might decrease the inflammatory-oxidative stress on rodent's blood cells and myocardium induced by the exposures of radiofrequency radiation of the mobile phones.

<https://www.ncbi.nlm.nih.gov/pubmed/30806932>

ARE MF AND EMF OF ANTHROPOGENIC ORIGIN POTENTIAL THREATS TO EARLY LIFE STAGES OF FISH?

Fey DP, Jakubowska M, Greszkiewicz M, Andrulewicz E, Otremba Z, Urban-Malinga B. *Aquat Toxicol.* 2019 Jan 30;209:150-158. doi: 10.1016/j.aquatox.2019.01.023.

Abstract

The number of underwater cables transferring electric current in sea and freshwater environments is constantly increasing. As a result, the risk of negative effects of magnetic fields generated in the vicinity of those cables on fish eggs and larvae is also growing. This is especially the case for species that settle on the bottom for certain periods of time during early development. To study those effects, eggs and larvae of rainbow trout, *Oncorhynchus mykiss*, were subjected under experimental conditions to a static magnetic field (MF) of 10 mT and a 50 Hz electromagnetic field (EMF) of 1 mT for a period of 36 days (i.e., from eyed egg stage to approximately 26 days post hatching, dph). Neither MF nor EMF had significant effect on embryonic or larval mortality, hatching time, larval growth, or the time of larvae swim-up from the bottom. However, both MF and EMF enhanced the yolk-sac absorption rate. Although it was not related directly to magnetic field effect, it was also shown that larvae with absorbed yolk-sacs by the time of swim-up were less efficient in taking advantage of available food at first feeding (i.e., obtained smaller weight at age). That indicates the importance of processes affecting yolk-sac absorption rate.

<https://www.ncbi.nlm.nih.gov/pubmed/30780112>

THE PROTECTIVE ROLE OF SPERMINE AGAINST MALE REPRODUCTIVE ABERRATIONS INDUCED BY EXPOSURE TO EMF - AN EXPERIMENTAL INVESTIGATION IN THE RAT

Shahin NN, El-Nabarawy NA, Gouda AS, Mégarbane B. The protective role of spermine against male reproductive aberrations induced by exposure to electromagnetic field - An experimental investigation in the rat. *Toxicol Appl Pharmacol.* 2019 Mar 13. pii: S0041-008X(19)30091-2. doi: 10.1016/j.taap.2019.03.009.

Abstract

The exponentially increasing use of electromagnetic field (EMF)-emitting devices imposes substantial health burden on modern societies with particular concerns of male infertility. Limited studies have addressed the modulation of this risk by protective agents. We investigated the hazardous effects of rat exposure to EMF (900 MHz, 2 h/day for 8 weeks) on male fertility and evaluated the possible protective effect of the polyamine, spermine, against EMF-induced alterations. Exposure to EMF significantly decreased sperm count, viability and motility, and increased sperm deformities. EMF-exposed rats exhibited significant reductions in serum inhibin B and testosterone along with elevated activin A, follicle-stimulating hormone, luteinizing hormone and estradiol concentrations. Testicular steroidogenic acute regulatory protein (StAR), c-kit mRNA expression and testicular activities of the key androgenic enzymes 3 β - and 17 β -hydroxysteroid dehydrogenases were significantly attenuated following exposure to EMF. Exposure led to testicular lipid peroxidation, decreased catalase and glutathione peroxidase activities and triggered nuclear factor-kappa B p65, inducible nitric oxide synthase, cyclooxygenase-2 and caspase-3 overexpression. EMF-exposed rats showed testicular DNA damage as indicated by elevated comet parameters. Spermine administration (2.5 mg/Kg/day intraperitoneally for 8 weeks) prevented EMF-induced alterations in the sperm and hormone profiles, StAR and c-kit expression and androgenic enzyme activities. Spermine hampered EMF-induced oxidative, inflammatory, apoptotic and DNA perturbations. Histological and histomorphometric analysis of the testes supported all biochemical findings. In conclusion, rat exposure to EMF disrupts sperm and hormone profiles with underlying impairment of steroidogenesis and spermatogenesis. Spermine confers protection against EMF-associated testicular and reproductive aberrations, at least in part, via antioxidant, anti-inflammatory and anti-apoptotic mechanisms.

<https://www.ncbi.nlm.nih.gov/pubmed/30878504>

CARCINOGENICITY OF INTERMEDIATE FREQUENCY MAGNETIC FIELD IN MICE

Nishimura I, Doi Y, Imai N, Kawabe M, Mera Y, Shiina T. Carcinogenicity of intermediate frequency magnetic field in Tg.rasH2 mice. *Bioelectromagnetics.* 2019 Mar 15. doi: 10.1002/bem.22177.

Abstract

Although the likelihood of exposure to leaking intermediate frequency magnetic fields (MFs) from electronic devices, such as induction-heating and wireless power transfer systems, has increased, biological data assessing the health risks associated with human exposure remain insufficient. We examined the carcinogenicity of a 20 kHz MF, a typical frequency produced by induction-heating cookers, using a transgenic rasH2 mouse model. Twenty-five male and female CByB6F1-Tg(HRAS)2Jic mice were exposed to a 0.20 mT, 20 kHz MF (22 h/day) or sham-exposed for 26 weeks. As a positive control, 10 male and female rasH2 mice from the

same batch were administered a single intraperitoneal injection of 75 mg/kg N-methyl-N-nitrosourea. A blinded histopathological evaluation was performed, and the same experiments were conducted twice, independently, to confirm the reproducibility of the results. Histopathological examination revealed that spontaneous neoplastic lesions, such as splenic hemangiosarcomas and gastric squamous cell papillomas, were less (1-3 per group) in the MF- and sham-exposed groups. The frequency of the neoplastic lesions was not significantly different between the groups. Eight to ten mice in each positive-control group exhibited malignant lymphoma. The outcomes were consistent between duplicated experiments, which indicates lack of carcinogenicity of 20 kHz MF in the rasH2 mouse model <https://www.ncbi.nlm.nih.gov/pubmed/30875092>

UPPER BOUND ON THE BIOLOGICAL EFFECTS OF 50/60 HZ MAGNETIC FIELDS MEDIATED BY RADICAL PAIRS

Hore PJ. Upper bound on the biological effects of 50/60 Hz magnetic fields mediated by radical pairs. *Elife*. 2019 Feb 25;8. pii: e44179. doi: 10.7554/eLife.44179.

Abstract

Prolonged exposure to weak ($\sim 1 \mu\text{T}$) extremely-low-frequency (ELF, 50/60 Hz) magnetic fields has been associated with an increased risk of childhood leukemia. One of the few biophysical mechanisms that might account for this link involves short-lived chemical reaction intermediates known as radical pairs. In this report, we use spin dynamics simulations to derive an upper bound of 10 parts per million on the effect of a $1 \mu\text{T}$ ELF magnetic field on the yield of a radical pair reaction. By comparing this figure with the corresponding effects of changes in the strength of the Earth's magnetic field, we conclude that if exposure to such weak 50/60 Hz magnetic fields has any effect on human biology, and results from a radical pair mechanism, then the risk should be no greater than travelling a few kilometres towards or away from the geomagnetic north or south pole.

Open access paper: <https://elifesciences.org/articles/44179>

WEAK MAGNETIC FIELDS ALTER STEM CELL-MEDIATED GROWTH

Van Huizen AV, Morton JM, Kinsey LJ, Von Kannon DG, Saad MA, Birkholz TR, Czajka JM, Cyrus J, Barnes FS, Beane WS. Weak magnetic fields alter stem cell-mediated growth. *Science Advances*. 5(1). 30 Jan 2019. DOI: 10.1126/sciadv.aau7201.

Abstract

Biological systems are constantly exposed to electromagnetic fields (EMFs) in the form of natural geomagnetic fields and EMFs emitted from technology. While strong magnetic fields are known to change chemical reaction rates and free radical concentrations, the debate remains about whether static weak magnetic fields (WMFs; $<1 \text{ mT}$) also produce biological effects. Using the planarian regeneration model, we show that WMFs altered stem cell proliferation and subsequent differentiation via changes in reactive oxygen species (ROS) accumulation and downstream heat shock protein 70 (Hsp70) expression. These data reveal that on the basis of field strength, WMF exposure can increase or decrease new tissue formation in vivo, suggesting WMFs as a potential therapeutic tool to manipulate mitotic activity. Open access paper: <http://advances.sciencemag.org/content/5/1/eaau7201>

REVIEW OF BIOLOGICAL EFFECTS OF EMF IN INTERMEDIATE FREQUENCY RANGE (300 HZ TO 1 MHZ)

Bodewein L, Schmiedchen K, Dechent D, Stunder D, Graefrath D, Winter L, Kraus T, Driessen S. Systematic review on the biological effects of electric, magnetic and electromagnetic fields in the intermediate frequency range (300 Hz to 1 MHz). *Environ Res.* 2019 Jan 9;171:247-259. doi: 10.1016/j.envres.2019.01.015.

Highlights

- Biological effects of intermediate frequency fields were systematically analyzed.
- Fifty-six experimental studies were eligible.
- Weak field strengths and frequencies > 100 kHz have been hardly investigated.
- Low quality of evidence for adverse effects for most examined endpoints.
- Methodical limitations lowered credibility of the results.

Excerpt

"... a few studies that were of moderate quality, revealed some potentially adverse effects of MF in the IF range, such as an increased number of abnormal chicken embryos (Juutilainen and Saali, 1986), or an increase in inflammatory mediators and oxidative stress markers in the young mouse brain (Win-Shwe et al., 2015). Such studies should be replicated by independent laboratories."

Abstract

BACKGROUND: Many novel technologies, including induction cookers or wireless power transfer, produce electric fields (EF), magnetic fields (MF) or electromagnetic fields (EMF) in the intermediate frequency (IF) range. The effects of such fields on biological systems, however, have been poorly investigated. The aim of this systematic review was to provide an update of the state of research and to evaluate the potential for adverse effects of EF, MF and EMF in the IF range (300 Hz to 1 MHz) on biological systems.

METHODS: The review was prepared in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Methodical limitations in individual studies were assessed using the Office of Health Assessment and Translation (OHAT) Risk of Bias Rating Tool for Human and Animal Studies.

RESULTS: Fifty-six studies exposing humans, animals or in vitro systems were eligible for this review. In these studies, many different endpoints were examined and most of the findings were obtained in studies with exposure to MF. For most endpoints, however, the reviewed studies yielded inconsistent results, with some studies indicating no effect and some linking IF exposure with adverse effects. In the majority of the included studies, the applied field strengths were above the International Commission on Non-Ionizing Radiation Protection (ICNIRP) reference levels for the general public and the applied frequencies were mainly below 100 kHz. Furthermore, many of the reviewed studies suffered from methodical limitations which lowered the credibility of the reported results.

CONCLUSION: Due to the large heterogeneity in study designs, endpoints and exposed systems, as well as the inconsistent results and methodical limitations in many studies, the quality of evidence for adverse effects remains inadequate for drawing a conclusion on

investigated biological effects of IF fields for most endpoints. We recommend that in future studies, effects of EF, MF and EMF in the IF range should be investigated more systematically, i.e., studies should consider various frequencies to identify potential frequency-dependent effects and apply different field strengths, especially if threshold-dependent effects are expected. Priority should be given to the investigation of acute effects, like induction of phosphenes, perception, excitation of nerves or muscles and thermal effects. This would be an important step towards the validation of the reference levels recommended by ICNIRP. Furthermore, we recommend that any new studies aim at implementing high quality dosimetry and minimizing sources of risk of bias.

<https://www.ncbi.nlm.nih.gov/pubmed/30690271>

TRENDS AND PATTERNS OF INCIDENCE OF DIFFUSE GLIOMA IN ADULTS IN THE UNITED STATES, 1973-2014

Li K, Lu D, Guo Y, Wang C, Liu X, Liu Y, Liu D. Trends and patterns of incidence of diffuse glioma in adults in the United States, 1973-2014. *Cancer Med.* 2018 Oct;7(10):5281-5290. doi: 10.1002/cam4.1757.

Abstract

INTRODUCTION: The objective of the study was to identify trends in incidence of adult diffuse gliomas in the United States and evaluate the contribution of age, period, and cohort effects to the trends.

METHODS: Using the Surveillance, Epidemiology, and End Results 9 database, primary diffuse glioma patients (≥ 20 years old) diagnosed from 1973 to 2014 were identified. Incidence trends were analyzed using joinpoint regression and age-period-cohort modeling.

RESULTS: Overall, the incidence for adult glioma decreased slowly from 1985 to 2014 (annual percent change [APC] = 0.5%, 95% confidence intervals [CI], 0.3%-0.6%). In histology subtype-stratified analysis, glioblastoma and nonglioblastoma exhibited opposite trends. The incidence for glioblastoma increased from 1978 to 2014 (APC for year 1978-1992 = 2.7%, 95% CI, 1.8%-3.6%; APC for 1992-2014 = 0.3%, 95% CI, 0%-0.6%), while the incidence for nonglioblastoma decreased significantly from 1982 to 2014 (APC = 2.2%, 95% CI, 2.0%-2.5%). Age- period-cohort modeling revealed significant period and cohort effects, with the patterns for glioblastoma and nonglioblastoma distinctive from each other. Compared with adults born 1890s, those born 1920s had approximately 4-fold the risk of glioblastoma after adjustment of age and period effects, while the risk of nonglioblastoma was reduced by half in individuals in the 1939 cohort as compared with those in the 1909 cohort.

CONCLUSIONS: The results support the hypothesis of etiological heterogeneity of diffuse gliomas by histology subtypes. The established risk factors cannot fully explain the distinct patterns by histology subtypes, which necessitate further epidemiological studies.

Open access paper: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6198197/>

EFFECTS OF EVENING EXPOSURE TO 3G MOBILE PHONE EMF ON HEALTH AND NIGHT SLEEP EEG ARCHITECTURE

Lowden A, Nagai R, Åkerstedt T, Hansson Mild K, Hillert L. Effects of evening exposure to electromagnetic fields emitted by 3G mobile phones on health and night sleep EEG architecture. *J Sleep Res.* 2019 Jan 15:e12813. doi: 10.1111/jsr.12813.

Abstract

Studies on sleep after exposure to radiofrequency electromagnetic fields have shown mixed results. We investigated the effects of double-blind radiofrequency exposure to 1,930-1,990 MHz, UMTS 3G signalling standard, time-averaged 10 g specific absorption rate of 1.6 W kg⁻¹ on self-evaluated sleepiness and objective electroencephalogram architecture during sleep. Eighteen subjects aged 18-19 years underwent 3.0 hr of controlled exposure on two consecutive days 19:45-23:00 hours (including 15-min break); active or sham prior to sleep, followed by full-night 7.5 hr polysomnographic recordings in a sleep laboratory. In a cross-over design, the procedure was repeated a week later with the second condition. The results for sleep electroencephalogram architecture showed no change after radiofrequency exposure in sleep stages compared with sham, but power spectrum analyses showed a reduction of activity within the slow spindle range (11.0-12.75 Hz). No differences were found for self-evaluated health symptoms, performance on the Stroop colour word test during exposure or for sleep quality. These results confirm previous findings that radiofrequency post-exposure in the evening has very little influence on electroencephalogram architecture but possible on spindle range activity.

<https://www.ncbi.nlm.nih.gov/pubmed/30648318>

TELECOMMUNICATION DEVICES USE, SCREEN TIME AND SLEEP IN ADOLESCENTS

Cabré-Riera A, Torrent M, Donaire-Gonzalez D, Vrijheid M, Cardis E, Guxens M. Telecommunication devices use, screen time and sleep in adolescents. *Environ Res.* 2018 Nov 1;171:341-347. doi: 10.1016/j.envres.2018.10.036.

Abstract

PURPOSE: To investigate the association between telecommunication and other screen devices use and subjective and objective sleep measures in adolescents at 17-18 years.

METHODS: Cross-sectional study on adolescents aged 17-18 years from a Spanish population-based birth cohort established in Menorca in 1997-1998. Information on devices use was collected using self-reported questionnaires. Mobile Phone Problematic Use Scale was used to assess mobile phone use dependency. Pittsburgh Sleep Quality Index was used to assess subjective sleep (n = 226). ActiGraph wGT3X-BT for 7 nights was used to assess objective sleep (n = 110).

RESULTS: One or more cordless phone calls/week was associated with a lower sleep quality [Prevalence Ratio (PR) 1.30 (95% Confidence Interval (CI) 1.04; 1.62)]. Habitual and frequent problematic mobile phone use was associated with a lower sleep quality [PR 1.55 (95%CI 1.03; 2.33) and PR 1.67 (95% CI 1.09; 2.56), respectively]. Higher tablet use was associated with decreased sleep efficiency and increased minutes of wake time after sleep onset [β -1.15 (95% CI -1.99; -0.31) and β 7.00 (95% CI 2.40; 11.60) per increase of 10 min/day of use, respectively]. No associations were found between other devices and sleep measures.

CONCLUSIONS: Frequency of cordless phone calls, mobile phone dependency, and tablet use were related to an increase of subjective and objective sleep problems in adolescents. These results seem to indicate that sleep displacement, mental arousal, and exposure to blue light screen emission might play a more important role on sleep than a high RF-EMF exposure to the brain. However, more studies are needed assessing personal RF-EMF levels to draw conclusions.

<https://www.ncbi.nlm.nih.gov/pubmed/30716511>

Note: The increased cancer incidence observed in the cell phone radiation studies conducted by the National Toxicology Program (NTP) and the Ramazzini Institute was not likely due to heating, that is, it was not a thermal effect because hyperthermia alone is not carcinogenic according to this 2003 review paper. Dr. John Bucher pointed this out in the NTP's media teleconference about the study.

CARCINOGENIC EFFECTS OF HYPERTHERMIA

Dewhirst MW, Lora-Michiels M, Viglianti BL, Dewey WC, Repacholi M. Carcinogenic effects of hyperthermia. *Int J Hyperthermia*. 2003 May-Jun;19(3):236-51.

Abstract

The purpose of this paper is to assess the evidence for and against the premise that hyperthermia is carcinogenic. The paper is one of several published in this issue of the *International Journal of Hyperthermia* on the subject of the health risks of hyperthermia. The motivation for this issue of the journal was the result of a World Health Organization workshop that dealt with this issue, as it relates to exposure of the population to RF fields. Since hyperthermia can be a natural consequence of such exposures, the health risks of hyperthermia are relevant in this context. Particularly in the case of carcinogenesis, it is necessary to provide a brief overview of the data that have been generated to examine the carcinogenic risks of RF exposure, so that these results can be compared with studies that have examined the carcinogenic risks of hyperthermia. For this reason, the paper is organized into three sections dealing with: (1) effects of heat on DNA damage/repair and mutations, (2) in vivo studies evaluating the carcinogenic potential of heat alone and combined with other carcinogens, and (3) in vivo studies involving RF exposures. The bulk of the data presented indicate that hyperthermia alone is not carcinogenic. If hyperthermia occurs in the presence of exposure to known carcinogens, such as radiation or chemical carcinogens there is the potential for modulation of carcinogenic effects of those agents. In some circumstances, hyperthermia can actually protect against tumour formation. In other instances, hyperthermia clearly increases incidence of tumour formation, but this occurs following thermal exposures (several degrees C temperature rise for up to 1 h or more) and radiation (therapeutic levels as for treatment of cancer) or chemical carcinogen doses higher than would be encountered by the general population. The extrapolation of these results to the general population, where radiation exposure levels would be at background and temperature rise from incidental RF exposure, such as cell phones (which are estimated to cause no more than 0.1 degrees C temperature rise) is not recommended. Current evidence indicates that the temperature elevations resulting from RF exposure are not carcinogenic. Caution should be used in situations where exposure to known carcinogens is combined with thermal exposures high enough to cause tissue damage. A summary of thermal thresholds for tissue damage from hyperthermia is presented in another paper in this special issue (Dewhirst

et al.). No data exist that examine the carcinogenic risks of chronic thermal exposures below the threshold for detectable tissue damage, either alone or in combination with known carcinogens. This is an important goal for future research.
<https://www.ncbi.nlm.nih.gov/pubmed/12745970>

SIGNIFICANCE OF MICRONUCLEI IN BUCCAL SMEARS OF MOBILE PHONE USERS: A COMPARATIVE STUDY

Vanishree M, Manvikar V, Rudraraju A, Reddy KMP, Kumar NHP, Quadri SJM. Significance of micronuclei in buccal smears of mobile phone users: A comparative study. J Oral Maxillofac Pathol. 2018 Sep-Dec;22(3):448. doi: 10.4103/jomfp.JOMFP_201_18.

Abstract

AIMS AND OBJECTIVES: The present study was designed to evaluate the frequency of micronuclei (MN) in the buccal exfoliated cells of mobile phone users. In addition, comparison of MN frequency between high and low mobile phone users was also done.

MATERIALS AND METHODS: A total of 30 male and 30 female participants between the age group of 20-28 years were selected from the Outpatient Department of Navodaya Dental College and Hospital, Raichur, Karnataka. The participants were divided into two groups: Group A - low mobile phone users and Group B - high mobile phone users. Cell sampling and preparation was done on the slide. All the slides were observed for a total of 1000 cells for the presence and number of MN in each cell.

RESULTS: There was a significant increase in the mean MN count in Group B in comparison to the Group A. There was highly significant difference in the mean MN count of participants using (code division multiple access) CDMA than (global system for mobiles) GSM mobile phones. The MN mean count was found to be significantly increased in non-headphone users in comparison to headphone users. In Group B, the MN count on the side of mobile phone use was found to be statistically significantly elevated in comparison to the opposite side.

CONCLUSION: Mobile phone radiation even in the permissible range when used for longer duration can cause significant genotoxicity. The genotoxicity accentuates when mobile phones are frequently used on the same side which may be due to more amount of radiation and increase in the temperature. Headphone usage reduces the genotoxicity of mobile phone radiation to some extent.

Open access paper: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6306606/>

TRANSDERMAL PATCHES LOADED WITH L-CYSTEINE HCL AS A STRATEGY FOR PROTECTION FROM CELL PHONE RADIATION

Omar SM, Nasr M, Rafla DA. Transdermal patches loaded with L-cysteine HCL as a strategy for protection from mobile phone-emitting electromagnetic radiation hazards. Saudi Pharm J. 2019 Jan;27(1):112-125. doi: 10.1016/j.jsps.2018.09.004.

Abstract

Mobile phone usage has been increased in the last few years emitting electromagnetic radiation (EMR), which disturbs normal cellular processes via oxidative stress. L-cysteine, a glutathione precursor, prevents oxidative damage.

Transdermal patches (TDPs) loaded with L-cysteine hydrochloride (L-CyS-HCL) were fabricated by dispersion of L- CyS-HCL 5% w/w and different concentrations of sorbitol as a plasticizer in room-temperature vulcanizable synthetic silicone matrices (RTV-Si). The effect of sorbitol on patch physicochemical parameters was assessed; in-vitro L-CyS-HCL release profiles and ex-vivo permeation were studied. Pharmacokinetic parameters of endogenous synthesized in-vivo glutathione, after receiving IV bolus dose of L- CyS-HCL and L-CyS-HCL-RTV-Si- TDPs were studied in rat model. The influence of L-CyS-HCL-RTV-Si-TDPs against damaging effects of mobile phone EMR on rats' blood and brain tissues was studied.

The results revealed that patch plasticity, intensity reflections, surface porosity, L-CyS-HCL release rate and skin permeation increased with increasing sorbitol concentration. Pharmacokinetic profile for IV dose and L-CyS-HCL- RTV-Si-TDPs revealed that the L-CyS-HCL-RTV-Si-TDPs provided a sustained glutathione plasma concentration- time profile over entire patch application. High significant differences in biological parameters (blood and brain samples) were observed for radiated rats using the patch in study compared with positive control rats.

Promising long-term strategy for protection against mobile phone hazards was obtained. Open access paper: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6323147/>

HIGH AMBIENT RADIOFREQUENCY RADIATION IN STOCKHOLM CITY, SWEDEN

Carlberg M, Hedendahl L, Koppel T, Hardell L. High ambient radiofrequency radiation in Stockholm city, Sweden. Oncol Lett. 2019 Feb;17(2):1777-1783. doi: 10.3892/ol.2018.9789.

Abstract

We measured the radiofrequency (RF) radiation at central parts in Stockholm, Sweden in March and April 2017. The same measurement round tour was used each time. We used EME Spy 200 for the measurements as in our previous studies in Stockholm. The results were based on 11,482 entries, corresponding to more than 12 h measurements. The total mean level was 5,494 $\mu\text{W}/\text{m}^2$ (median 3,346; range 36.6-205,155). The major contributions were down links from LTE 800 (4G), GSM + UMTS 900 (3G), GSM 1800 (2G), UMTS 2100 (3G) and LTE 2600 (4G). Regarding different places, the highest RF radiation was measured at the Hay Market with a mean level of 10,728 $\mu\text{W}/\text{m}^2$ (median 8,578; range 335-68,815). This is a square used for shopping, and both retailers and visitors may spend considerable time at this place. Also, the Sergel Plaza had high radiation with a mean of 7,768 $\mu\text{W}/\text{m}^2$. All measurements exceeded

the target level of 30-60 $\mu\text{W}/\text{m}^2$ based on non-thermal (no heating) effects, according to the BioInitiative Report. Based on short-term thermal effects, The International Commission on Non-Ionizing Radiation Protection established guideline 2 of 10 W/m^2 (2,000,000-10,000,000 $\mu\text{W}/\text{m}^2$) depending on frequency in 1998, and has not changed it despite solid evidence of non-thermal biological effects at substantially lower exposure levels. These environmental RF radiation levels are expected to increase with the introduction of 5G for wireless communication.

Open access paper: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6341832/>

ALTERNATING ELECTRIC FIELDS (TTFIELDS) ACTIVATE CAV1.2 CHANNELS IN HUMAN GLIOBLASTOMA CELLS

Neuhaus E, Zirjacks L, Ganser K, Klumpp L, Schöler U, Zips D, Eckert F, Huber SM. Alternating Electric Fields (TTFIELDS) Activate Cav1.2 Channels in Human Glioblastoma Cells. *Cancers* (Basel). 2019 Jan 18;11(1). pii: E110. doi: 10.3390/cancers11010110.

Abstract

Tumor treating fields (TTFIELDS) represent a novel FDA-approved treatment modality for patients with newly diagnosed or recurrent glioblastoma multiforme. This therapy applies intermediate frequency alternating electric fields with low intensity to the tumor volume by the use of non-invasive transducer electrode arrays. Mechanistically, TTFIELDS have been proposed to impair formation of the mitotic spindle apparatus and cytokinesis. In order to identify further potential molecular targets, here the effects of TTFIELDS on Ca^{2+} -signaling, ion channel activity in the plasma membrane, cell cycle, cell death, and clonogenic survival were tested in two human glioblastoma cell lines in vitro by fura-2 Ca^{2+} imaging, patch-clamp cell-attached recordings, flow cytometry and pre-plated colony formation assay. In addition, the expression of voltage-gated Ca^{2+} (Cav) channels was determined by real-time RT-PCR and their significance for the cellular TTFIELDS response defined by knock-down and pharmacological blockade. As a result, TTFIELDS stimulated in a cell line-dependent manner a Cav1.2-mediated Ca^{2+} -entry, G_1 or S phase cell cycle arrest, breakdown of the inner mitochondrial membrane potential and DNA degradation, and/or decline of clonogenic survival suggesting a tumoricidal action of TTFIELDS. Moreover, inhibition of Cav1.2 by benidipine aggravated in one glioblastoma line the TTFIELDS effects suggesting that Cav1.2-triggered signaling contributes to cellular TTFIELDS stress response. In conclusion, the present study identified Cav1.2 channels as TTFIELDS target in the plasma membrane and provides the rationale to combine TTFIELDS therapy with Ca^{2+} antagonists that are already in clinical use.

<https://www.mdpi.com/2072-6694/11/1/110>

COMPLICATIONS OF NONIONIZING RADIOFREQUENCY ON DIVIDED ATTENTION

Bamdad K, Adel Z, Esmaeili M. Complications of nonionizing radiofrequency on divided attention. *J Cell Biochem*. 2019 Feb 3. doi: 10.1002/jcb.28343.

Abstract

Exposure to electromagnetic fields is considered as a potential hazard for biological systems. The objective of our investigation is the study of probable consequences of radiofrequency electromagnetic fields from Wi-Fi router devices on the short-term memory, and attention's levels. A population consisting of 312 female college students (14 to 17 years old) was elected by cluster random sampling. Teenagers were divided into two groups of control group (Wi-Fi

nonusers; n = 138), and experiment group (Wi-Fi users; n = 174). Both groups have been examined using short-term memory tests; selective attention, and also divided attention tests. According to the results, there was no significant difference between using Wi-Fi router devices on levels of selective attentions and short-term memory of the sample students with the control group. However, analyses revealed that there is a significant correlation between the use of Wi-Fi routers and declining levels of divided attentions. Our investigation has demonstrated the adverse consequences of 2.4-2.48 GHz radiofrequency electromagnetic fields of Wi-Fi router devices on divided attention levels of female university students that should be mentioned as a technological risk factor and taken into account by healthcare organizations.

<https://www.ncbi.nlm.nih.gov/pubmed/30714205>

Note: This was an observational study, not a randomized trial. The observed difference on divided attention may be due to confounding.

EFFECT OF 900-, 1800-, AND 2100-MHZ RADIOFREQUENCY RADIATION ON DNA AND OXIDATIVE STRESS IN BRAIN

Alkis ME, Bilgin HM, Akpolat V, Dasdag S, Yegin K, Yavas MC, Akdag MZ. *Electromagn Biol Med*. 2019 Jan 22;1-16. doi: 10.1080/15368378.2019.1567526.

Abstract

Ubiquitous and ever increasing use of mobile phones led to the growing concern about the effects of radiofrequency radiation (RFR) emitted by cell phones on biological systems. The aim of this study is to explore whether long-term RFR exposure at different frequencies affects DNA damage and oxidant-antioxidant parameters in the blood and brain tissue of rats. 28 male Sprague Dawley rats were randomly divided into four equal groups (n = 7). They were identified as Group 1: sham-control, Group 2: 900 MHz, Group 3: 1800 MHz, and Group 4: 2100 MHz. Experimental groups of rats were exposed to RFR 2 h/day for 6 months. The sham-control group of rats was subjected to the same experimental condition but generator was turned off. Specific absorption rates (SARs) at brain with 1 g average were calculated as 0.0845 W/kg, 0.04563 W/kg, and 0.03957, at 900 MHz, 1800 MHz, and 2100 MHz, respectively. Additionally, malondialdehyde (MDA), 8- hydroxydeoxyguanosine (8-OHdG), total antioxidant status (TAS), and total oxidant status (TOS) analyses were conducted in the brain tissue samples. Results of the study showed that DNA damage and oxidative stress indicators were found higher in the RFR exposure groups than in the sham-control group. In conclusion, 900-, 1800-, and 2100-MHz RFR emitted from mobile phones may cause oxidative damage, induce increase in lipid peroxidation, and increase oxidative DNA damage formation in the frontal lobe of the rat brain tissues. Furthermore, 2100-MHz RFR may cause formation of DNA single-strand breaks. <https://www.ncbi.nlm.nih.gov/pubmed/30669883>

Conclusion

RFR at different mobile phone frequencies seems to cause oxidative stress, lipid peroxidation, and DNA damage by changing oxidant and antioxidant levels in frontal lobe of the brain tissue. However, the increase in the frequency and the increase in the level of damage suggest that RFRs at higher frequencies may negatively affect brain tissue and may lead to the development of damage. Our study is consistent with many recent studies and supports the hypothesis that RFR causes damage to biological tissues. However, in order to reach solid conclusions, detailed long-term studies at molecular level are definitely needed.

EFFECTS OF RADIOFREQUENCY ELECTROMAGNETIC RADIATION (RF-EMF) ON HONEY BEE QUEEN DEVELOPMENT AND MATING SUCCESS

Odemer R, Odemer F. Effects of radiofrequency electromagnetic radiation (RF-EMF) on honey bee queen development and mating success. *Science of The Total Environment*. 661:553-562. April 15, 2019.

Highlights

- Chronic RF-EMF exposure significantly reduced hatching of honey bee queens.
- Mortalities occurred during pupation, not at the larval stages.
- Mating success was not adversely affected by the irradiation.
- After the exposure, surviving queens were able to establish intact colonies.

Abstract

Mobile phones can be found almost everywhere across the globe, upholding a direct point-to-point connection between the device and the broadcast tower. The emission of radiofrequency electromagnetic fields (RF-EMF) puts the surrounding environment inevitably into contact with this radiation. We have therefore exposed honey bee queen larvae to the radiation of a common mobile phone device (GSM band at 900 MHz) during all stages of their pre-adult development including pupation. After 14 days of exposure, hatching of adult queens was assessed and mating success after further 11 days, respectively. Moreover, full colonies were established of five of the untreated and four of the treated queens to contrast population dynamics. We found that mobile phone radiation had significantly reduced the hatching ratio but not the mating success. If treated queens had successfully mated, colony development was not adversely affected. We provide evidence that mobile phone radiation may alter pupal development, once succeeded this point, no further impairment has manifested in adulthood. Our results are discussed against the background of long-lasting consequences for colony performance and the possible implication on periodic colony losses.

Conclusions

Even though detrimental effects on ontogenetic queen development were revealed by the outcome of our study, caution is needed in interpreting these results. So far, there have been no serious records of colony losses associated with mobile phone radiation. Moreover, we have created by far a worst case operator scenario to which honey bee colonies would not be exposed under realistic beekeeping conditions. Duration and level were similar to average operator exposure by the use of a mobile phone, but not to those present at an apiary, neither in rural nor in urban areas. And yet, queens that survived the treatment were able to establish full functional colonies, demonstrating an immense recovering potential. Therefore we do not assume any acute negative effects on bee health in the mid-term. However, we do not rule out an influence through lower doses of permanent irradiation, in particular on a chronic sublethal level present in major city environments. Hence, we urgently suggest further research should be carried out in the long-term to ascertain what impacts are to be expected in the context of a suitable risk assessment for electromagnetic fields on bee health.

<https://www.sciencedirect.com/science/article/pii/S0048969719301718>

ROOM TEMPERATURE AND SELECTIVE TRIGGERING OF SUPRAMOLECULAR DNA ASSEMBLY/ DISASSEMBLY BY NON-IONIZING RADIATION

Greschner AA, Ropagnol X, Kort M, Zuberi N, Perreault J, Razzari L, Ozaki T, Gauthier MA. Room temperature and selective triggering of supramolecular DNA assembly/disassembly by non-ionizing radiation. *J Am Chem Soc*. 2019 Feb 1. doi: 10.1021/jacs.8b10355.

Abstract

Recent observations have suggested that non-ionizing radiation in the microwave and terahertz (THz; far infrared) regimes could have an effect on double-stranded DNA (dsDNA). These observations are of significance owing to the omnipresence of microwave emitters in our daily lives (e.g., food preparation, telecommunication, wireless internet) and the increasing prevalence of THz emitters for imaging (e.g., concealed weapon detection in airports, screening skin cancer) and communication technologies. By examining multiple DNA nanostructures as well as two plasmid DNA, microwaves were shown to promote the repair and assembly of DNA nanostructures and single-stranded regions of plasmid DNA, while intense THz pulses had the opposite effect (in particular for short dsDNA). Both effects occurred at room temperature within minutes, showed a DNA-length dependence, and did not affect the chemical integrity of the DNA. Intriguingly, the function of seven proteins (enzymes and antibodies) was not affected by exposure to either forms of radiation under the conditions examined. This particularity was exploited to assemble a fully-functional hybrid DNA-protein nanostructure in a bottom-up manner. This study therefore provides entirely new perspectives for the effects, on a molecular level, of non-ionizing radiation on biomolecules. Moreover, the proposed structure-activity relationships could be exploited in the field of DNA nanotechnology, which paves the way for designing a new range of functional DNA nanomaterials that are currently inaccessible to state-of-the-art assembly protocols. <https://www.ncbi.nlm.nih.gov/pubmed/30707028>

EXPOSURE TO EMF OF HIGH VOLTAGE OVERHEAD POWER LINES AND FEMALE INFERTILITY

Esmailzadeh S, Delavar MA, Aleyassin A, Gholamian SA, Ahmadi A. Exposure to Electromagnetic Fields of High Voltage Overhead Power Lines and Female Infertility. *Int J Occup Environ Med*. 2019 Jan;10(1):11-16. doi: 10.15171/ijoem.2019.1429.

Abstract

BACKGROUND: Living in the vicinity of high voltage power lines has brought about a range of health woes, but the effect of residential exposure to electromagnetic fields from the power lines on female fertility has not been explored yet.

OBJECTIVE: To test the hypothesis if residential proximity to high voltage power lines could be associated with the increased risk of female infertility.

METHODS: In a case-control study, 462 women with confirmed diagnosis of unexplained infertility or behavioral and environmental factors were assessed between February 2014 and December 2016. Control group comprised of 471 persons with no history of infertility selected using randomized-digit dialing from the numbers registered in a birth registry between 2014 and 2016. The nearest linear distance from high voltage power lines to the participants'

residence of cases and controls was measured using a Geographical Information System (GIS) and Google Earth aerial evaluation for high voltage power lines (240-400 kV).

RESULTS: 112 (14.1%) houses were within 500 meters from a high voltage power line. Women living within 500 meters of the lines (OR 4.14, 95% CI 2.61 to 6.57) and 500-1000 meters of the line (OR 1.61, 95% CI 1.05 to 2.47) carried a significantly higher risk of infertility than those women living more than 1000 meters away from the power lines. After adjusting for confounding factors, women living within 500 meters of the lines carried a higher risk (aOR 4.44, 95% CI 2.77 to 7.11) of infertility compared with women living more than 1000 meters of the lines.

CONCLUSION: The current safety guidelines for electromagnetic fields exposure seems to be not adequate for protecting people from the hazardous effects of the field.
<https://www.ncbi.nlm.nih.gov/pubmed/30685773>

CHILDHOOD LEUKEMIA RISK IN THE CALIFORNIA POWER LINE STUDY: MAGNETIC FIELDS VERSUS DISTANCE FROM POWER LINES

Catherine M.Crespi, JohnSwanson, Ximena P.Vergara, LeekaKheifets Environmental Research.January 11, 2019. <https://doi.org/10.1016/j.envres.2019.01.022>.

Highlights

- Magnetic field strength and power line proximity are related but distinguishable
- Childhood leukemia risk was higher only when highly exposed to both
- Factors other than magnetic fields may explain higher leukemia risk near lines Abstract

Pooled analyses have suggested a small increased risk of childhood leukemia associated with distance and with exposure to high magnetic fields from power transmission lines. Because magnetic fields are correlated with distance from lines, the question of whether the risk is due to magnetic fields exposure or to some other factor associated with distance from lines is unresolved. We used data from a large records-based case-control study to examine several research questions formulated to disentangle the relationships among magnetic fields, distance from high voltage lines, and childhood leukemia risk. In models examining an interaction between distance and magnetic fields exposure, we found that neither close proximity to high voltage lines alone nor exposure to high calculated fields alone were associated with childhood leukemia risk. Rather, elevated risk was confined to the group that was both very close to high voltage lines (<50 m) and had high calculated fields ($\geq 0.4 \mu\text{T}$) (odds ratio 4.06, 95% CI 1.16, 14.3). Further, high calculated fields ($\geq 0.4 \mu\text{T}$) that were due solely to lower voltage lines (<200 kV) were not associated with elevated risk; rather, risk was confined to high fields attributable to high voltage lines. Whilst other explanations are possible, our findings argue against magnetic fields as a sole explanation for the association between distance and childhood leukemia and in favor of some other explanation linked to characteristics of power lines.

<https://www.sciencedirect.com/science/article/pii/S0013935119300258>

CHANGES OVER TIME IN THE REPORTED RISK FOR CHILDHOOD LEUKEMIA AND MAGNETIC FIELDS

Swanson J, Kheifets LI, Vergara X. Changes over time in the reported risk for childhood leukaemia and magnetic fields. *J Radiol Prot.* 2019 Feb 8. doi: 10.1088/1361-6498/ab0586.

Abstract

There have been many studies from 1979 to the present reporting raised risks for childhood leukaemia with exposure to power-frequency magnetic fields. There are also suggestions that the reported risk has been decreasing. We examine trends in the risk over time from all available studies. For 41 studies, we combine reported risks using inverse-variance weighting, drawing risk estimates from previous pooled analyses where possible for greater consistency. We examine the cumulative risk for studies published up to each successive calendar year for all studies and for various subsets, and test for a trend over the period. The cumulative relative risk has indeed declined, for our most rigorous analysis from a maximum 2.44 in 1997 to 1.58 in 2017, but not statistically significantly when tested as a linear trend. We find suggestions of higher risks in studies looking at higher exposures and in studies with better quality exposure assessment. We conclude that there is a decline in reported risk from the mid-1990s to now, which is unlikely to be solely explained by improving study quality but may be due to chance, and an elevated risk remains.

<https://www.ncbi.nlm.nih.gov/pubmed/30736028>

WEAK MAGNETIC FIELDS ALTER STEM CELL-MEDIATED GROWTH

Van Huizen AV, Morton JM, Kinsey LJ, Von Kannon DG, Saad MA, Birkholz TR, Czajka JM, Cyrus J, Barnes FS, Beane WS. Weak magnetic fields alter stem cell-mediated growth. *Science Advances.* 5(1). 30 Jan 2019. DOI: 10.1126/sciadv.aau7201.

Abstract

Biological systems are constantly exposed to electromagnetic fields (EMFs) in the form of natural geomagnetic fields and EMFs emitted from technology. While strong magnetic fields are known to change chemical reaction rates and free radical concentrations, the debate remains about whether static weak magnetic fields (WMFs; <1 mT) also produce biological effects. Using the planarian regeneration model, we show that WMFs altered stem cell proliferation and subsequent differentiation via changes in reactive oxygen species (ROS) accumulation and downstream heat shock protein 70 (Hsp70) expression. These data reveal that on the basis of field strength, WMF exposure can increase or decrease new tissue formation in vivo, suggesting WMFs as a potential therapeutic tool to manipulate mitotic activity.

Open access paper: <http://advances.sciencemag.org/content/5/1/eaau7201>

PRENATAL EXPOSURE TO EXTREMELY LOW FREQUENCY MAGNETIC FIELD AND ITS IMPACT ON FETAL GROWTH

Ren Y, Chen J, Miao M, Li DK, Liang H, Wang Z, Yang F, Sun X, Yuan W. Prenatal exposure to extremely low frequency magnetic field and its impact on fetal growth. *Environ Health*. 2019 Jan 11;18(1):6. doi: 10.1186/s12940-019-0447-9.

Abstract

OBJECTIVE: Studies on the effect of prenatal exposure to magnetic field (MF) on fetal growth is inconclusive and subject to some methodological limitations, particularly in measurement of MF exposure. The present study aimed to examine the association between maternal extremely low frequency MF (ELF-MF) exposure during pregnancy and fetal growth in offspring.

METHODS: A total of 128 pregnant women were recruited at their 3rd trimester and asked to wear an EMDEX Lite meter for 24 h to capture daily ELF-MF exposure. Time-weighted average (TWA), P50, and P75 of personal 24-h measurements were used to evaluate prenatal ELF-MF exposure. The medians of these measurements were used as cut-off points of high and low prenatal ELF-MF exposure. Fetal growth was measured by infant's birth weight, skinfold thickness of triceps, abdomen, and back, and circumference of head, upper arm, and abdomen. These measures were conducted within 24-h after birth. Generalized Linear Model was used to examine the association between maternal ELF-MF level and fetal growth indices after potential confounders were adjusted for.

RESULTS: Compared with girls with lower prenatal ELF-MF exposure, girls with higher exposure had a lower birth weight, thinner skinfold of triceps, abdomen and back, and smaller circumference of head, upper arm and abdomen in all three ELF-MF matrices. The differences were statistically significant for birth weight and most other growth measurements ($P < 0.05$). These measures had no significant difference between higher and lower prenatal ELF-MF exposure in boys except back skinfold thickness.

CONCLUSION: Prenatal exposure to higher ELF-MF levels was associated with decreased fetal growth in girls, but not in boys.

Open access paper: <https://ehjournal.biomedcentral.com/articles/10.1186/s12940-019-0447-9>

THE ROLE OF TOXIC STIMULI COMBINATIONS IN DETERMINING SAFE EXPOSURE LIMITS

Kostoff RN, Goumenou M, Tsatsakis A. *Toxicol Rep*. 2018 Nov 7;5:1169-1172. doi: 10.1016/j.toxrep.2018.10.010.

Abstract

This editorial addresses the effects of toxic stimuli combinations on determination of safe Exposure Limits. Examination of thousands of Medline abstracts showed typically that combinations of toxic stimuli can produce damage even when the exposure level of each member of the combination is less than the lowest exposure level of the member that produced damage when tested in isolation. The synergy of the toxic stimuli in combination means less of each component stimulus is required to cause damage compared to exposure levels when tested in isolation. This Editorial concludes there is no reason to believe today

that the Exposure Limits on potentially toxic stimuli that have been set by the regulatory agencies are fully protective against serious adverse health effects in all real life exposure scenarios. The conclusion is applicable to essentially all potential contributing factors to disease amenable to Exposure Limits, including not only chemicals but other types of exposures such as radiofrequency radiation (RFR).

Open access paper:

<https://www.sciencedirect.com/science/article/pii/S221475001830622X?via%3Dihub>

PUBLIC HEALTH AND THE RADIO FREQUENCY RADIATION EMITTED BY CELLPHONE TECHNOLOGY, SMART METERS AND WIFI

Pockett S. Public health and the radio frequency radiation emitted by cellphone technology, smart meters and WiFi. New Zealand Medical Journal. 131(1487):97-107. Dec 14, 2018.

Abstract

This paper argues that the prevailing official narrative in New Zealand concerning the relationship between public health and the radio frequency emissions (RF) from cellphone technology, WiFi and electricity smart meters is scientifically and ethically flawed. The main regulatory document in the area, NZS2772.1:1999, is 20 years out of date and ignores existing laboratory evidence disproving its core assumption that the only biological effect of non-ionising radiation is tissue heating. This and further laboratory evidence for harmful effects of RF continues to be ignored, nominally on the contradictory grounds that (a) cellphone manufacturers say their products now emit less RF than early models, so early lab studies exposed tissue to RF levels higher than those now relevant (b) given the lack of actual data on population exposures either then or now, all laboratory evidence is unconvincing anyway. The official narrative further opines that since there exist both laboratory and epidemiological studies concluding that RF is not biologically harmful, as well as studies concluding that RF is harmful, the appropriate response is to count up the number on each side, declare the "weight of evidence" to be such that "causation is not proven" and, pending unspecified further studies, continue exposing to unmonitored levels of RF the entire population of the country, none of whom has given informed consent to participate in the experiment. This approach is obviously unethical. It is also unacceptable scientifically. First, the algebraic model is flawed: studies that do find a harmful effect of RF are not invalidated by differently constructed studies that fail to find an effect. Secondly, while causation is relatively easy to study in the laboratory, it is difficult if not impossible to prove epidemiologically, given that (1) the very narrative under discussion has ensured that there is now no unexposed control group and (2) interpretation of timeline correlation studies is hampered by changes in the way new cancer registrations have been recorded over the years and the perennial problem of multiple possible causal factors. The present paper concludes that a precautionary approach is justified, and ends with a number of specific suggestions on how to start implementing such an approach.

<https://www.ncbi.nlm.nih.gov/pubmed/30543616>

IMPORTANCE OF EXPOSURE DURATION AND METRICS ON CORRELATION BETWEEN RF ENERGY ABSORPTION AND TEMPERATURE INCREASE IN A HUMAN MODEL

Cavagnaro M, Lin J. Importance of exposure duration and metrics on correlation between RF energy absorption and temperature increase in a human model. IEEE Transactions on Biomedical Engineering. Dec 12, 2018. DOI: 10.1109/TBME.2018.2886475

Abstract

Objective: This study investigated the influence of absorption metrics and averaging schemes on correlation between RF/microwave energy and induced temperature elevation for plane wave exposures.

Methods: A voxel-based, anatomically realistic model of the human body was considered. Correlation of electromagnetic fields and temperature increases were evaluated at several frequencies. Both Specific Absorption Rate (SAR) and Volume Absorption Rate (VAR) were considered.

Results: The best correlation with temperature increase occurs for exposure durations between 1 and 2 min both for SAR and VAR for most of the 700- to 2700-MHz frequencies considered. In this case, a 1-g mass or 1-cm³ volume appears to be optimal. However, for VAR, as frequency increases to above 900 MHz, a better correlation is achieved at slightly increased exposure times and volumes. For longer exposures, the maximum correlation coefficient is reduced, and the correlation favors larger averaging mass or volume. At steady-state (30 min), correlation of temperature increase with SAR is maximum for a mass of 9 g for all frequencies considered, whereas the volume for VAR maximum correlation is 15 cm³ for higher frequencies and 20 cm³ for lower frequencies. **Conclusions:** In general, SAR provides a better correlation with temperature compared to VAR for short exposures, while VAR renders better correlations for higher frequencies and longer exposures.

Significance: The correlation between electromagnetic absorption and temperature increases has implications in guidelines for limiting human exposure to electromagnetic fields and in biomedical applications such as imaging, sensing, and hyperthermia.

<https://ieeexplore-ieee-org.libproxy.berkeley.edu/document/8573824>

CHARACTERIZING RADIATED POWER IN NEAR FIELD OF A PHONE OPERATING IN 3G+ AND 4G+ COMMUNICATION STANDARDS

Sârbu A, Bechet A, Bălan T, Robu D, Bechet P, Simona Miclăuș S. Measurement. 134:874-887. February, 2019. <https://doi.org/10.1016/j.measurement.2018.12.018>.

Highlights

- Near field radiated power density measured by both E and H field probes.
- Real life operating situations considered for correct exposure assessment.
- Highest exposure expected at using 4G+ as compared to 3G+.
- CCDF measurements provide realistic representation of user exposure profiles.

Abstract

In this article, an original method to assess the radiated power density of the near field in the immediate vicinity of mobile terminals using both electric and magnetic field strengths determination is proposed. The complementary cumulative distribution function (CCDF) is used for the first time to assess exposure. A demonstration of the CCDF's capabilities for providing a realistic representation of different wireless communication usage profiles is provided. Following the methodology description, an experimental setup was designed and a measurement campaign was conducted on a mobile terminal. The exposure assessment was performed for real life operating situations by selecting seven common application services used by mobile subscribers.

For 4G+ communication technologies the near field power density is the highest during file upload, followed by VoIP, video call, file download, streaming services and browsing. For 3G+ networks the higher to lower power density values were associated with: file upload, file download, streaming, VoIP, video call and browsing services. The total near field radiated power density was found to be on average 34 times higher for the tested applications running in the 4G+ as compared to the 3G+, with values ranging from 180 times - during file upload, down to 1.2 times - during video streaming. Significantly higher radiated power densities were emitted while using VoIP and video call on 4G+ network as compared to 3G+ network. Present results strongly suggest that higher exposure is expected for the same application running under 4G+ rather than under 3G+.

By applying an original procedure, it has been experimentally highlighted that different generations of communication technologies will lead to different exposure shapes in amplitude and in time, suggesting a future need for introducing the dose rate quantification.

<http://www.sciencedirect.com/science/article/pii/S0263224118311631>

SAR AND TEMPERATURE ELEVATION IN HUMAN HEAD DUE TO OVEREXPOSURE TO MOBILE PHONE RADIATION WITH DIFFERENT USAGE PATTERNS

Bhargava D, Leeprechanon N, Rattanadecho P, Wessapan T. International Journal of Heat and Mass Transfer.130:1178-1188. March, 2019.

<https://doi.org/10.1016/j.ijheatmasstransfer.2018.11.031>

Highlights

- The distribution parameters in tissues are significantly influenced by the considered cases.
- The temperature increase in the head tissues are lower to cause any thermal damage.
- The resultant SAR values in head models for some cases exceed the ICNIRP 2 W/kg exposure limit.

Abstract

Accidental overexposure to non-standard mobile phone radiation can occur in many situations. The overpower limit of mobile phone radiation interacts with the human body which could result in an adverse effect on human health. It is envisaged that the severity of the physiological effect can take place with small temperature increase in the delicate organs or tissues such as eyes, brain, skin, etc. However, the resulting thermo- physiological response

of the body tissues to overpower limit of mobile phone radiation is still not well implemented. The aim of this study is to analyze the effect of overexposure of mobile phone radiation on the specific absorption rate (SAR) and temperature increase in three-dimensional heterogeneous human head models. The study focuses attention on the differences in the electromagnetic (EM) absorption characteristics with higher power level among different usage pattern. The effect of three different usage patterns - voice calling, video calling, and texting- on SAR and temperature distributions in different types of head tissues is systematically investigated. This paper also investigates the effects of different user ages, radiated powers, and gap distances between mobile phone and human heads, on SAR and temperature distributions. Results obtained from this analysis considering the safety guidelines show a high impact of mobile phone radiation in the voice calling position. Hence, comparisons of the absorption of mobile phone radiation are calculated between an adult and a 7-year-old child head model, for the voice calling position at different gap distances. In addition, the results indicate that child head always has a higher absorption rate of mobile phone radiation than the adult head. The rate of absorption in tissue increases as the distance between mobile phone and head decreases and the radiated power increases, depending on their dielectric and thermal properties. The obtained results can be helpful in determining exposure limits for the power output of the mobile phone, and the distance a user should maintain from the mobile phone in thermo-physiological aspects.

Conclusion

The paper investigates the increase in SAR and temperature in anatomical human head models of child and adult in overexposure situations. The comparison of the three different mobile phone usage patterns is studied when the head models are exposed to mobile phone radiation at 900 MHz frequency and 5 W radiating power. The study also includes a comparison of the distribution parameters in child and adult heads, effect of different gap distances and radiated powers. The results show that among all the cases, the SAR and temperature increase are found to be highest in the voice calling case for 0.5 cm gap distance and 5 W radiated power. Also, it is evident from the results that the SAR and temperature increase in the tissues do not directly correspond to each other but are related to the physical parameters of biological tissues such as thermal conductivity, dielectric properties, blood perfusion rate, etc. This shows the importance of performing transient thermal analysis along with the dosimetry analysis to clearly understand the interaction between mobile phone radiation and human tissues. Comparing to the ICNIRP exposure limit, the resulting SAR values in skin layer, in voice and video calling cases, are found to exceed the exposure limit. But, comparing the temperature increase in the brain, it does not approach the possible physiological damage.

This study shows the concern regarding the non-standard mobile phone devices which may be harmful to human health from excessive radiation power. Moreover, the obtained results from the study also show that the children are more exposed and have a greater possibility of a serious adverse effect than the adult when exposed to mobile phone radiation.

<http://www.phadungsak.me.engr.tu.ac.th/downloads/2019-01%20%20inter%20J%20heat&mass%20transfer.pdf>

MOBILE PHONE USERS AND ITS EFFECT OF HEARING IN TERMS OF DISTORTION PRODUCT OTOACOUSTIC EMISSION

Kumar G, Gupa N, Sinha NK. Mobile phone users and its effect of hearing in terms of distortion product otoacoustic emission (DPOAE). Journal of Evolution of Medical and Dental Sciences. 7(52):5520-5523. Dec. 24, 2018. DOI:10.14260/jemds/2018/1222.

Abstract

BACKGROUND Cellular phones/ mobile phones are the new addiction in today's society. They can do pretty much everything from making calls to controlling remotely located devices/cameras. Mobile phones, owing to their user-friendly interface and reasonable prices are being used by people from every socioeconomic section and almost all the age groups. Such a rampant use of these devices makes them potentially powerful tools. The convenience, that these devices offer, easily overlooks the cost our health has to pay because of their continuous and prolonged use. The main technology that these devices use nowadays is Global System for Mobile Communications (GSM). Mobile phones emit a pulsed high-frequency electromagnetic (EM) field that may have adverse effects. The disturbances of the mechano-electrical transduction during cellular phone use, especially because there is a close proximity of the cellular phone to the cochlea resulting in a fairly high absorption rate of the incident electromagnetic field (EM).

Aim - To assess hearing loss in mobile phone users.

MATERIALS AND METHODS This is a descriptive study conducted among mobile phone users in the Department of ENT at T.S. Misra Medical College and Hospital from January 2017 to June 2018 consisting of 190 healthy volunteers between the age of 21 and 50 years.

RESULTS Mostly in Rt. handed mobile user had shown Refer/Fail OAE 21%, out of which, higher frequency 6 KHz is affected more in comparison of all four frequency of (2, 3, 4 & 6 KHz).

CONCLUSION The study concludes that the use of mobile phones can cause damage to the Outer Hair Cells (OHCs) in the Cochlea especially in the basal turn which may impair hearing in long term use. Oto Acoustic Emissions from the cochlea can reliably detect this damage and thus has proven to be an excellent diagnostic tool.

https://jemds.com/abstract.php?at_id=16414

POST-NORMAL SCIENCE AND THE MANAGEMENT OF UNCERTAINTY IN BIOELECTROMAGNETIC CONTROVERSIES

Wood AW. Letter: Post-normal science and the management of uncertainty in bioelectromagnetic controversies. Bioelectromagnetics. January 7, 2019.

No abstract. <https://www.ncbi.nlm.nih.gov/pubmed/30615800>

CELL PHONE RADIATION CHANGES CORTICOTROPHIN HORMONE LEVELS & HISTOLOGY OF BRAIN AND ADRENAL GLANDS IN MALE RATS

Shahabi S, Hassanzadeh Taji I, Hoseinnezhaddarzi M, Mousavi F, Shirchi S, Nazari A, Zarei H, Pourabdolhossein F. Exposure to cell phone radiofrequency changes corticotrophin hormone levels and histology of the brain and adrenal glands in male Wistar rat. Iran J Basic Med Sci. 2018 Dec;21(12):1269-1274. doi: 10.22038/ijbms.2018.29567.7133.

Abstract

Objectives: Nowadays, the electromagnetic field-emitting devices are used routinely in our lives. Controversial reports exist concerning the effects of mobile radiofrequency (RF) on different parts of the body, especially stress hormones. The main goal of the present work was to study the long-term effects of mobile RF900 MHz exposure with special focus on the adrenal gland pathophysiology and function.

Materials and Methods: Adult male Wistar rats were exposed to mobile RF 6 hr daily for 4-8 weeks. Intact and switched-off exposed animals were considered as controls. Plasma ACTH and cortisol levels were measured by the ELISA method. At the end of the experiment, a histological study was done on adrenal gland and brain tissues by hematoxylin and eosin staining. The thickness of the fasciculate layer of the adrenal gland, and its cell count and perimeter were measured using the Fiji software.

Results: Enhanced plasma ACTH and cortisol levels were found after prolonged exposure to mobile RF. The fasciculata layer of adrenal cortex eventually thickened following mobile RF radiation. While the number of cells in zona fasciculata remained constant, the cell size and perimeter increased during RF exposure. Finally, we found that vacuolization in brain tissue and the number and size of vacuoles considerably increased during two months of RF exposure.

Conclusion: Cell phone RF exposure induced significant hormonal and structural changes in adrenal gland and brain tissues. Therefore, the public should be aware and limit their exposure as much as possible.

Open access paper: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6312682/>