Bulletin de veille
Champs électromagnétiques
N°4 - Juillet Août 2023

La validation des informations fournies (exactitude, fiabilité, pertinence par rapport aux principes de prévention, etc.) est du ressort des auteurs des articles signalés dans la veille. Les informations ne sont pas le reflet de la position de l'INRS.

Les liens mentionnés dans le bulletin donnent accès aux documents sous réserve d'un abonnement à la ressource.

Exposition professionnelle, études épidemiologiques

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

EEFTENS M., S. PUJOL, A. KLAIBER, G. CHOPARD, A. RISS, F. SMAYRA, B. FLUCKIGER, T. GEHIN, K. DIALLO, J. WIART, T. MAZLOUM, F. MAUNY and M. ROOSLI,

Environmental Research 231 (Aug 2023),

Introduction: The real-life short-term implications of electromagnetic fields (RF-EMF) on cognitive performance and health-related quality of life have not been well studied. The SPUTNIC study (Study Panel on Upcoming Technologies to study Non-Ionizing radiation and Cognition) aimed to investigate possible correlations between mobile phone radiation and human health, including cognition, health-related quality of life and sleep.Methods: Adult participants tracked various daily markers of RF-EMF exposures (cordless calls, mobile calls, and mobile screen time 4 h prior to each assessment) as well as three health outcomes over ten study days: 1) cognitive performance, 2) health-related quality of life (HRQoL), and 3) sleep duration and quality. Cognitive performance was measured through

six "game-like" tests, assessing verbal and visuo-spatial performance repeatedly. HRQoL was assessed as fatigue, mood and stress on a Likert-scale (1-10). Sleep duration and efficiency was measured using activity trackers. We fitted mixed models with random intercepts per participant on cognitive, HRQoL and sleep scores. Possible time-varying confounders were assessed at daily intervals by questionnaire and used for model adjustment. Results: A total of 121 participants ultimately took part in the SPUTNIC study, including 63 from Besancon and 58 from Basel. Self-reported wireless phone use and screen time were sporadically associated with visuo-spatial and verbal cognitive performance, compatible with chance findings. We found a small but robust significant increase in stress 0.03 (0.00-0.06; on a 1-10 Likert-scale) in relation to a 10-min increase in mobile phone screen time. Sleep duration and quality were not associated with either cordless or mobile phone calls, or with screen time.Discussion: The study did not find associations between short-term RF-EMF markers and cognitive performance, HRQoL, or sleep duration and quality. The most consistent finding was increased stress in relation to more screen time, but no association with cordless or mobile phone call time.
https://doi.org/10.1016/j.envres.2023.116011

Assessment of the occupational exposure to the static magnetic field of radiographers from a research facility working in the vicinity of 3T and 7T MRI scanners with a portable magnetic monitoring device,

GIMBERT M., M. DOYEN, N. WEBER, A. DELMAS, A. VIGNAUD, I. FABRE, C. GINISTY, Y. LECOMTE, V. BERLAND, S. B. DESMIDT, S. ROGER and J. FELBLINGER,

Archives Des Maladies Professionnelles Et De L Environnement 84, no. 3 (Jun 2023),

Introduction. - Magnetic Resonance Imaging (MRI) scanners permanently produce a Static Magnetic Field (SMF), B0. The European Directive 2013/35/EU, transposed into French law with the decree of August 3rd, 2016 restricts workers' exposure regarding the SMF to 2 T. It does however allow trained employees working in the vicinity of MRI scanners to exceed this threshold. A worker moving in the SMF generates a motion-induced time-varying magne-tic field, dB/dt. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) recommends not to reach an exposition to dB/dt > 2.7 T.s-1 or AB/3 sec > 2 T to avoid transient symptoms such as vertigo. Method. - Between 2016 and 2020, 5 radiographers working in the vicinity of a 3 T and a 7 T MRI scanners from the neuro-imaging department in an MRI research facility wore a portable magnetic monitoring device developed in Nancy. All recorded data were analyzed in order to quantify the number of events corresponding to an exposure to B0 > 2 T, and the number of dB/dt > 2.7 T.s-1 and AB/3 sec > 2 T. The average time spent by each radiographers for the 5 fol-lowing exposure categories was also assessed: [0.1T-0.5T[; [0.5T-1T[; [1T-1.5T[; [1.5T-2T[; >2 T. Results. - In total, 966 shifts carrying the device were analyzed, corresponding to 4839.8 hours of recording, including approximately 231 hours with an exposure greater than 0.1 T. 111 events with an exposure to B0 > 2 T were identified. A radiographer totalized 80 events and was exposed to the higher B0 of 2,67 T. Only one event was preceded by a dB/dt > 2.7 T.s-1. 14 events were followed by a AB/3 sec > 2 T. Conclusion. - This device might help MRI workers control their movements in order to com-ply with the exposure threshold recommended by the European Directive and not experience symptoms during their work.
https://doi.org/10.1016/j.admp.2022.101702

Prevalence and correlation of multiple chemical sensitivity and electromagnetic hypersensitivity with age, sex, and depression in the Japanese population: a retrospective study,

LU X., S. HOJO, A. MIZUKOSHI and T. KATOH,

Bmc Public Health 23, no. 1 (Jun 2023),

BackgroundIn Japan, there are currently no definitive conclusions regarding the characteristics of multiple chemical sensitivity (MCS) and electromagnetic hypersensitivity (EHS). This study aimed to determine the prevalence and correlation of MCS and EHS with age, sex, and depression in the Japanese population.MethodsAn anonymous self-report questionnaire was distributed to 2,007 participants. Variables such as MCS, EHS, depression score, and demographic characteristics were individually evaluated using the U-test, chi-squared test, and correlation analyses. Moreover, we performed a covariance structure analysis to build a structural equation model.ResultsOlder individuals and women were more likely to exhibit MCS and EHS symptoms. Moreover, depression was correlated with MCS and EHS.ConclusionsAlthough MCS and EHS are strongly correlated, they exhibit distinct characteristics and symptoms, indicating that they can be regarded as separate conditions. https://doi.org/10.1186/s12889-023-16152-2

Occupational exposure to radiofrequency electromagnetic fields,

STAM R.,

Industrial Health 60, no. 3 (2022): 201-215,

High exposures to radiofrequency electromagnetic fields (RF EMF) are possible in workplaces involving sources used for broadcasting, telecommunication, security and identification, remote sensing and the heating and drying of goods. A systematic literature review of occupational RF EMF exposure measurements could help to clarify where more attention to occupational safety may be needed. This review identifies specific sources of occupational RF EMF exposure and compares the published maximum exposures to occupational exposure limits. A systematic search for peer-reviewed publications was conducted via PubMed and Scopus. Relevant grey literature was collected via web searches. For each publication, the highest measured electric field strength, magnetic flux density or power density was extracted. Maximum exposures exceeding the limits were reported for dielectric heating, scanners for security and radiofrequency identification, plasma devices and broadcasting and telecommunication transmitters. Occupational exposure exceeding the limits was rare for microwave heating and radar applications. Some publications concerned cases studies of occupational accidents followed by a medical investigation of thermal health effects. These were found for broadcasting antennas, radar installations and a microwave oven and often involved maintenance personnel. New sources of occupational exposure such as those in fifth generation telecommunication systems or energy transition will require further assessment. https://doi.org/10.2486/indhealth.2021-0129

Analysis of Multilayer Spherical Head Model Exposed to EM Radiation from Arbitrary Source Using Spherical Vector Wave Functions,

ALIAN M. and N. NOORI,

Advanced Electromagnetics 12, no. 3 (2023): 10-18,

A semi-analytical method is presented for the assessment of the induced electromagnetic field inside a multilayer spherical head model exposed to radiation of an arbitrary source antenna. First, the isolated source antenna is simulated in a full-wave software to evaluate its radiation characteristics. By sampling the radiated fields, their spherical vector wave function (SVWF) amplitudes are evaluated. Next, the well-known translation addition theorem for SVWFs is implemented to translate the SVWFs of the radiated fields to the local coordinate system of the head model. It's assumed that the presence of the head model does not affect the primary radiated fields by the antenna due to the adequate distance between them. By applying the boundary conditions on the head model, the unknown SVWF amplitudes of the induced fields inside each layer as well as those of the scattered field outside the model are evaluated. The verification of the proposed method is shown through some numerical examples. In comparison with a fullwave numerical method, the proposed method provides an efficient repeatable simulation approach due to the independent analysis of the source and head model, provided that the reaction of the head model to the antenna is negligible. https://doi.org/

Assessment of Electromagnetic Field Exposure on European Roads: A Comprehensive In Situ Measurement Campaign,

ATANASOVA G. L., B. N. ATANASOV and N. T. ATANASOV,

Sensors 23, no. 13 (Jul 2023),

The rapid evolution of wireless communication technologies (such as fifth-generation (5G) cellular networks) in the last years has allowed connecting different objects (from wearable electronics to vehicles) and people through communication networks, and at the same time, has led to widespread deployment of base stations. Along with this growth, questions about the potential adverse effects on human health due to electromagnetic fields (EMFs) from base station antennas have also been raised. In this paper, we focus on the assessment of EMFs in automobiles during short (between cities) and long (between countries) trips on several European roads. Comprehensive measurement campaigns were carried out in several European countries: Austria, Bulgaria, Croatia, Hungary, Italy, Slovenia, and the Republic of Serbia. The results show that the median total electric field is 0.23-0.24 V/m in Bulgaria, Croatia, Hungary, Italy, and the Republic of Serbia. In Austria and Slovenia, the median is 0.28-0.31 V/m. Austria demonstrated the highest value for the total electric field, at 17.4 V/m. https://doi.org/10.3390/s23136050

How to Control Exposure to Fifth-Generation Radiofrequencies in Preterm Newborns in Incubator,

CHARDON K., S. DELANAUD, P. TOURNEUX and E. S. BLANCHARD,

Neonatology (2023 Jun 2023),

Infant and family centered development care reduces infant distress and supports the parent and infant's individual abilities. However, a new environmental factor is daily encountered: the radiofrequency electromagnetic fields (RF EMFs) with the most recent fifth-generation (5G) technology. Currently, the effects of RF EMF during development are discussed in animal models. The neonatal intensive care units are not spared from this stressor. The objective of this study was to evaluate the efficacy of a novel, electromagnetically insulating incubator cover to prevent the preterm infant from RF EMF exposure. A personal dosimeter was placed on the mattress of a closed incubator. Periods of exposure to low, medium, and high levels of 5G RF were delivered in the presence or absence of the incubator cover. The use of a silver-copper cover reduced the intensity of 5G radiofrequency levels from 52% to 57% ($p < 0.0001$), allowing to easily apply the precautionary principle. https://doi.org/10.1159/000530658

Estimation of the general population and children under five years of age in France exposed to magnetic field from high or very high voltage power line using geographic information system and extrapolated field data,

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Environmental Research 232 (Sep 2023),

Background: The effects of extremely low-frequency magnetic fields, especially their long-term health effects, including childhood leukaemia, remain elusive. The International Agency for Research on Cancer has classified the exposure to magnetic fields >0.4 & mu;T as 'possibly carcinogenic to humans (group 2 B)' for childhood leukaemia. However, the number of exposed individuals, particularly children, remains poorly documented in international literature. The objective of this study was to estimate the number of individuals living near a high or very high voltage line in France (& GE;63 kV), among the general population and children under the age of five years.Methods: The estimate considered different exposure scenarios depending on the line voltage and the distance of the housing from it, and whether the line is overhead or underground. The exposure scenarios were obtained using a multilevel linear model created from a measurement database published by "Re & PRIME;seau de transport d'e & PRIME;lectricite & PRIME;", the operator of the French electricity transmission network.Results: Between 0.11% (n = 67,893) and 1.01% (n = 647,569) of the French population and between 0.10% (n = 4712) and 1.03% (n = 46,950) of children under five years of age were estimated to be living in an area potentially exposed to a magnetic field, depending on the exposure scenario (>0.4 & mu;T and >0.1 & mu;T, respectively).Conclusions: By making it possible to estimate the total number of residents, schools, and health institutions near high-voltage power lines, the proposed methodology can help identify potential co-exposures near high-voltage power lines, which are regularly cited as a possible explanation for contradictory results from epidemiological studies. https://doi.org/10.1016/j.envres.2023.116425

Specific absorption rate of different phone brands and health students' awareness, attitude, and performance towards mobile phone hazards,

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Environmental Health Engineering and Management Journal 10, no. 2 (2023): 149-156,

Background: This study aimed to assess the specific absorption rate (SAR) due to the exposure to the radiations from different brands of cellphones, and to compare it with guideline values. The SAR is calculated using the mathematic equation based on the measured energy.Methods: In this regard, 204 cellphones from different brands were randomly surveyed. A questionnaire composed of demographic and self-reported questions was designed to survey the students' awareness and attitude about cellphone brands, usage duration and observed health effects. The Kolmogorov-Smirnov test was used for statistical analysis at frequencies of 900 and 1800 MHz and the differences between brands were assessed by the Kruskal-Wallis test.Results: According to the results, it was found that 46.7% and 8.4% of people used cellphones for less than 4 and more than 12 hours per day, respectively. According to the statistical tests, students with higher talk time, sent messages, and Internet usage, and those using wireless hands-free, had the most reported symptoms of headache, tinnitus, eye burning and eyestrain, sleep disturbances, and skin color changes.Conclusion: The authors found that there was no significant difference between different brands based on the SAR values. However, Samsung and Nokia brands had the highest SAR values and ASUS brand had the lowest ones. Also, the type of game apps (online/offline) was significantly correlated with possible health effects. Therefore, regarding these cases, as well as the fact that many dangers of cellphone use are unknown, it is recommended to use cellphones cautiously.
https://doi.org/10.34172/ehem.2023.17

Dosimetric assessment in the brain for downlink EMF exposure in Korean mobile communication networks,

LEE A. K. and H. D. CHOI,

Environmental Research 234 (Oct 2023),

Because the position and direction of the human body is not fixed in an actual environment, the incidence di-rection of the electromagnetic field (EMF) from mobile communication base stations, WiFi access points, broadcasting towers, and other far-field sources is arbitrary. To analyze the overall health effects of radio fre-quency EMF exposure, the dosimetric assessment for such environmental exposures created from an unspecified number of sources in daily life, along with exposures from specific EMF sources, must be quantified. This study is aimed at numerically evaluating the time-averaged specific absorption rate (SAR) of the human brain for environmental EMF exposure in the frequency range of 50-5800 MHz. Whole-body exposure to EMFs that are evenly incident spatially is considered. By comparing the results of several incidence directions and the number of polarizations, an optimal calculation condition has been derived. Finally, based on the results measured in Seoul at the end of 2021, the SAR and daily specific energy absorption (SA) in the brains of both a child and an adult for downlink exposures from 3G to 5G base stations are reported. Comparison results of the daily brain SA for exposure to DL EMF in all 3G to 5G mobile networks and exposure to a 10-min voice call (uplink EMF) using a mobile phone

connected to a 4G network show that the SA from the downlinks is much higher than that from the uplinks. https://doi.org/10.1016/j.envres.2023.116542

Identification of electric field strength in aircrafts,

MICHALOWSKA J., P. TOMILO, J. PYTKA, L. PUZIO and A. TOFIL,

Przeglad Elektrotechniczny 99, no. 2 (2023): 222-225,

The development of new technologies contributes to an increase in the value of the electromagnetic field. The article presents the identification of the electric field with the use of cluster analysis. The research on the value of the electric component of the electromagnetic field (EMF) was determined with the NHT3DL broadband meter from Microrad with the 01E measuring probe during training flights. The developed model for cluster analysis using the DBSCAN (density-based spatial clustering of applications with noise) algorithm is used to identify the electric field exposure value in the context of flight safety analysis. https://doi.org/10.15199/48.2023.02.43

EVALUATION OF HUMAN EXPOSURE TO ELECTROMAGNETIC FIELD USING DATA PROVIDED BY THE NATIONAL AUTONOMOUS ELECTROMAGNETIC FIELD MONITORING SYSTEM,

NEDELCU M. N. and T. PETRESCU,

University Politehnica of Bucharest Scientific Bulletin Series C-Electrical Engineering and Computer Science 85, no. 2 (2023): 175-184,

With the start of discussions about the implementation of 5G (fifth generation) technology, there were voices expressing reluctance, which is why monitoring the ambient electromagnetic field is a very useful measure these days. The present paper uses the data measured during one year by the sensor system developed at the national level by the National Authority for Administration and Regulation in Communications (ANCOM). The measured values were compared with the reference levels provided by the national legislation. The results show that the level of the ambient electromagnetic field is reduced compared to the reference levels. https://doi.org/

Large-Area Monitoring of Radiofrequency Electromagnetic Field Exposure Levels from Mobile Phone Base Stations and Broadcast Transmission Towers by Car-Mounted Measurements around Tokyo,

ONISHI T., K. ESAKI, K. TOBITA, M. IKUYO, M. TAKI and S. WATANABE,

Electronics 12, no. 8 (Apr 2023),

Car-mounted measurements of radiofrequency electromagnetic exposure levels were carried out in a large area around Tokyo. Prior to the electric field (E-field) measurements using a car, the effect of the car body was evaluated in an anechoic chamber. The measurements between May 2021 and February 2022 were carried out within a radius of

100 km centering on Nihonbashi, Tokyo, with a measurement distance of about 13,800 km. The measurement results were averaged in the reference area mesh (1 km(2)). It was found that the E-field strengths of FM/TV frequency bands are lower than that of mobile phone base stations. It was also found that the E-field strength of only the 5G frequency band is approximately 20-30 dB lower than that of all mobile phone systems. However, note that it is possible to depend on the data traffic of 5G. The E-field strength of all bands is higher in Tokyo than in other prefectures. Additionally, repeated measurements were carried out to investigate the reproducibility of the measured E-field. The standard deviation is less than 3 dB along the same route, and a similar tendency of E-field strength by the car to the time-averaged results of spot measurements in the past was confirmed. Finally, the relationship of E-field strength with population density was investigated. It was found that the E-field strength from mobile phone base stations has a positive relationship with population density. https://doi.org/10.3390/electronics12081835

Human Exposure to Non-Ionizing Radiation from Indoor Distributed Antenna System: Shopping Mall Measurement Analysis,

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Sensors 23, no. 10 (May 2023),

It is crucial to monitor the levels of Non-Ionizing Radiation (NIR) to which the general population may be exposed and compare them to the limits defined in the current standards, in view of the rapid rise of communication services and the prospects of a connected society. A high number of people visits shopping malls and since these locations usually have several indoor antennas close to the public, it is therefore a kind of place that must be evaluated. Thus, this work presents measurements of the electric field in a shopping mall located in Natal, Brazil. We proposed a set of six measurement points, following two criteria: places with great the flow of people and the presence of one or more Distributed Antenna System (DAS), co-sited or not with WiFi access points. Results are presented and discussed in terms of the distance to DAS (conditions: near and far) and flow density of people in the mall (scenarios: low and high number of people). The highest peaks of electric field measured were 1.96 and 3.26 V/m, respectively corresponding to 5% and 8% of the limits defined by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Brazilian National Telecommunication Agency (ANATEL). https://doi.org/10.3390/s23104579

Analysis of Electromagnetic Radiation of Mobile Base Stations Co-located with High-Voltage Transmission Towers,

YANG Z. C., D. DANG, X. CHENG, J. MO, X. Y. ZHOU, Y. Q. FANG and Y. PENG,

Symmetry-Basel 15, no. 6 (Jun 2023),

This paper presents the analysis of electromagnetic radiation of mobile base stations co-located with high-voltage transmission towers. Although the layout of power poles and towers is uniform and symmetrical, the electromagnetic field radiated to the outside world is asymmetric. Field measurements were conducted in different co-located base station

scenarios, and the field strength results in both the vertical and horizontal directions were analyzed in depth. Then, the ray tracing simulation method was used to obtain the electromagnetic field distribution characteristics for the 5G base station co-located high-voltage tower. Finally, the specific absorption rate (SAR) was adopted to evaluate human exposure in co-located base station scenarios, and a physical area-based human exposure assessment method proposed. The obtained results can be useful for inspectors of mobile base stations co-located with high-voltage transmission towers to avoid or reduce the impact of electromagnetic radiation. https://doi.org/10.3390/sym15061252

Société, politique et valeurs limites

Understanding consumer's belief and fear: The case of smart meter installation,

ARCHANA,

International Journal of Rf Technologies-Research and Applications 13, no. 1 (2023): 1-20,

This paper aims to understand the issues related to the perceived negative health effects of electromagnetic field (emf) radiation due to smart devices from the consumer's perspective. With the recent technological advancement, more and more devices like smartphones, smart locks, smart TVs, smart meters, etc., are becoming integral parts of human lives. On the one hand, these devices have added comfort and efficiency, while on the other hand, the negative health impacts of persistent exposure to emf radiation from these devices can't be denied. This paper used smart meter as an example of a smart device to explore potential adverse health effects of emf radiation by applying Soft System Methodology (SSM). Semi-structured interviews and workshops were conducted to gain insight into the research domain. The objective hierarchy has been proposed as a result of applying SSM. Some key concerns that must be considered for addressing consumers' health concerns were identified as the outcome of the conducted SSM workshops. The proposed hierarchy suggests creating a risk-management team of knowledgeable individuals and provides a roadmap for executives, government officials and policymakers. https://doi.org/10.3233/rft-220318

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

KAVET R. and R. A. TELL,

Health Physics 124, no. 5 (May 2023): 351-371,

The Institute for Electrical and Electronic Engineers (IEEE) and the International Commission on Non-ionizing Radiation Protection (ICNIRP) have established limits for exposures to electromagnetic fields across the 0-300 GHz (non-ionizing) spectrum,

including limits on contact currents (CC) specified by IEEE for 0-110 MHz (ICNIRP issued a CC "guidance level"). Both sets of limits seek to protect against potentially adverse effects, including aversive electrostimulation at frequencies 100 kHz. For the most part, CC is linked to electric field (E-field) exposures for an ungrounded person contacting a grounded object, with the short-circuit current (I-SC) through the contact point (usually the hand) equivalent to the current through the grounded feet of a free-standing person exposed to a vertically polarized E-field. The physical linkage between these two quantities dictates that their respective exposure limits align with one another, which is presently not the case, especially with respect to frequencies from100 kHz to 110 MHz. Here we focus specifically on recommendations for revisions to the IEEE standard, IEEE Std C95.1 & TRADE;-2019 ("IEEE C95.1"), in which the E-field exposure limit (E-field exposure reference levels, ERLs) >100 kHz induces substantially greater currents than the CC ERLs currently prescribed. The most important scenario deserving of attention concerns finger contact through a 1-cm(2) cross-sectional interface between the skin and a grounded conductor in which the rate of temperature rise in the presence of an E-field ERL can be rapid enough to cause a burn injury. This rate is highly dependent on the moistness/dryness of the skin at the contact point (i.e., its impedance)-a highly variable value-with temperature increasing more rapidly with increasing dryness (greater contact impedance). The two main remedies to alleviate the possibility of injury in this "touch" scenario are to (a) limit the time of finger contact to 1 s in all cases and (b) revise the E-field ERL between 100 kHz and 30 MHz from a "hockey-stick-shaped" curve vs. frequency to a "ramp" across this frequency range. These measures factored in with the real-world prevalence of potentially hazardous scenarios should afford greater protection against adverse outcomes than is presently the case. IEEE C95.1 also specifies limits for grasp contact (15 cm(2) in the palm) and associated wrist heating, plus heating in the ankles from free-standing induction. However, these scenarios are more manageable compared to finger touch due mainly to the comparatively lower rates of tissue heating attributable to the wrist's and ankle's relatively greater cross-sectional area. Recommendations for grasp can thus be dealt with separately. Two identified but unaddressed issues in IEEE C95.1 deserving of further attention are first, the circumstance in which a grounded person contacts an ungrounded object situated in an electric field for which there are countless numbers of scenarios that are not amenable to a single ERL. Second, arcing between an extended limb and E-field-exposed object is perhaps the most hazardous of all scenarios. Both of these scenarios cannot be stereotyped and must be dealt with on a case-by-case basis. Future revisions of IEEE Std C95.1-2019 (and the ICNIRP guidelines) will benefit from improved insight into strategies of affording protection from potentially adverse effects in these circumstances.
https://doi.org/10.1097/hp.0000000000001659

Computation of Whole-Body Average SAR in Realistic Human Models From 1 to 100 GHz,

KODERA S., K. TAGUCHI, Y. L. DIAO, T. KASHIWA and A. HIRATA,

Ieee Transactions on Microwave Theory and Techniques (2023 Jul 2023),

The reliability of numerical human modeling, espe-cially for the skin, is one of the challenging topics in the frequency region above 6 GHz. This study provides a first computation of the frequency dependence of whole-body average specific absorp-tion rate (WBASAR) from 1 to 100 GHz to provide the limit of external power density of the international guidelines using high-resolution anatomical human models. A high-resolution anatomical model with fine-tuned skin thickness was developed to compute the WBASAR. The effects of skin thickness on the WBASAR were evaluated at frequencies >6 GHz where

power deposition in the skin predominates. The absorption cross section (ACS) was derived according to the results acquired using a high-resolution model for semianalytically estimating the WBASAR. The WBASAR is affected by skin thicknesses at fre-quencies =20 GHz. Above 20 GHz, the WBASARs in the models without surface smoothness were 10%-17% higher compared with those in a model with surface smoothing. A simple estimation of WBASAR is also presented in terms of the ACS, in which the ACS becomes close to the projection area above 10 GHz. The WBASAR can be estimated according to a projection area with an accuracy of 5% above 10 GHz. https://doi.org/10.1109/tmtt.2023.3289562

Toxicité sur l'homme

Quantitative proteomics reveals effects of environmental radiofrequency electromagnetic fields on embryonic neural stem cells,

AN G. Z., Y. T. JING, T. ZHAO, W. ZHANG, L. GUO, J. GUO, X. MIAO, J. L. XING, J. LI, J. Y. LIU and G. R. DING,

Electromagnetic Biology and Medicine (2023 Aug 2023),

The effects of environmental radiofrequency electromagnetic fields (RF-EMF) on embryonic neural stem cells have not been determined, particularly at the proteomic level. This study aims to elucidate the effects of environmental levels of RF-EMF radiation on embryonic neural stem cells. Neuroectodermal stem cells (NE-4C cells) were randomly divided into a sham group and an RF group, which were sham-exposed and continuously exposed to a 1950 MHz RF-EMF at 2 W/kg for 48 h. After exposure, cell proliferation was determined by a Cell Counting Kit-8 (CCK8) assay, the cell cycle distribution and apoptosis were measured by flow cytometry, protein abundance was detected by liquid chromatography-tandem mass spectrometry (LC-MS/MS), and mRNA expression was evaluated by quantitative reverse transcription polymerase chain reaction (qRT-PCR). We did not detect differences in cell proliferation, cell cycle distribution, and apoptosis between the two groups. However, we detected differences in the abundance of 23 proteins between the two groups, and some of these differences were consistent with alterations in transcript levels determined by qRT-PCR ($P < 0.05$). A bioinformatics analysis indicated that the differentially regulated proteins were mainly enriched in 'localization' in the cellular process category; however, no significant pathway alterations in NE-4C cells were detected. We conclude that under the experimental conditions, low-level RF-EMF exposure was not neurotoxic but could induce minor changes in the abundance of some proteins involved in neurodevelopment or brain function. https://doi.org/10.1080/15368378.2023.2243980

Thyroid Function: A Target for Endocrine Disruptors, Air Pollution and Radiofrequencies,

DI CIAULA A., L. BONFRATE, M. NOVIELLO and P. PORTINCASA,

Endocrine Metabolic & Immune Disorders-Drug Targets 23, no. 8 (2023): 1032-1040,

Thyroid diseases, including congenital hypothyroidism, thyroiditis, and childhood thyrotoxicosis, are progressively increasing. The incidence of thyroid cancer in children and adolescents has also increased in recent decades, mirroring the trends observed in adults. These epidemiologic trends develop in parallel with the rising costs associated with diagnosis and treatment of thyroid diseases. Both genetic and environmental factors are involved in these diseases, and a number of widely diffused toxic chemicals of anthropogenic origin can impair thyroid function and make thyroid cancer worse. Synthetic substances persistently contaminate environmental matrices (i.e., air, soil, water) and the food chain and bio-accumulate in humans, starting from in utero life. Environmental toxins such as air pollutants, endocrine disruptors, and high-frequency electromagnetic fields can act on common targets through common pathways, combined mechanisms, and with trans-generational effects, all of which contribute to thyroid damage. Both experimental and epidemiologic observations show that mechanisms of damage include: modulation of synthesis; transportation and metabolism of thyroid hormones; direct interference with hormone receptors: modulation of gene expression; and autoimmunity. We should not underestimate the available evidence linking environmental pollutants with thyroid disease, cancer included, since toxic substances increasingly diffuse and thyroid hormones play a key role in maintaining systemic metabolic homeostasis during body development. Thus, primary prevention measures are urgently needed in particular to protect children, the most exposed and vulnerable subjects. https://doi.org/10.2174/1871530321666210909115040

FDTD Assessment of Exposures to Far-Field mmWave Beams in Anatomical Head Model,

DIAO Y. L. and A. HIRATA,

Ieee Transactions on Electromagnetic Compatibility (2023 Jul 2023),

In new fifth generation wireless communication systems, the radiation from a small cell base station antenna may form a beam. Unlike conventional wireless systems and local exposures from mobile phones, different body parts, including complex surfaces (e.g., nose and pinna), are exposed to an intense beam. This article adopts a hybrid spherical near-field transformation and finite-difference time-domain method to assess the power absorption and resultant temperature rise in a human head model exposed to a radiation beam from a patch array at 28 GHz in the far-field region. Unlike previous studies, the spherical near-field measurement can be used as an input and thus can combine nonreactive near-field measurement (computation) with dosimetry analysis. We then considered electrically larger antenna-body distances than local exposure scenarios, ranging from 0.25 to 2 m with various incident angles, corresponding to canonical beam exposure from a small-cell base station. For a single head model exposed to the antenna array, parameter variations create a total of 112 cases providing a diversity of exposure scenarios. Peak spatial-average absorbed power density and skin temperature rise were assessed for our computations of the selected scenarios. Higher temperature rises were observed around the nose or pinna due to the interference fringe effect. This effect is more pronounced when the beamwidth at the head surface is large, leading to slightly higher heating factors than those previously obtained using a planar body model with plane-wave approximation. https://doi.org/10.1109/temc.2023.3289450

The Effects of mmW and THz Radiation on Dry Eyes: A Finite-Difference Time-Domain (FDTD) Computational Simulation Using XFdtd,

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Sensors 23, no. 13 (Jul 2023),

The importance of investigating the health effects of RF radiation on the cornea cannot be overstated. This study aimed to address this need by utilizing a mathematical simulation to examine the absorption of millimeter wave (mmW) and terahertz (THz) waves by the cornea, considering both normal and pathological conditions. The simulation incorporated variations in tear film thickness and hydration levels, as these factors play a crucial role in corneal health. To assess the impact of RF radiation on the cornea, the study calculated temperature rises, which indicate heating effects for both dry and normal eyes. XFdtd, a widely used commercial software based on the Finite-Difference Time Domain (FDTD) method, was employed to evaluate the radiation absorption and resulting temperature changes. The outcomes of this study demonstrated a crucial finding, i.e., that changes in the water ratio and thickness of the tear film, which are associated with an increased risk of dry eye syndrome, directly impact the absorption of mmW and THz waves by the cornea. This insight provides valuable evidence supporting the interconnection between tear film properties and the vulnerability of the cornea to RF radiation.
https://doi.org/10.3390/s23135853

Spatiotemporal estimations of temperature rise during electroporation treatments using a deep neural network,

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Computers in Biology and Medicine 161 (Jul 2023),

The nonthermal mechanism for irreversible electroporation has been paramount for treating tumors and cardiac tissue in anatomically sensitive areas, where there is concern about damage to nearby bowels, ducts, blood vessels, or nerves. However, Joule heating still occurs as a secondary effect of applying current through a resistive tissue and must be minimized to maintain the benefits of electroporation at high voltages. Numerous thermal mitigation protocols have been proposed to minimize temperature rise, but intraoperative temperature monitoring is still needed. We show that an accurate and robust temperature prediction AI model can be developed using estimated tissue properties (bulk and dynamic conductivity), known geometric properties (probe spacing), and easily measurable treatment parameters (applied voltage, current, and pulse number). We develop the 2-layer neural network on realistic 2D finite element model simulations with conditions encom-passing most electroporation applications. Calculating feature contributions, we found that temperature pre-diction is mostly dependent on current and pulse number and show that the model remains accurate when incorrect tissue properties are intentionally used as input parameters. Lastly, we show that the model can predict temperature rise within ex vivo perfused porcine livers, with error <0.5 degrees C. This model, using easily acquired parameters, is shown to predict temperature rise in over 1000 unique test conditions with <1 degrees C error and no observable outliers. We believe the use of simple, readily available input parameters would allow this model to be incorporated in many already available electroporation systems for real-time temperature estimations.
https://doi.org/10.1016/j.compbiomed.2023.107019

Determination of lethal electric field threshold for pulsed field ablation in ex vivo perfused porcine and human hearts,

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Frontiers in Cardiovascular Medicine 10 (Jun 2023),

IntroductionPulsed field ablation is an emerging modality for catheter-based cardiac ablation. The main mechanism of action is irreversible electroporation (IRE), a threshold-based phenomenon in which cells die after exposure to intense pulsed electric fields. Lethal electric field threshold for IRE is a tissue property that determines treatment feasibility and enables the development of new devices and therapeutic applications, but it is greatly dependent on the number of pulses and their duration.MethodsIn the study, lesions were generated by applying IRE in porcine and human left ventricles using a pair of parallel needle electrodes at different voltages (500-1500 V) and two different pulse waveforms: a proprietary biphasic waveform (Medtronic) and monophasic 48 x 100 & mu;s pulses. The lethal electric field threshold, anisotropy ratio, and conductivity increase by electroporation were determined by numerical modeling, comparing the model outputs with segmented lesion images.ResultsThe median threshold was 535 V/cm in porcine ((N = 51 lesions in n = 6 hearts) and 416 V/cm in the human donor hearts ((N = 21 lesions in n = 3 hearts) for the biphasic waveform. The median threshold value was 368 V/cm in porcine hearts ((N = 35 lesions in n = 9 hearts) cm for 48 x 100 & mu;s pulses.DiscussionThe values obtained are compared with an extensive literature review of published lethal electric field thresholds in other tissues and were found to be lower than most other tissues, except for skeletal muscle. These findings, albeit preliminary, from a limited number of hearts suggest that treatments in humans with parameters optimized in pigs should result in equal or greater lesions. https://doi.org/10.3389/fcvm.2023.1160231

Sirtuin 3 controls cardiac energetics and protects against oxidative stress in electromagnetic radiation-induced cardiomyopathy,

NIU T. H., Y. ZHI, L. Z. WEI, W. J. LIU, X. X. JU, W. P. PI, Z. J. FU, H. TONG, H. X. HU and J. DONG,

Free Radical Biology and Medicine 205 (Aug 2023): 1-12,

Electromagnetic radiation can cause injuries to both the structures and functions of the heart. No therapy is currently available to inhibit these untoward effects. Mitochondrial energetic damage and oxidative stress are drivers of electromagnetic radiation-induced cardiomyopathy (eRIC); however, the pathways that mediate these events are poorly defined. Sirtuin 3 (SIRT3) has been emerged as a key target for maintaining mitochondrial redox potential and metabolism, but its role in eRIC remains unknown. Here, Sirt3-KO mice and cardiac-specific SIRT3 transgenic mice were subjected to the investigation of eRIC. We found that Sirt3 protein expression level was down-regulated in eRIC mice model. Sirt3-KO markedly exaggerated decreases in cardiac energetics and increases in oxidative stress in microwave irradiation (MWI)-stressed mice. Conversely, cardiac-specific SIRT3 overexpression protected the hearts from these effects and rescued cardiac malfunction. Mechanistically, Sirt3 maintained AMP-activated protein kinase (AMPK) signaling pathway

in MWI-stressed hearts in vivo. In conclu-sion, electromagnetic radiation repressed SIRT3 expression and disturbed cardiac energetics and redox ho-meostasis. The increased SIRT3 expression and AMPK activation in vivo prevented eRIC, indicating that SIRT3 will be a potential therapeutic target for curative interventions in eRIC.
https://doi.org/10.1016/j.freeradbiomed.2023.05.031

Evaluation of DNA Methylation Profiles of LINE-1, Alu and Ribosomal DNA Repeats in Human Cell Lines Exposed to Radiofrequency Radiation,

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International Journal of Molecular Sciences 24, no. 11 (May 2023),

A large body of evidence indicates that environmental agents can induce alterations in DNA methylation (DNAm) profiles. Radiofrequency electromagnetic fields (RF-EMFs) are radiations emitted by everyday devices, which have been classified as "possibly carcinogenic"; however, their biological effects are unclear. As aberrant DNAm of genomic repetitive elements (REs) may promote genomic instability, here, we sought to determine whether exposure to RF-EMFs could affect DNAm of different classes of REs, such as long interspersed nuclear elements-1 (LINE-1), Alu short interspersed nuclear elements and ribosomal repeats. To this purpose, we analysed DNAm profiles of cervical cancer and neuroblastoma cell lines (HeLa, BE(2)C and SH-SY5Y) exposed to 900 MHz GSM-modulated RF-EMF through an Illumina-based targeted deep bisulfite sequencing approach. Our findings showed that radiofrequency exposure did not affect the DNAm of Alu elements in any of the cell lines analysed. Conversely, it influenced DNAm of LINE-1 and ribosomal repeats in terms of both average profiles and organisation of methylated and unmethylated CpG sites, in different ways in each of the three cell lines studied.
https://doi.org/10.3390/ijms24119380

Non-Contact Irreversible Electroporation in the Esophagus With a Wet Electrode Approach,

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Journal of Biomechanical Engineering-Transactions of the Asme 145, no. 9 (Sep 2023),

Our objective was to develop a technique for performing irreversible electroporation (IRE) of esophageal tumors while mitigating thermal damage to the healthy lumen wall. We investigated noncontact IRE using a wet electrode approach for tumor ablation in a human esophagus with finite element models for electric field distribution, joule heating, thermal flux, and metabolic heat generation. Simulation results indicated the feasibility of tumor ablation in the esophagus using an catheter mounted electrode immersed in diluted saline. The ablation size was clinically relevant, with substantially lesser thermal damage to the healthy esophageal wall when compared to IRE performed by placing a monopolar electrode directly into the tumor. Additional simulations were used to estimate ablation size and penetration during noncontact wet-electrode IRE (wIRE) in the healthy swine esophagus. A novel catheter electrode was manufactured and wIRE evaluated in seven pigs. wIRE was performed by securing the device in the esophagus and using diluted saline

to isolate the electrode from the esophageal wall while providing electric contact. Computed tomography and fluoroscopy were performed post-treatment to document acute lumen patency. Animals were sacrificed within four hours following treatment for histologic analysis of the treated esophagus. The procedure was safely completed in all animals; post-treatment imaging revealed intact esophageal lumen. The ablations were visually distinct on gross pathology, demonstrating full thickness, circumferential regions of cell death (3.52 & PLUSMN; 0.89 mm depth). Acute histologic changes were not evident in nerves or extracellular matrix architecture within the treatment site. Catheter directed noncontact IRE is feasible for performing penetrative ablations in the esophagus while avoiding thermal damage. https://doi.org/10.1115/1.4062491

A Multiscale Computational Model of Skeletal Muscle Electroporation Validated Using In Situ Porcine Experiments,

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Ieee Transactions on Biomedical Engineering 70, no. 6 (Jun 2023): 1826-1837,

Objective: The goal of our study was to determine the importance of electric field orientation in an anisotropic muscle tissue for the extent of irreversible electroporation damage by means of an experimentally validated mathematical model. Methods: Electrical pulses were delivered to porcine skeletal muscle in vivo by inserting needle electrodes so that the electric field was applied in direction either parallel or perpendicular to the direction of the muscle fibres. Triphenyl tetrazolium chloride staining was used to determine the shape of the lesions. Next, we used a single cell model to determine the cell-level conductivity during electroporation, and then generalised the calculated conductivity changes to the bulk tissue. Finally, we compared the experimental lesions with the calculated field strength distributions using the Sorensen-Dice similarity coefficient to find the contours of the electric field strength threshold beyond which irreversible damage is thought to occur. Results: Lesions in the parallel group were consistently smaller and narrower than lesions in the perpendicular group. The determined irreversible threshold of electroporation for the selected pulse protocol was 193.4 V/cm with a standard deviation of 42.1 V/cm, and was not dependent on field orientation. Conclusion: Muscle anisotropy is of significant importance when considering electric field distribution in electroporation applications. Significance: The paper presents an important advancement in building up from the current understanding of single cell electroporation to an in silico multiscale model of bulk muscle tissue. The model accounts for anisotropic electrical conductivity and has been validated through experiments in vivo. https://doi.org/10.1109/tbme.2022.3229560

Effects of extremely low frequency electromagnetic fields on the tumor cell inhibition and the possible mechanism,

SUN J., Y. Y. TONG, Y. JIA, X. JIA, H. WANG, Y. CHEN, J. M. WU, W. Y. JIN, Z. MA, K. CAO, X. D. LI, Z. L. CHEN and G. H. YANG,

Scientific Reports 13, no. 1 (Apr 2023),

Low-frequency magnetic fields exert a significant inhibitory effect on tumor growth and have been developed as a therapeutic modality. However, the effect of a low-frequency magnetic

field on the interaction between cells is still poorly understood. This study aimed to preliminarily evaluate the direct effect of magnetic field ditectely on cultured cells and indirect effect mediated by cell-environment (conditioned medium). 293 T cells, Hepg2 cells, A549 cells have been cultured at 37 +/- 0.18 degrees C in presence of an extremely low-frequency magnetic field of 20 Hz, 5-mT. The adherent tumor cells were more sensitive to magnetic field inhibition in the original environment (conditioned medium) with adherence inhibition rate for Hepg2 and A549 estimated at 18% and 30% respectively. The inhibition effect was suppressed when the suspended cells separated or clump density at a low density. The nontumor cell lines showed no inhibitory effect on exposure to a low-frequency magnetic field. The intracellular ion fluorescence (IIF) showed that the magnetic field significantly altered the membrane potential, indicating hyperpolarization of the adherent cells (Delta IIF 293 T cells: - 25%, Delta IIF Hepg2 cells: - 20% and Delta IIF A549 cells: - 13%) and depolarization of the suspended cells (Delta IIF Raji cells: + 9%). In addition, the conditioned media collected after magnetic field exposure acted on unexposed tumor cells and caused inhibition. Our findings might provide a basis for the mechanism of magnetic field interaction between cells and cell environment in the future.
https://doi.org/10.1038/s41598-023-34144-5

Low-energy amplitude-modulated radiofrequency electromagnetic fields as a systemic treatment for cancer: Review and proposed mechanisms of action,

TUSZYNSKI J. A. and F. COSTA,

Frontiers in Medical Technology 4 (Sep 2022),

Exposure to Low-Energy Amplitude-Modulated Radiofrequency Electromagnetic Fields (LEAMRFEMF) represents a new treatment option for patients with advanced hepatocellular carcinoma (AHCC). We focus on two medical devices that modulate the amplitude of a 27.12 MHz carrier wave to generate envelope waves in the low Hz to kHz range. Each provides systemic exposure to LEAMRFEMF via an intrabuccal antenna. This technology differs from so-called Tumour Treating Fields because it uses different frequency ranges, uses electromagnetic rather than electric fields, and delivers energy systemically rather than locally. The AutemDev also deploys patient-specific frequencies. LEAMRFEMF devices use 100-fold less power than mobile phones and have no thermal effects on tissue. Tumour type-specific or patient-specific treatment frequencies can be derived by measuring haemodynamic changes induced by exposure to LEAMRFEMF. These specific frequencies inhibited growth of human cancer cell lines in vitro and in mouse xenograft models. In uncontrolled prospective clinical trials in patients with AHCC, minorities of patients experienced complete or partial tumour responses. Pooled comparisons showed enhanced overall survival in treated patients compared to historical controls. Mild transient somnolence was the only notable treatment-related adverse event. We hypothesize that intracellular oscillations of charged macromolecules and ion flows couple resonantly with LEAMRFEMF. This resonant coupling appears to disrupt cell division and subcellular trafficking of mitochondria. We provide an estimate of the contribution of the electromagnetic effects to the overall energy balance of an exposed cell by calculating the power delivered to the cell, and the energy dissipated through the cell due to EMF induction of ionic flows along microtubules. We then compare this with total cellular metabolic energy production and conclude that energy delivered by LEAMRFEMF may provide a beneficial shift in cancer cell metabolism away from aberrant glycolysis. Further clinical research may confirm that LEAMRFEMF has therapeutic value in AHCC.
https://doi.org/10.3389/fmedt.2022.869155

Immunomodulatory role of non-ionizing electromagnetic radiation in human leukemia monocytic cell line,

YADAV H. and R. SINGH,

Environmental Pollution 331 (Aug 2023),

In daily life, people are usually exposed to radiofrequency radiations (RFR). The effects of RFR on human physiology have been a major source of controversy since the WHO declared that these radiations are a type of environmental energy that interacts with the physiological functioning of the human body. The immune system provides internal protection and promotes long-term health and survival. However, the relevant research on the innate immune system and radiofrequency radiation is scant. In this connection, we hypothesized that innate immune responses would be influenced by exposure to non-ionizing electromagnetic radiation from mobile phones in a cell-specific and time-dependent manner. To test this hypothesis, human leukemia monocytic cell lines were exposed to 2318 MHz (MHz) RFR emitted by mobile phones at a power density of 0.224 W/m2 in a controlled manner for various time durations (15, 30, 45, 60, 90, and 120 min). Systematic studies on cell viability, nitric oxide (NO), superoxide (SO), pro-inflammatory cytokine production, and phagocytic assays were performed after the irradiation. The duration of exposure seems to have a substantial influence on the RFRinduced effects. It was noticed that after 30 min of exposure, the RFR dramatically enhanced the proinflammatory cytokine IL-1 & alpha; level as well as reactive species such as NO and SO generation as compared to the control. In contrast, the RFR dramatically reduced the phagocytic activity of monocytes during 60 min of treatment when compared to the control. Interestingly, the irradiated cells restored their normal functioning until the final 120-min of exposure. Furthermore, mobile phone exposure had no influence on cell viability or TNF-& alpha; level. The results showed that RFR exhibits a time-dependent immune-modulatory role in the human leukemia monocytic cell line. Nevertheless, more research is needed to further determine the long-term effects and precise mechanism of action of RFR.
https://doi.org/10.1016/j.envpol.2023.121843

Modifiable risk factors for glioblastoma: a systematic review and meta-analysis,

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Neurosurgical Review 46, no. 1 (Jun 2023),

Glioblastoma (GBM) is the most common and aggressive glioma histological subtype, associated with high disability and poor survival. The etiology of this condition is still mostly unknown, and evidence about risk factors is elusive. The aim of this study is to identify modifiable risk factors for GBM. Electronic search was performed by two reviewers independently using the keywords and MeSH terms 'glioblastoma' OR 'glioma' OR 'brain tumor' AND 'risk factor'. The inclusion criteria were (1) observational studies or experimental studies on humans, (2) studies assessing the association between glioblastoma and exposure to modifiable conditions, and (3) studies published in English or Portuguese. Studies on the pediatric population or about exposure to ionizing radiation were excluded. A total of 12 studies were included. Seven were case-control studies, and five were cohort studies. The risk factors assessed included body mass index, alcohol

consumption, exposure to magnetic fields, diabetes mellitus type 2 (DM2), and use of non-steroidal anti-inflammatory drugs (NSAID). No significant link was found between GBM incidence and DM2 or magnetic field exposure. On the other hand, higher BMI, alcohol consumption, and NSAID use demonstrated a protective effect on GMB risk. However, given the limited number of studies, it is not possible to obtain a behavioral recommendation; instead, these findings are relevant to guide future basic scientific studies on GBM oncogenesis. https://doi.org/10.1007/s10143-023-02051-y

Toxicité sur les animaux et l'environnement

Behavioral and neural responses to high-strength magnetic fields are reduced in otolith mutant mice,

COTE J. M., A. HOOD, B. KWON, J. C. SMITH and T. A. HOUPT,

American Journal of Physiology-Regulatory, Integrative and Comparative Physiology 325, no. 2 (Aug 2023): R181-R192,

Static high magnetic fields (MFs) interact with the vestibular system of humans and rodents. In rats and mice, exposure to MFs causes perturbations such as head movements, circular locomotion, suppressed rearing, nystagmus, and conditioned taste aversion acquisition. To test the role of otoconia, two mutant mouse models were examined, head-tilt Nox3(het) (het) and tilted Otop1 (tlt), with mutations, respectively, in Nox3, encoding the NADPH oxidase 3 enzyme, and Otop1, encoding the otopetrin 1 proton channel, which are normally expressed in the otolith organs, and are critical for otoconia formation. Consequently, both mutants show a near complete loss of otoconia in the utricle and saccule, and are nonresponsive to linear acceleration. Mice were exposed to a 14.1 Tesla MF for 30 min. After exposure, locomotor activity, conditioned taste aversion and c-Fos (in het) were assessed. Wild-type mice exposed to the MF showed suppressed rearing, increased latency to rear, locomotor circling, and c-Fos in brainstem nuclei related to vestibular processing (prepositus, spinal vestibular, and supragenual nuclei). Mutant het mice showed no response to the magnet and were similar to sham animals in all assays. Unlike het, tlt mutants exposed to the MF showed significant locomotor circling and suppressed rearing compared with sham controls, although they failed to acquire a taste aversion. The residual responsiveness of tlt versus het mice might reflect a greater semicircular deficit in het mice. These results demonstrate the necessity of the otoconia for the full effect of exposure to high MFs, but also suggest a semicircular contribution.
https://doi.org/10.1152/ajpregu.00317.2022

Electromagnetic field as a factor affecting the activity of the synthesis of the enzyme 3 beta-hydroxysteroid dehydrogenase (3 beta-HSD) in the cells of the adrenal cortex of lambs,

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Przeglad Elektrotechniczny 99, no. 2 (2023): 202-205,

The article presents the results of studies on the impact of extremely low-frequency electromagnetic field on the level of 3 beta-steroid dehydrogenase (3 beta-HSD) in the adrenal cells of sexually immature lambs. Adrenal tissue cultures were performed and exposed to 50 or 120 Hz electromagnetic fields. Immunohistological analysis showed the presence of 3 beta HSD receptors in adrenal tissues. There were no significant differences in the amount of 3-beta-hydroxysteroid dehydrogenase receptor present in the cells of the adrenal cortex at different times of exposure (2 or 4 hours) for both tested frequencies compared to tissues from the control group. The obtained results show that the influence of the electromagnetic field on the level of steroid dehydrogenase in the adrenal glands is insignificant, regardless of the frequency of the electromagnetic field (in the extremely low range) and the duration of exposure. https://doi.org/10.15199/48.2023.02.38

Hippocampal ferroptosis is involved in learning and memory impairment in rats induced by microwave and electromagnetic pulse combined exposure,

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Environmental Science and Pollution Research (2023 Jun 2023),

Microwave (MW) and electromagnetic pulse (EMP) are considered environmental pollutants, both of which can induce learning and memory impairments. However, the bioeffects of combined exposure to MW and EMP have never been explored. This paper aimed to investigate the effects of combined exposure to MW and EMP on the learning and memory of rats as well as its association with ferroptosis in the hippocampus. In this study, rats were exposed to EMP, MW, or EMP and MW combined radiation. After exposure, impairment of learning and memory, alterations in brain electrophysiological activity, and damage to hippocampal neurons were observed in rats. Moreover, we also found alterations in ferroptosis hallmarks, including increased levels of iron, lipid peroxidation, and prostaglandin-endoperoxide synthase 2 (PTGS2) mRNA, as well as downregulation of glutathione peroxidase 4 (GPX4) protein in the rat hippocampus after exposure. Our results suggested that either single or combined exposure to MW and EMP radiation could impair learning and memory and damage hippocampal neurons in rats. Moreover, the adverse effects caused by the combined exposure were more severe than the single exposures, which might be due to cumulative effects rather than synergistic effects. Furthermore, ferroptosis in the hippocampus might be a common underlying mechanism of learning and memory impairment induced by both single and combined MW and EMP exposure. https://doi.org/10.1007/s11356-023-28280-8

Effects of moderate static magnetic fields on the lipogenesis and lipolysis in different genders of Caenorhabditis elegans,

LIU Z. C., L. CHENG, B. L. YANG, Z. X. CAO, M. SUN, Y. FENG and A. XU,

Ecotoxicology and Environmental Safety 259 (Jul 2023),

With the rapid development of magnetic technology, the biological effects of moderate static magnetic fields (SMFs) have attracted increasing research interest due to their potential

medical diagnosis and treatment application. The present study explored the effects of moderate SMFs on the lipid metabolism of Caenorhabditis elegans (C. elegans) in different genders including male, female, and hermaphrodite. We found that the fat content was significantly decreased by moderate SMFs in wild-type N2 worms, which was associated with their devel-opment stages. The diameters of lipid droplets in N2 worms, him-5 worms, and fog-2 worms were greatly decreased by 19.23%, 15.38%, and 23.07% at young adult stage under 0.5 T SMF, respectively. The mRNA levels of lipolysis related genes atgl-1 and nhr-76 were significantly up-regulated by SMF exposure, while the mRNA levels of the lipogenesis related genes fat-6, fat-7, and sbp-1 were down-regulated by SMF, whereas the con-centration of beta-oxidase was increased. There was a slight effect of SMF on the mRNA levels of beta-oxidation related genes. Moreover, the insulin and serotonin pathway were regulated by SMF, instead of the TOR pathway. In wild-type worms, we found that their lifespan was prolonged by exposure to 0.5 T SMF. Our data suggested that moderate SMFs could significantly modify the lipogenesis and lipolysis process in C. elegans in a gender and development stage-dependent manner, which could provide a novel insight into understanding the function of moderate SMFs in living organisms.
https://doi.org/10.1016/j.ecoenv.2023.115005

Metformin Ameliorates 2.856 GHz Microwave- Radiation-Induced Reproductive Impairments in Male Rats via Inhibition of Oxidative Stress and Apoptosis,

MEN J., L. ZHANG, R. Y. PENG, Y. Y. LI, M. LI, H. WANG, L. ZHAO, J. ZHANG, H. Y. WANG, X. P. XU, J. DONG, J. WANG, B. W. YAO and J. B. GUO,

International Journal of Molecular Sciences 24, no. 15 (Aug 2023),

The reproductive system has been increasingly implicated as a sensitive target of microwave radiation. Oxidative stress plays a critical role in microwave radiation -induced reproductive damage, though precise mechanisms are obscure. Metformin, a widely used antidiabetic drug, has emerged as an efficient antioxidant against a variety of oxidative injuries. In the present study, we hypothesized that metformin can function as an antioxidant and protect the reproductive system from microwave radiation. To test this hypothesis, rats were exposed to 2.856 GHz microwave radiation for 6 weeks to simulate real-life exposure to high-frequency microwave radiation. Our results showed that exposure to 2.856 GHz microwave radiation elicited serum hormone disorder, decreased sperm motility, and depleted sperm energy, and it induced abnormalities of testicular structure as well as mitochondrial impairment. Metformin was found to effectively protect the reproductive system against structural and functional impairments caused by microwave radiation. In particular, metformin can ameliorate microwave-radiation-induced oxidative injury and mitigate apoptosis in the testis, as determined by glutathione/-oxidized glutathione (GSH/GSSG), lipid peroxidation, and protein expression of heme oxygenase-1 (HO-1). These findings demonstrated that exposure to 2.856 GHz microwave radiation induces obvious structural and functional impairments of the male reproductive system, and suggested that metformin can function as a promising antioxidant to inhibit microwave-radiation-induced harmful effects by inhibiting oxidative stress and apoptosis.
https://doi.org/10.3390/ijms241512250

Changes in Gene Expression After Exposing Arabidopsis thaliana Plants to Nanosecond High Amplitude Electromagnetic Field Pulses,

PORCHER A., N. WILMOT, P. BONNET, V. PROCACCIO and A. VIAN,

Bioelectromagnetics (2023 Jul 2023),

The biological effects of exposure to electromagnetic fields due to wireless technologies and connected devices are a subject of particular research interest. Ultrashort high-amplitude electromagnetic field pulses delivered to biological samples using immersed electrodes in a dedicated cuvette have widely demonstrated their effectiveness in triggering several cell responses including increased cytosolic calcium concentration and reactive oxygen species (ROS) production. In contrast, the effects of these pulses are poorly documented when electromagnetic pulses are delivered through an antenna. Here we exposed Arabidopsis thaliana plants to 30,000 pulses (237 kV m(-1), 280 ps rise-time, duration of 500 ps) emitted through a Koshelev antenna and monitored the consequences of electromagnetic fields exposure on the expression levels of several key genes involved in calcium metabolism, signal transduction, ROS, and energy status. We found that this treatment was mostly unable to trigger significant changes in the messenger RNA accumulation of calmodulin, Zinc-Finger protein ZAT12, NADPH oxidase/respiratory burst oxidase homolog (RBOH) isoforms D and F, Catalase (CAT2), glutamate-cystein ligase (GSH1), glutathione synthetase (GSH2), Sucrose non-fermenting-related Kinase 1 (SnRK1) and Target of rapamycin (TOR). In contrast, Ascorbate peroxidases APX-1 and APX-6 were significantly induced 3 h after the exposure. These results suggest that this treatment, although quite strong in amplitude, is mostly ineffective in inducing biological effects at the transcriptional level when delivered by an antenna. & COPY; 2023 The Authors. Bioelectromagnetics published by Wiley Periodicals LLC on behalf of Bioelectromagnetics Society. https://doi.org/10.1002/bem.22475

Investigation of gene expression levels in thyroid tissues of rats treated with Wi-Fi electromagnetic wave (2.4-3 GHz Wi-Fi RF-EMF),

SERIN M., S. SOYLU, S. D. DASTAN, S. KOC and A. KURT,

Journal of Molecular Structure 1288 (Sep 2023),

In this study, it was aimed to examine the effects of wireless waves applied to rats in the thyroid tissue by evaluating gene expression levels on 12 determined gene regions. 20 healthy 16-week-old Wistar albino female rats weighting 200-220 g were used. In the experiments, two groups, control and experimental groups, were formed, and ten female rats were used in each group. While WI-FI electromagnetic field was applied to the experimental group of these rats, nothing was applied to the control group. Many different gene regions, including beta catenin, beta-actin, GAPDH, L3B, HIF 1-Alpha, GSk-3B, TCF, WNT7a, WNT10a, WNT2, Beclin 1 and Beclin 2, ATG5 and ATG12, were investigated. ACTB and GAPDH gene primers were used as a house keeping gene. The fold change values were calculated statistically from the data obtained from the gene expression results. Compared to the control group, it was observed that the experimental group had significant increases in gene expression levels of many gene regions investigated in the study ($P<0.05$). Among the study groups, 12 different genes such as beta catenin, beta-actin, GAPDH, L3B, HIF 1-Alpha, GSk-3B, TCF, WNT7a, WNT10a, WNT2, Beclin 1 and Beclin 2, ATG5 and ATG12, which we have determined according to the literature, are known to be related to autophagy and oxidative stress. When the expression levels were investigated, it was determined that the expression coefficients of all the genes studied in the wnt/ss catenin pathway in the experimental group of rats exposed to the Wi-Fi EM field,

except for ATG5 and ATG12, were quite high, and there was significant differences between the groups. https://doi.org/10.1016/j.molstruc.2023.135741

Long-term radiofrequency electromagnetic fields exposure attenuates cognitive dysfunction in 5xFAD mice by regulating microglial function,

SON Y., H. J. PARK, Y. JEONG, H. D. CHOI, N. KIM and H. J. LEE,

Neural Regeneration Research 18, no. 11 (Nov 2023): 2497-2503,

We have previously found that long-term effects of exposure to radiofrequency electromagnetic fields in 5xFAD mice with severe late-stage Alzheimer's disease reduced both amyloid-beta deposition and glial activation, including microglia. To examine whether this therapeutic effect is due to the regulation of activated microglia, we analyzed microglial gene expression profiles and the existence of microglia in the brain in this study. 5xFAD mice at the age of 1.5 months were assigned to sham- and radiofrequency electromagnetic fields-exposed groups and then animals were exposed to 1950 MHz radiofrequency electromagnetic fields at a specific absorption rate of 5 W/kg for 2 hours/day and 5 days/week for 6 months. We conducted behavioral tests including the object recognition and Y-maze tests and molecular and histopathological analysis of amyloid precursor protein/amyloid-beta metabolism in brain tissue. We confirmed that radiofrequency electromagnetic field exposure for 6 months ameliorated cognitive impairment and amyloid-beta deposition. The expression levels of Iba1 (pan-microglial marker) and colony-stimulating factor 1 receptor (CSF1R; regulates microglial proliferation) in the hippocampus in 5xFAD mice treated with radiofrequency electromagnetic fields were significantly reduced compared with those of the sham-exposed group. Subsequently, we analyzed the expression levels of genes related to microgliosis and microglial function in the radiofrequency electromagnetic fields-exposed group compared to those of a CSF1R inhibitor (PLX3397)-treated group. Both radiofrequency electromagnetic fields and PLX3397 suppressed the levels of genes related to microgliosis (Csf1r, CD68, and Ccl6) and pro-inflammatory cytokine interleukin-1 beta. Notably, the expression levels of genes related to microglial function, including Trem2, Fcgr1a, Ctss, and Spi1, were decreased after long-term radiofrequency electromagnetic field exposure, which was also observed in response to microglial suppression by PLX3397. These results showed that radiofrequency electromagnetic fields ameliorated amyloid-beta pathology and cognitive impairment by suppressing amyloid-beta deposition-induced microgliosis and their key regulator, CSF1R. https://doi.org/10.4103/1673-5374.371379

Effect of WiFi signal exposure in utero and early life on neurodevelopment and behaviors of rats,

WU H. M., D. Y. MIN, B. X. SUN, Y. F. MA, H. P. CHEN, J. WU, P. REN, J. B. WU, Y. G. CAO, B. S. ZHAO and P. WANG,

Environmental Science and Pollution Research (2023 Aug 2023),

The aim of this study is to examine the long-term effects of prenatal and early-life WIFI signal exposure on neurodevelopment and behaviors as well as biochemical alterations of Wistar rats. On the first day of pregnancy (E0), expectant rats were allocated into two groups: the control group (n = 12) and the WiFi-exposed group (WiFi group, n = 12). WiFi

group was exposed to turn on WiFi for 24 h/day from E0 to postnatal day (PND) 42. The control group was exposed to turn-off WiFi at the same time. On PND7-42, we evaluated the development and behavior of the offspring, including body weight, pain threshold, and swimming ability, spatial learning, and memory among others. Also, levels of proteins involved in apoptosis were analyzed histologically in the hippocampus in response to oxidative stress. The results showed that WiFi signal exposure in utero and early life (1) increased the body weight of WiFi + M (WiFi + male) group; (2) no change in neuro-behavioral development was observed in WiFi group; (3) increased learning and memory function in WiFi + M group; (4) enhanced comparative levels of BDNF and p-CREB proteins in the hippocampus of WiFi + M group; (5) no neuronal loss or degeneration was detected, and neuronal numbers in hippocampal CA1 were no evidently differences in each group; (6) no change in the apoptosis-related proteins (caspase-3 and Bax) levels; and (7) no difference in GSH-PX and SOD activities in the hippocampus. Prenatal WiFi exposure has no effects on hippocampal CA1 neurons, oxidative equilibrium in brain, and neurodevelopment of rats. Some effects of prenatal WiFi exposure are sex dependent. Prenatal WiFi exposure increased the body weight, improved the spatial memory and learning function, and induced behavioral hyperactivity of male rats.
https://doi.org/10.1007/s11356-023-29159-4

Méthodes

Enhanced Methodology to Characterize 3-D Power Monitoring and Control Features for 5G NR Systems Embedding Multi-User MIMO Antennas,

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Ieee Transactions on Instrumentation and Measurement 72 (2023),

Multi-User MIMO (MU-MIMO) is widely used in the fifth generation (5G) cellular network to improve network performance at high traffic loads. When demonstrating the compliance of 5G antennas with the radio frequency (RF) electromagnetic fields standards, beamforming and MU-MIMO must be considered, since a 5G MU-MIMO antenna radiation pattern changes in both the space and time domain, adapting to changes of the user's position. To cope with the time and space variability of the power radiated by 5G systems, mobile operators can activate automatic tools to monitor and control the transmitted power (power lock (PL) systems) to ensure that a given radiated power threshold is not exceeded. This article extends and enhances the methodology introduced by the authors in previous work, by testing and verifying PL systems in an MU-MIMO and beamforming scenario (3-D PL systems, 3DPL) through field measurements, controlling the power transmitted by each beam, i.e., in each direction. Measurement results confirm that the 3DPL feature limits the average power of the traffic channels transmitted in each direction, regardless of the configured total maximum power. More specifically, it is shown that the 3DPL reduces the maximum average transmitted power by the expected 2 dB when only one user is active (i.e., in a single-user MIMO (SU-MIMO) scenario), while it does not operate any reduction when two users are active (MU-MIMO scenario) because the power transmitted toward

each user is already half (i.e., -3 dB) of the maximum power that can be transmitted. https://doi.org/10.1109/tim.2023.3284016

Skin and Artificial Skin Models in Electrical Sensing Applications,

EHTIATI K., J. EILER, A. BOCHYNSKA, L. L. NISSEN, E. STROBECH, L. F. NIELSEN and E. THORMANN,

Acs Applied Bio Materials 6, no. 8 (Aug 2023): 3033-3051,

Skin electrical properties play a significant role inrecordingbiopotentials by using electrophysiological sensors. To test and evaluatesensor systems, it is commonly accepted to employ artificial skinmodels due to complications associated with testing on living tissues.The first goal of this Review is to provide a systematic understandingof the relation between skin structure and skin electrochemical behaviorat an appropriate depth for electrophysiological sensing applicationsthrough a focus on skin structure, electrochemical properties of skin,and theoretical models (equivalent circuits) representing skin electrochemicalbehavior. The second goal is to review artificial skin models mimickingthe electrochemical properties of skin and to give suggestions forfuture studies on relevant skin models based on a comparison betweenthe behavior of skin and that of artificial skin models. The Reviewaims to help the reader to analyze the relation between the structure,elements of the equivalent circuits, and the resulting impedance datafor both skin and artificial skin models. https://doi.org/10.1021/acsabm.3c00356

A High Performance All-Textile Wearable Antenna for Wristband Application,

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Micromachines 14, no. 6 (Jun 2023),

A compact, conformal, all-textile wearable antenna is proposed in this paper for the 2.45 GHz ISM (Industrial, Scientific and Medical) band. The integrated design consists of a monopole radiator backed by a 2 x 1 Electromagnetic Band Gap (EBG) array, resulting in a small form factor suitable for wristband applications. An EBG unit cell is optimized to work in the desired operating band, the results of which are further explored to achieve bandwidth maximization via floating EBG ground. A monopole radiator is made to work in association with the EBG layer to produce the resonance in the ISM band with plausible radiation characteristics. The fabricated design is tested for free space performance analysis and subjected to human body loading. The proposed antenna design achieves bandwidth of 2.39 GHz to 2.54 GHz with a compact footprint of 35.4 x 82.4 mm(2). The experimental investigations reveal that the reported design adequately retains its performance while operating in close proximity to human beings. The presented Specific Absorption Rate (SAR) analysis reveals 0.297 W/kg calculated at 0.5 W input power, which certifies that the proposed antenna is safe for use in wearable devices. https://doi.org/10.3390/mi14061169

GA-CSM based optimized clearances for the reduction of occupational exposure in EHV substation,

HARIMURUGAN D. and G. S. PUNEKAR,

Electric Power Systems Research 214 (Jan 2023),

The magnitude of the electric field (E-field) in a 765 kV substation is reduced by altering the conductor clearances in view of the occupational exposure limits. Multi-objective genetic algorithm (GA) along with the charge simulation method (CSM) is utilized in arriving at the optimal clearances of the substation conductors. An EHV substation is modeled with the dimensions and the clearances as in the actual layout of a substation. The E-field results obtained using the finite-line based modeling and infinite-line based modeling of conductors, are compared in terms of the model accuracy and the computational time. The advantages of using the infinite-line based CSM model in view of the occupational exposure is detailed. With the proposed GA-CSM routine, the maximum value of the E-field in the substation is reduced to 10 kV/m (from the existing value of 13 kV/m). The proposed method is used with the existing topology and the best possible transposed topology to obtain the modified layouts. A novel EHV substation layout with different ground clearances for the inner bays and the outer bays is presented. The GA-CSM routine proposed in this work is applicable to any EHV substation with the multiple conductor arrangements. https://doi.org/10.1016/j.epsr.2022.108855

Electromagnetic field exposure to human head model with various metal objects at sub-6 GHz frequencies,

IL N., K. ATES and S. OZEN,

Electromagnetic Biology and Medicine (2023 Jun 2023),

In recent years, the interactions of metal objects in human body with electromagnetic fields caused by devices working at fifth-generation (5G) frequencies have been studied by various researchers. A motivation behind this research was to evaluate the human body absorption of electromagnetic energy operating at sub-6 GHz 5G applications. According to this, the specific absorption rate (SAR) caused by new generation mobile phones was investigated in human heads wearing metal-framed spectacles and having metallic implants or earrings to analyse electromagnetic field exposure. A realistic human head model, including some metal objects, was numerically calculated, and analysed in terms of non-ionizing dosimetry. Simulations were carried out with the finite integration technique (FIT) based commercial software in the frequencies of 0.9, 1.8, 2.1, 2.45, 3.5 and 5 GHz, respectively. The maximum SAR of 14 x 10(-5) W/kg for 10 g average tissue was calculated at 2.45 GHz frequency in the head model with earrings. The highest electric field strength of 0.52 V/m was observed at a 1.8 GHz frequency in the head model with all metal objects equipped. Results show that metal objects such as spectacles, dental implants and earrings can cause an increase in the SAR values for external biological tissues, and metal objects can behave as a kind of shield for deeper tissues. However, the obtained values are below the limits of international organisations. https://doi.org/10.1080/15368378.2023.2220736

Magneto-Responsive Textiles for Non-Invasive Heating,

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International Journal of Molecular Sciences 24, no. 14 (Jul 2023),

Magneto-responsive textiles have emerged lately as an important carrier in various fields, including biomedical engineering. To date, most research has been performed on single magnetic fibers and focused mainly on the physical characterization of magnetic textiles. Herein, from simple woven and non-woven textiles we engineered materials with magnetic properties that can become potential candidates for a smart magnetic platform for heating treatments. Experiments were performed on tissue-mimicking materials to test the textiles' heating efficiency in the site of interest. When the heat was induced with magneto-responsive textiles, the temperature increase in tissue-mimicking phantoms depended on several factors, such as the type of basic textile material, the concentration of magnetic nanoparticles deposited on the textile's surface, and the number of layers covering the phantom. The values of temperature elevation, achieved with the use of magnetic textiles, are sufficient for potential application in magnetic hyperthermia therapies and as heating patches or bandages. https://doi.org/10.3390/ijms241411744

DEVELOPMENT OF MR-BASED PROCEDURES FOR THE IMPLEMENTATION OF PATIENT-SPECIFIC DIELECTRIC MODELS FOR CLINICAL USE,

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Journal of Mechanics in Medicine and Biology 23, no. 06 (Aug 2023),

Nowadays, many medical techniques are based on the application of electromagnetic fields (EMF) on human body. For the optimization of these techniques, it is necessary to understand the mechanisms of interaction between the biological system under exposure and the applied EMF. Since this interaction is described by the dielectric properties of the biological system, an accurate dielectric characterization of human body is necessary. Biological tissues are complex and heterogeneous, and their dielectric properties can vary significantly from the ex-vivo to the in vivo condition. For this reason, there is the need to measure these properties for a specific subject. Unfortunately, traditional techniques used to measure dielectric properties of tissues are not able to reach this aim and an alternative method must be devised. In this work, a model is proposed for the reconstruction of dielectric properties of biological tissues from MR acquisitions. This model is wideband, specific, applicable in vivo and useful for those medical techniques that need a precise dielectric characterization of the patients. https://doi.org/10.1142/s0219519423400316

Fuzzy Decision Algorithm for Health Impact Assessment in a 5G Environment,

PANTELIC S., B. VULEVIC and S. MILIC,

Applied Sciences-Basel 13, no. 11 (May 2023),

The widespread use of mobile phones and other wireless communication devices raises concerns about radiation's impact on humans. A new algorithm for making decisions for the assessment of the biological impact of non-ionizing radiation is presented in this paper. The algorithm was developed according to ICNIRP (the International Commission on Non-Ionizing Radiation Protection) guidelines using fuzzy logic. Appropriate membership

function choices and optimized fuzzy rule selections are crucial for fuzzy modeling. Fuzzy logic is widely applied for multiparameter process modeling using linguistic forms and mathematical expressions. A comprehensive analysis of 4G and 5G network parameters was carried out including electrical and magnetic field strengths, frequency ranges, power densities, and exposure times. The proposed hands-on fuzzy decision-making algorithm can be used for fast, easy, and reliable non-ionizing radiation risk assessment for the following social groups: residents, on-site workers, and professional users. https://doi.org/10.3390/app13116439

PIRET-A Platform for Treatment Planning in Electroporation-Based Therapies,

PERERA-BEL E., K. N. AYCOCK, Z. S. SALAMEH, M. GOMEZ-BAREA, R. V. DAVALOS, A. IVORRA and M. A. G. BALLESTER,

Ieee Transactions on Biomedical Engineering 70, no. 6 (Jun 2023): 1902-1910,

Tissue electroporation is the basis of several therapies. Electroporation is performed by briefly exposing tissues to high electric fields. It is generally accepted that electroporation is effective where an electric field magnitude threshold is overreached. However, it is difficult to preoperatively estimate the field distribution because it is highly dependent on anatomy and treatment parameters. Objective: We developed PIRET, a platform to predict the treatment volume in electroporation-based therapies. Methods: The platform seamlessly integrates tools to build patient-specific models where the electric field is simulated to predict the treatment volume. Patient anatomy is segmented from medical images and 3D reconstruction aids in placing the electrodes and setting up treatment parameters. Results: Four canine patients that had been treated with high-frequency irreversible electroporation were retrospectively planned with PIRET and with a workflow commonly used in previous studies, which uses different general-purpose segmentation (3D Slicer) and modeling software (3Matic and COMSOL Multiphysics). PIRET outperformed the other workflow by 65 minutes (x 1.7 faster), thanks to the improved user experience during treatment setup and model building. Both approaches computed similarly accurate electric field distributions, with average Dice scores higher than 0.93. Conclusion: A platform which integrates all the required tools for electroporation treatment planning is presented. Treatment plan can be performed rapidly with minimal user interaction in a stand-alone platform. Significance: This platform is, to the best of our knowledge, the most complete software for treatment planning of irreversible electroporation. It can potentially be used for other electroporation applications. https://doi.org/10.1109/tbme.2022.3232038

Numerical Assessment of Human EMF Exposure to Collocated and Distributed Massive MIMO Deployments in an Industrial Indoor Environment,

SHIKHANTSOV S., A. THIELENS, G. VERMEEREN, P. DEMEESTER, L. MARTENS and W. JOSEPH,

Ieee Transactions on Electromagnetic Compatibility (2023 Jun 2023),

This article presents a comparative numerical study of collocated and distributed massive multiple-input-multiple-output (MIMO) deployments at 3.5 GHz in an industrial indoor environment from the point of view of downlink human electromagnetic field (EMF) exposure. A collection of environmental models incorporating elements with stochastic

geometry is generated, in which the EMF propagation is calculated using the ray-tracing (RT) method. To evaluate the human exposure, the finite-difference time-domain (FDTD) method is used, including a realistic human phantom and a user equipment model, into which the excitation is introduced based on the RT results. Single-user maximum ratio transmission and multiuser zero-forcing scenarios are studied. Small-scale EMF distributions in proximity to the phantom's head are assessed in FDTD and analysed for different user locations in the environment and user equipment placement with respect to the head. The massive MIMO hot-spot is characterized in terms of its size, instantaneous and time-averaged EMF enhancement, and position with respect to the head and the user equipment. The human exposure is assessed using the peak-spatial specific absorption rate averaged over 10 g, referenced to the hot-spot EMF amplitude, and compared to international guidelines. It is shown that the distributed deployment results in a more accurate and consistent EMF hot-spot around the user equipment with a higher average E-field gain, compared to the collocated deployment. In addition, the distributed configuration produced more compact hot-spots relative to the collocated one, leading to a more than tenfold average exposure reduction in a multiuser scenario.
https://doi.org/10.1109/temc.2023.3273475

RF-induced Heating Evaluation for Passive Device in Tissue-Reduced Virtual Family Models at 1.5 T

XIA M. Q., R. GUO, J. F. ZHENG, J. CHEN and IEEE (2022). IEEE International Symposium on Electromagnetic Compatibility, Signal and Power Integrity (EMCSI), Spokane, WA.

Tissue-reduced virtual family models are developed for the RF-induced heating assessment of passive implantable medical devices. The models are developed based on the Gaussian mixture model. The RF-induced heating of four representative passive device systems is evaluated inside the original human models, tissue-reduced human models, and the ASTM phantom at three landmark positions under a 1.5 T MRI system. From the results of these simulations, it is observed that the RF-induced heating from the tissue-reduced virtual family models is highly correlated to that obtained from the original human body models. It demonstrates the feasibility of using tissue-reduced models for the RF-induced heating testing of implantable medical devices. https://doi.org/10.1109/emcsi39492.2022.9889637