Bulletin de veille
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Exposition professionnelle

Electromagnetic radiation detection and monitoring in high-voltage transmission lines using machine learning techniques,
Anand, N. and Moses, M. B., *Measurement*, Sep 2025, Vol. 253.

Electromagnetic radiation (EMR) from high-voltage transmission lines (HVTL) poses significant risks to both human health and electrical infrastructure. Accurate detection and monitoring of EMR are essential for assessing its impact, severity, and potential mitigation strategies. This study investigates EMR data collected from transmission lines operating at 400 kV, 230 kV, 110 kV, 22 kV, and 11 kV at multiple locations, leveraging Machine Learning (ML) techniques based on Artificial Intelligence (AI) for classification and regression analysis. The dataset comprises electric and magnetic field measurements as input features, while transmission line voltage, EMR impact, and severity serve as target variables. To achieve precise classification and prediction, multiple ML models, including Random Forest (RF), Decision Trees (DT), Support Vector Machines (SVM), k-Nearest Neighbors (k-NN), Ensemble methods, and Artificial Neural Networks (ANN), were employed. A comparative performance analysis demonstrated that the Ensemble Bagged Trees

algorithm outperformed other models in terms of accuracy, sensitivity, specificity, false positive rate (FPR), and F1 score. The model achieved an impressive accuracy of 90.1 % in classifying transmission line voltage levels and 99.4 % in predicting EMR severity, making it a highly effective tool for real-time monitoring. By integrating ML-based classification and prediction frameworks, this research provides a robust and scalable approach to real-time EMR assessment, enhancing power grid reliability and electromagnetic safety. The findings contribute to improved safety protocols for power line workers, UAV operations, and proactive fault detection in power systems. https://doi.org/10.1016/j.measurement.2025.117645

Worker Safety in High-Field NMR Spectroscopy Laboratories: Challenges and Risk Assessment, Flori, A., Acri, G., D'avanzo, M. A., Mattozzi, M. and Hartwig, V., *Environments*, Apr 2025, Vol. 12, no. 4.

Magnetic Resonance (MR) technology is extensively used in academic and industrial research laboratories and represents one of the most significant methodologies in clinical radiology. Although MR does not use ionizing radiation, it cannot be considered risk-free due to the strong static magnetic fields and time-varying electromagnetic fields employed in the technology. To mitigate risks for MR operators, the European Community and ICNIRP have established safety limits based on the existing literature, primarily related to diagnostic MR. However, the literature on occupational exposure in non-clinical nuclear magnetic resonance (NMR) spectroscopy is limited. Due to their specificity, non-medical NMR environments present unique challenges from the point of view of operator exposure. NMR spectrometers are characterized by extremely high static magnetic fields, reaching up to 28 T in commercial systems; moreover, routine activities performed near the magnet, where field gradients are highest, increase operator exposure. Such environments are not typically perceived as hazardous and are frequented by various types of personnel, often without specific training. This study aims to highlight the critical issues in managing a preclinical MR laboratory equipped with a high-field NMR spectrometer, discussing operator safety challenges and presenting risk assessment data. https://doi.org/10.3390/environments12040113

EMF Exposure of Workers Due to 5G Private Networks in Smart Industries, Gajsek, P., Apostolidis, C., Plets, D., Samaras, T. and Valic, B., *Electronics*, Jun 30 2025, Vol. 14, no. 13.

5G private mobile networks are becoming a platform for 'wire-free' networking for professional applications in smart industry sectors, such as automated warehousing, logistics, autonomous vehicle deployments in campus environments, mining, material processing, and more. It is expected that most of these Machine-to-Machine (M2M) and Industrial Internet of Things (IIoT) communication paths will be realized wirelessly, as the advantages of providing flexibility are obvious compared to hard-wired network installations. Unfortunately, the deployment of private 5G networks in smart industries has faced delays due to a combination of high costs, technical challenges, and uncertain returns on investment, which is reflected in troublesome access to fully operational private networks. To obtain insight into occupational exposure to radiofrequency electromagnetic fields (RF EMF) emitted by 5G private mobile networks, an analysis of RF EMF due to different types of 5G equipment was carried out on a real case scenario in the production and logistic (warehouse) industrial sector. A private standalone (SA) 5G network operating at 3.7 GHz in a real industrial environment was numerically modeled and compared with in situ RF EMF measurements. The results show that RF EMF exposure of the workers was far below the existing exposure limits due to the relatively low power (1 W) of indoor 5G base stations in private networks, and thus similar exposure scenarios could also be expected in other deployed 5G networks. In the analyzed RF EMF exposure scenarios, the radio transmitter-so-called 'radio head'-installation

heights were relatively low, and thus the obtained results represent the worst-case scenarios of the workers' exposure that are to be expected due to private 5G networks in smart industries.
https://doi.org/10.3390/electronics14132662

Analyzing the impact of occupational exposures on male fertility indicators: A machine learning approach,
Mohammadi, H., Khoddam, S., Golbabaei, F. and Dehghan, S. F., *Reproductive Toxicology*, Sep 2025, Vol. 136.

Occupational exposures are critical factors affecting workers' reproductive health. This study investigates the impact of magnetic fields, electric fields, whole-body vibration, noise levels, and heat stress on male reproductive indicators using advanced machine learning models. The aim is to identify key risk factors and provide predictive insights into workers' reproductive health over the next decade. Data were collected from 80 male workers in an automobile part manufacturing plant, capturing demographic characteristics, occupational exposures, biochemical markers, hormone levels, and sperm parameters. Five machine learning models logistic regression, bagging classifier, extreme gradient boosting, random forest, and support vector machine were trained and evaluated using 5-fold cross-validation to determine effective predictors of reproductive health outcomes. Exposure to whole-body vibration, magnetic fields, electric fields, and heat stress closely affected free testosterone levels, with SHAP importance indicating: Magnetic Field Exposure (0.339) and Wet Bulb Globe Temperature (0.138). Worker Age (0.244) was the most influential demographic factor negatively impacting Free Testosterone. The XGBoost and random forest achieved the highest AUC (0.99), outperforming other models in predictive accuracy. The Random Forest model Importance (% Increase in MSE) predicted that Electric Field Exposure (5 %) and Magnetic Field Exposure (4.7 %) would have the most substantial negative impact on Free Testosterone, followed by Worker Age (4.1 %). This study underscores the need for targeted interventions, such as improved workplace safety protocols and regular health monitoring, to protect workers' reproductive health.
https://doi.org/10.1016/j.reprotox.2025.108959

Etudes épidémiologiques

Chicken or egg? Attribution hypothesis and nocebo hypothesis to explain somatization associated to perceived RF-EMF exposure,
Ariccio, S., Traini, E., Portengen, L., Martens, A., Slottje, P., Vermeulen, R. and Huss, A., *Frontiers in Public Health*, Apr 2025, Vol. 13.

Introduction The aim of this study is to understand the temporal relationship between the somatization usually attributed to RF-EMFs, and to evaluate the attribution hypothesis and the nocebo hypothesis in this context.Method In this longitudinal study, data from the Dutch Occupational and Environmental Health Cohort Study (AMIGO) was analyzed, consisting of a baseline questionnaire collected in 2011 (14,829 participants) and a follow-up questionnaire collected in 2015 (7,904 participants). Participants completed a questionnaire providing information on their health status, perceived environmental exposures, and demographics. Two sets of multiple regressions were conducted to evaluate the two hypotheses.Results Results show that the attribution hypothesis overall explained symptom reporting in association to perceived RF-EMF base station exposure and perceived electricity exposure more frequently than the nocebo hypothesis.Discussion This finding stands out from most of the existing literature, which primarily points to the nocebo effect as the main explanation for somatization in response to RF-EMF

exposure. While this does not exclude, in absolute terms, the existence of a nocebo effect, potentially at other time scales, this finding has relevant consequences at the policy making level. The emerging relevance of the attribution hypothesis moves the focus on the discomfort of people with unexplained symptoms and their need to find a plausible explanation for their discomfort. https://doi.org/10.3389/fpubh.2025.1561373

Does Electromagnetic Pollution in the ART Laboratory Affect Sperm Quality? A Cross-Sectional Observational Study,
Baldini, G. M., Lot, D., Ferri, D., Montano, L., Tartagni, M. V., Malvasi, A., Laganà, A. S., Palumbo, M., Baldini, D. and Trojano, G., *Toxics*, Jun 18 2025, Vol. 13, no. 6.

In recent decades, exposure to electromagnetic fields (EMFs) generated by standard devices has raised concerns about possible effects on reproductive health. This cross-sectional observational study examined the impact of EMFs on sperm motility in a sample of 102 healthy males aged 20-35 years in the IVF laboratory. Semen samples were exposed to different sources of EMF for one hour, and motility was assessed immediately thereafter. The results showed a significant reduction in progressive sperm motility after exposure to EMFs generated by mobile phones and Wi-Fi repeaters in the laboratory. In contrast, other equipment showed no significant effects. The study demonstrated a statistically significant reduction in progressive sperm motility following in vitro exposure to electromagnetic fields (EMFs) emitted by mobile communication devices and wireless local area network access points. Conversely, other electromagnetic emitting devices evaluated did not elicit significant alterations in this parameter. These findings suggest a potential negative impact of specific EMF sources on semen quality, underscoring the necessity for further comprehensive research to elucidate the clinical implications and to develop potential mitigation strategies aimed at reducing risks to male reproductive health. This study discourages the introduction of mobile phones in IVF laboratories and recommends positioning Wi-Fi repeaters on the ceiling. https://doi.org/10.3390/toxics13060510

Non-ionization radiation hazard: Effect of mobile phone use on human cognitive functions in data exchange mode,
Heydari, F., Yoosefee, S., Khalili, P., Ayoobi, F. and Shafiei, S. A., *International Journal of Radiation Research*, Jan 2025, Vol. 23, no. 1.

Background: The Cell phones are a major part of people's lives in contemporary societies. Might their radiation be able to affect some cognitive functions while people drive? This study aims to investigate the effect of cell phone radiation on the brain's cognitive functions. Materials and Method: Forty female students without depression or anxiety volunteered in the cross-sectional study. During one session, the volunteers were randomly exposed to cell phone radiation (20 participants in the first and 20 participants in the second). Participants performed four cognitive tests in each session. A p-value of less than 0.05 was taken as the cut-off point to consider a statistically significant result. Results: In the congruent part of the Stroop test, the reaction time (RT) was reduced in both groups during the time volunteers were exposed to radiation and there were significant differences between sessions in both groups (P=0.005 and P<0.001). These differences were significant between the two groups in different sessions. However, the number of errors decreased during exposure to radiation and this difference was significant in the first group (P=0.015). In the incongruent part of the Stroop test, the treatment showed that the radiation of mobile phones had a significant effect on the reduction of RT (P<0.001). Conclusion: Based on this study, it seems that cell phone radiation waves have a limited effect on RT, cognitive and executive function. Therefore, traffic accidents that occur during a mobile phone conversation might be solely

due to the division of attention rather than a direct effect of cell phone waves. https://doi.org/10.61186/ijrr.23.1.21

Use of Electrical Household Appliances and Risk of All Types of Tumours: A Case-Control Study, Noori, S., Aleem, A., Sultan, I. N., Tareen, A. K., Ullah, H. and Khan, M. W., *Medical Sciences*, Apr 1 2025, Vol. 13, no. 2.

Introduction : The use of electrical appliances using extremely low frequency (ELF) electromagnetic fields (EMF) has increased in the past few years. These ELF MF are reported to be linked to several adverse health effects. However, only a couple of studies have been conducted on the association between risk of tumours and use of electronic devices using low frequency (LF) EMF. Methods : We studied the use of common household electrical appliances and suspected risk of tumours in a multi-hospital-based case-control study. In total, 316 patients were included in the final analysis. Results : The study results showed a below unity risk for most of the devices. A slight increased risk of tumour was observed for computer screen use OR: 1.13 (95% CI: 0.43-3.02) and use of microwave oven OR: 1.21 (95% CI: 0.36-4.04). We also had chance to investigate ELF MFs exposure association with tumour. Where we observed elevated odd ratios in individuals living near electricity transformer stations, with a statistically significant risk OR: 2.16 (95% CI: 1.30-3.59). However, the risk was below unity (OR: 0.98) in individuals residing close to powerlines. Conclusion : The current study serves as a pilot study of primary data and will be helpful in future epidemiological research studies on the topic in the region. https://doi.org/10.3390/medsci13020036

Bus-exposure matrix, a tool to assess bus drivers' exposure to physicochemical hazards, Remy, V. F. M., Innocent, G., Vernez, D. and Canu, I. G., *Annals of Work Exposures and Health*, Aug 2025, Vol. 69, no. 7, p. 736-751.

Swiss bus drivers suffer from musculoskeletal disorders, fatigue, and stress and have an excessive mortality from lung cancer and suicide compared to other workers. However, their occupational exposure is poorly documented. We created a bus-exposure matrix (BEM) to determine occupational exposures to 10 types of physical-chemical hazards for 705 bus models used in Switzerland since 1980. For this, we made a comprehensive bus inventory and review of 50 technical characteristics of each bus model, identified 10 bus models representative of the Swiss bus fleet evolution, and conducted static and dynamic exposure measurement campaigns in the representative buses. The measured values were then extended to the entire fleet using Integrated Nested Laplace Approximation (INLA) models. The choice of predictors and technical bus characteristics included in the models were based on directed acyclic graphs. To demonstrate the usefulness of the BEM as an exposure assessment tool, we used data from the 2022 survey of Swiss bus drivers who listed the bus models they had driven during their careers. The BEM linkage with these bus drivers' histories enabled us to estimate annual exposure to PM10 ratio (-), ultrafine particle ratio (-), whole-body vibration (m/s2), floor vibration (m/s2), equivalent noise (dB(A)), peak noise (dB(C)), high-frequencies electric fields (V/m), low-frequencies magnetic field (mu T), low-frequencies electric fields (V/m), and air exchange rate (1/h) of 809 Swiss bus drivers. Historical data assessment from 1985 through 2022 showed that peak noise, high- and low-frequencies electric field levels have increased, while PM10 ratio, ultrafine particle ratio, equivalent noise, whole-body vibration levels, and air exchange rate have decreased. This, first in the world, BEM is an original tool for retrospective exposure assessment that will enable further research in the occupational health of bus drivers. https://doi.org/10.1093/annweh/wxaf036

Greater prevalence of symptoms associated with higher exposures to mobile phone base stations in a hilly, densely populated city in Mizoram, India,
Sailo, L., Laldinpuii, Zosangzuali, M., Weller, S., Varte, C. L., Tochhawng, L., Mccredden, J. E. and Zothansiama, *Electromagnetic Biology and Medicine*, Jun 2025.

Members of the scientific community and the general public are raising concerns about the potential health and environmental effects of radio-frequency electromagnetic fields (RF-EMF) for those living nearby mobile phone base stations (MPBS). This study examined the impact of RF-EMF (900-1900 MHz) on symptoms spanning four health categories: mood-energy, cognitive-sensory, inflammatory, and anatomical issues. A questionnaire identifying health symptoms within these categories, was given to 183 highly exposed and 126 reference residents, matched on demographics. While years of residing near the MPBS influenced the prevalence of some symptoms, proximity to the base station and higher levels of exposure (measured using power density) influenced the prevalence of many of the symptoms. A higher proportion of symptoms was found in residents who were either living within 50 meters of a MPBS or who were exposed to power densities of 5-8 mW/m2, for all four health categories. This relationship between exposure level and symptom prevalence was further influenced by age, daily mobile phone use (over 5 h per day), and lifestyle factors, for certain symptoms. Hierarchical regression analysis revealed that level of exposure (power density) was the only factor contributing to the number of symptoms experienced by residents, for all four health categories. An unexpected finding was that among the more highly exposed residents, the younger individuals (under 40 years) reported more inflammation related issues than older individuals. These results underscore the need to inform policymakers regarding the benefits of adopting a precautionary approach to potential risks associated with RF-EMF exposures from MPBS. https://doi.org/10.1080/15368378.2025.2513900

Evaluation de l'exposition

ML Algorithms Analysis and Prediction of Broadband Electric Field Levels in Telecommunication Systems Environment,
Berisha, D., Jerliu, A. and Ibrani, M., *Telecommunication Systems*, Sep 2025, Vol. 88, no. 3.

This study investigates artificial intelligence neural networks to analyze and predict sub-3 GHz electric field exposure levels. The research encompasses a diverse set of environments including urban areas, residential zones, public transportation settings, and office spaces, which collectively represent realistic exposure environments for radio frequency electromagnetic field emissions. Empirical data, acquired from multiple urban and indoor settings, underpin the development of predictive models. The predictive models are developed using artificial neural network methodologies, specifically the Generalized Regression Neural Network and Radial Basis Function Neural Network. The study presents a detailed assessment of the simulation results, highlighting the effectiveness of these artificial neural network-based approaches in predicting electric field levels across varied environmental conditions. While optimized for broadband exposure, the models may not generalize to millimeter-wave frequencies, which behave differently in terms of propagation and penetration. The findings emphasize the potential of Generalized Regression and Radial Basis Function neural networks for accurate and reliable prediction of radio frequency electromagnetic field levels. https://doi.org/10.1007/s11235-025-01314-x

Electromagnetic Exposure Analysis of the Human Eye due to Virtual Reality Glasses
Il, N., Ates, K., Özen, S. and Ieee (2024). 2024 Medical Technologies Congress, Bodrum, TURKIYE.
With the development of wireless network technologies, there is a variety and innovation in wearable products. Virtual reality (VR) glasses are one of these innovations. VR glasses usually cover the eyes, which increases the exposure of large areas of that region. In this study, the specific absorption rate (SAR) and the electric field distribution in the eyes of a human model wearing VR glasses operating at the next-generation communication frequency band (2.4 GHz) were modeled and numerically analyzed. Simulations were carried out in a three-dimensional problem space, referencing the actual dielectric values of tissues as described in the literature. The maximum electric field strength in the human eye tissue calculated as 24 V/m. The corresponding maximum SAR value is 2.31 W/kg for 1 g average tissue. These findings provide essential insights into electromagnetic exposure safety requirements for the next generation of extended reality applications, in parallel with technological advancements.
https://doi.org/10.1109/tiptekno63488.2024.10755445

Absorbed power density in multilayer models based on human facial tissues for 6-300 GHz plane wave incidence
Lee, A. K., Hong, S. E., Moon, J. I. and Ieee (2024). 2024 Asia-Pacific Microwave Conference, null, INDONESIA.
At higher frequencies exceeding 6 GHz, the penetration depth of electromagnetic field in biological tissues becomes shorter, so specific absorption rate is no longer an appropriate physical quantity to evaluate a local exposure. The recently revised IEEE C95.1 standard and ICNIRP guidelines introduced a new physical quantity called "epithelial power density" and "absorbed power density (APD)", respectively. In this paper, research data on the thickness of the epidermis and dermis for various locations of the human face were investigated, and then the APD for a plane wave incident perpendicularly to the multilayer tissue model implemented based on the thickness data was calculated in the frequency range of 6-300 GHz. The effect of the thickness of the epidermis and dermis on APD are also analyzed and the relationship between APD and the (exposure) reference level set by the IEEE C95.1 standard and ICNIRP guidelines is discussed.
https://doi.org/10.1109/apmc60911.2024.10867652

Population density and DL EMF exposure levels by region in Korea
Lee, A. K., Jeon, S., Wang, S. S., Wiart, J., Choi, H. D., Moon, J. I. and Ieee (2024). 2024 Asia-Pacific Microwave Conference, null, INDONESIA.
In 2023, the electric field strength within mobile communication bands was measured in the largest city (Seoul), a small city (Gwangju, Gyeonggi province), and a rural area (Yangpyeong, Gyeonggi province) in South Korea. The three measurement regions were selected based on population density; The population densities of Seoul, Gwangju, and Yangpyeong are about 15,550/km(2), 856/km(2), and 133/km(2), respectively. Measurements were performed by mounting the SRM3006 antenna on the roof of a vehicle and driving for approximately 40 km in each region. In this paper, the authors report the results of analyzing downlink RF-EMF levels in mobile communication networks currently in operation by frequency, time, and region.
https://doi.org/10.1109/apmc60911.2024.10867416

Numerical simulation study of power-frequency exposure to driving windings of electromagnetic suspension high-speed maglev trains,
Pan, Q. Q. and Lu, M., *Radiation Protection Dosimetry*, May 2025, Vol. 201, no. 8, p. 552-567.

As a potential mode of future passenger transport, the electromagnetic environment inside maglev trains is directly related to the safety and health of passengers. To study the electromagnetic

exposure risk within the maglev train compartment, numerical models were established in this paper for the maglev track's long stator three-phase drive windings (serving as radiation sources), as well as for the train body and simplistic human body models representing passengers. The exposure levels of 50 Hz three-phase symmetrical current electromagnetic fields (EMFs) were numerically calculated for passengers positioned within the carriage. The numerical simulations focused on passengers' electromagnetic exposure resulting from the leakage of 50 Hz EMFs within the carriage and compared the results with established electromagnetic exposure limit guidelines. The findings indicated that the long stator three-phase drive windings generate electromagnetic leakage within the carriage, especially near the windows. Electromagnetic exposure levels vary, with passengers close to the windows experiencing more pronounced effects. Within the carriage, the maximum values of magnetic flux density (|B|) and induced electric field strength (|E|) for passengers' heads are similar to 0.59 mu T and 337 mu V/m, respectively. For passengers' torsos, the maximum values are similar to 1.53 mu T for |B| and 57.8 mu V/m for |E|. Passengers seated near the window exhibit higher values of |E| for their heads and higher values of |B| for their torsos. However, all of these values are well below the electromagnetic exposure limits (50 Hz) set by the International Commission on Non-Ionizing Radiation Protection. These findings provide valuable reference data for studying extremely low-frequency EMF exposure dosimetry in electromagnetic suspension high-speed maglev train systems. https://doi.org/10.1093/rpd/ncaf017

Evaluation of Personal Radiation Exposure From Wireless Signals in Indoor and Outdoor Environments,
Pan, R. J., Sali, A., Li, L., Mohyedin, M. Z. and Qahtan, S., *Ieee Access*, 2025 2025, Vol. 13, p. 106489-106510.

With the development of wireless technology, the public is exposed to electromagnetic fields (EMF), which has led to concerns about the potential health effects of EMF exposures. This paper aims to evaluate personal EMF exposures from wireless signals in indoor and outdoor micro-environments in Malaysia. According to the influencing factors, four different types of micro-environments are selected. A radiation exposure meter called ExpoM-RF 4 is used to measure the electric field strength across these micro-environments. From the measurement campaigns, three machine learning (ML) techniques are simulated to model the Electric Field Strength in each micro-environment. The ML techniques are Fully connected neural network (FCNN), eXtreme Gradient Boosting (XG Boost), and Linear Regression (LR) to predict the RMS and Maximum radiation exposure. From the ML models, Total Emission Ratio (TER), Root Mean Square Error (RMSE) and Coefficient of Determination (R-2) are evaluated to measure the performance of ML. By comparison, it is found that LR performs well with single and simple data set, while XG Boost and FCNN demonstrate superior capabilities in handling multiple types of data sets. The FCNN model provides the most accurate predictions, particularly in urban and suburban areas where extreme values are observed. Finally, the measured data and the predicted radiation exposure levels are compared against public exposure limit by International Commission on Non-Ionizing Radiation Protection (ICNIRP), Malaysian Communications and Multimedia Commission (MCMC) and Federal Communications Commission (FCC). The results demonstrate that typically personal radiation exposure is lower than the exposure limit (61.4 V/m), which is similar to the most research results. However, in areas with dense population and numerous base stations, the maximum exposure can approach 56.7365 V/m (measured data), which is close to the exposure limit.
https://doi.org/10.1109/access.2025.3579085

Assessment of Individual Exposure to Multiple Pollutants (Noise, Particulate Matter, and Extremely Low-Frequency Magnetic Fields) Related to Daily Life Microenvironments in the Brussels Capital Region: Protocol fora Cross-Sectional Study,
Salmon, A., Ledent, M., De Clercq, E. M., Vanhoutte, B. and Bouland, C., *Jmir Research Protocols*, 2025 2025, Vol. 14.

Background: Environmental factors are responsible for 13% of annual deaths in Europe. Citizens are constantly exposed to a variety of environmental factors, such as noise, air pollutants, and magnetic fields (MFs), which may interact with one another. To study multiple-pollutant exposures simultaneously, data on individual citizens, collected using portable measuring devices, provide a high level of detail for exposure characterization. Objective: The aims of this study are to (1) assess the exposure of urban citizens to multiple pollutants (noise, particulate matter [PM], and extremely low-frequency magnetic fields [ELF-MFs]) on a normal weekday, (2) estimate the contribution of each main daily life microenvironment in the multiple-pollutant exposure, and (3) estimate the role of measured exposure in the assessmentof perceived personal exposure. Methods: We collected the exposure levels of 490 individuals to multiple pollutants: PM, ELF-MFs, and noise levels. We used 3devicesperparticipant (Airbeam2, EMDEX II orEMDEX Lite, andasmartphonewiththeAircastingappfor PM, ELF-MFs, and noise, respectively). Participants wore them for 24 hours on a normal weekday. In parallel, they filled out a microenvironment diary and a questionnairefocusing on socioeconomic data, lifestyle, and perceived exposures. The analysiswill first describe the exposures as daily averages and aggregated by microenvironment. Several analyses will be conducted: (1) an estimation of the contribution of each microenvironment in the exposure levels of the 3 pollutants studied, (2) a linear mixed model (for each pollutant) to explain the measured levels of exposure, and (3) linear regression to assess the contribution of the measured personal exposure in self-reported perceived exposures. Results : Data collection was carried out from October 2020 to August 2022, with 490 individuals taking part. The databases have been gathered and cleaned. Future work will focus on data analysis. Conclusions: The collected data will allow us to describe the daily multiple-pollutant exposures faced by individuals within the general population and to characterize the main microenvironments of their daily lives according to multiple-pollutant exposures. This will help identify precise microenvironments to be targeted in policies aiming to reduce exposure to pollution. Because the sampling method is not probabilistic, it is not expected to be representative of the population of the Brussels Capital Region, but it will provide a first step in the understanding of multiple-pollutant exposures faced by individual citizens. International Registered Report Identifier (IRRID): DERR1-10.2196/69407
https://doi.org/10.2196/69407

Evaluation of Patient Radiation Dose in Cardiovascular Interventional Procedures Using Monte Carlo Simulation,
Song, T. H., Lee, K. Y., Kim, J. O., Gil, J. W., Jung, K. H. and Baek, C. H., *Journal of Magnetics*, Dec 2024, Vol. 29, no. 4, p. 565-574.

The International Commission on Radiological Protection (ICRP) has established diagnostic reference levels (DRLs), which set benchmarks for limiting electromagnetic radiation doses across various procedures. This study reviewed DRLs based on dose report data for cardiovascular interventional procedures and analyzed patient electromagnetic radiation doses using Monte Carlo simulations and the High-Definition Reference Korean model, which is utilized as the voxel phantom. The procedures examined include coronary angiography (CAG), percutaneous coronary intervention (PCI), and percutaneous transluminal coronary angioplasty (PTCA). The diagnostic X-ray energy spectrum was generated using the SRS-78 program. Based on dose reports, the irradiation field was set to 13 x 13 cm(2), with tube voltages of 80 kVp, 100 kVp, and 120 kVp and exposure times of 243

seconds, 1043 seconds, and 1423 seconds, respectively. The source-to-image and source-to-skin distances were set to 120 cm and 84 cm, respectively. The NDD(K) method, an indirect dose calculation technique, was used to perform dose calculations and estimate absorbed doses across various organs. Subsequently, effective doses were calculated in accordance with the recommendations set in ICRP 60 and ICRP 103. The effective doses for CAG at 80 kVp and 100 kVp were found to be 1.47 mSv and 3.34 mSv, respectively. In PCI, the effective doses at 80 kVp, 100 kVp, and 120 kVp were 14.70 mSv, 9.52 mSv, and 16.00 mSv, respectively. For PTCA, the effective doses at 80 kVp, 100 kVp, and 120 kVp were observed to be 9.95 mSv, 24.16 mSv, and 32.83 mSv, respectively. Following the guidelines in ICRP 60 and ICRP 103, the conversion factors for effective dose ranged from 0.202 mSv/Gy.cm(2) to 0.418 mSv/Gy.cm(2) and from 0.213 mSv/Gy.cm(2) to 0.443 mSv/Gy.cm(2), respectively. These findings are expected to contribute to establishing optimal electromagnetic radiation exposure limits, promoting the safe management of medical electromagnetic radiation, and preventing excessive radiation exposure.
https://doi.org/10.4283/jmag.2024.29.4.565

RF-EMF exposure assessment with add-on uplink exposure sensor in different microenvironments in seven European countries,
Van Bladel, H., Stroobandt, B., Veludo, A. F., Deprez, K., Roosli, M., Tognola, G., Politanski, P., Parazzini, M., Joseph, W., Polanska, K., Thuroczy, G., Parazzini, M., Wiart, J., Guxens, M. and Joseph, W., *Environment International*, Mar 2025, Vol. 197.

Introduction: Several devices have been developed to assess exposure to radiofrequency electromagnetic field (RFEMF). Since the existing solutions to measure the personal exposure induced by emerging 5G New Radio (NR) are expensive, complex, and bulky, a new cost efficient and low-complexity sensor is developed, that aims to measure RF-EMF exposure in different scenarios of data transmission within different areas. Methods: With this novel sensor, activity-based microenvironmental surveys were conducted across seven European countries: Belgium, Hungary, Italy, Poland, Switzerland, the Netherlands, and the United Kingdom. The device is attached to a smartphone to quantify the auto-induced uplink (a-UL) transmission component of the total exposure for a broadband frequency range from 100 MHz to 6000 MHz and is thus denoted as add-on sensor. In-situ measurements were performed for three usage scenarios, namely non-user (i.e., environmental exposure), maximum downlink (max DL), and maximum uplink (max UL) scenarios, in a large city, a secondary city, and three rural villages a priori selected within each country. Results: Power levels were lowest in non-user scenarios (median: -2.64 dBm or 0.54 mW), increasing by a factor of 5.00 dB in maximum downlink scenarios and by a factor of 14.15 dB in maximum uplink scenarios. In the maximum uplink scenarios, the highest median a-UL power of 18.68 dBm (= 73.79 mW) was recorded in The Netherlands, while the lowest median a-UL power of 4.77 dBm (= 3 mW) was observed in the UK. The analysis of the measured data showed a prominent trend of a 2.72 dB lower power in the cities compared to the villages. Further comparisons were made based on microenvironment groups, where the lowest a-UL power levels (median: 12.35 dBm) were measured in outdoor areas, with an increase of 1.78 dB and 1.91 dB in power was measured compared to public transport and public places, respectively. Conclusion: This study compares RF-EMF power levels between different countries, urbanization settings, and usage scenarios, which is important for future epidemiological studies. https://doi.org/10.1016/j.envint.2025.109368

Assessing radiofrequency electromagnetic field exposure in multiple microenvironments across ten European countries with a focus on 5G,
Veludo, A. F., Stroobandt, B., Van Bladel, H., Sandoval-Diez, N., Deprez, K., Aerts, S., Ben Chikha, W., Wiart, J., Vecsei, Z., Necz, P. P., Thuróczyf, G., Benini, M., Bonato, M., Gallucci, S., Tognola, G., Parazzini, M., Belácková, L., Vaupotici, N., Mamrot, P., Marianska, M., Politanski, P., Polanska, K.,

Stamets, M., De Llobet, P., Castaño-Vinyals, G., Guxens, M., Hulls, P. M., De Vocht, F., Joseph, W. and Röösli, M., *Environment International*, Jun 2025, Vol. 200.

To evaluate the implementation of 5G in Europe, we have systematically measured environmental, auto-induced downlink (DL) and uplink (UL) radiofrequency electromagnetic field (RF-EMF) exposure in more than 800 microenvironments in ten European countries. Outdoor, indoor, and public transport microenvironments were measured in two cities and three villages in each country. Exposure was measured during three mobile-phone user scenarios: flight mode (non-user), inducing maximum DL traffic (max DL) or maximum UL traffic (max UL). The mobile phone was carried in a backpack, placed 30 cm from an ExpoM-RF 4 that continuously measured 35 frequency bands (87.5 MHz-6 GHz). For each user scenario, mean exposure levels were calculated. In the non-user scenario, mean exposure levels ranged from 0.33 to 1.72 mW/m2 per country and were lower in Switzerland, Belgium and Italy. RF-EMF levels were, on average, 80 % lower in villages compared to cities, with DL bands contributing the most in this scenario. During max DL, exposure increased mainly due to the 5G band at 3.5 GHz (mean exposure per country 2.61-11.12 mW/m2). However, the time-division nature of this band prevents distinguishing between DL and UL signals with the ExpoM-RF 4. Exposure levels were the highest during max UL, particularly in the Netherlands, Italy and Belgium, with 50 % of the mean levels per country above 16 mW/m2. Exposure was, on average, 35 % higher in villages compared to cities. Environmental exposure levels were below international guideline values. Countries with precautionary limits had lower environmental exposure levels but higher auto-induced uplink exposure during data upload. https://doi.org/10.1016/j.envint.2025.109540

Assessment of RF Electromagnetic Exposure to Car Driver from Monopole Array Antennas in V2V Communications Considering Thermal Characteristics,
Wang, S. R. and Lu, M., *Sensors*, May 2025, Vol. 25, no. 10.

Vehicles are rapidly evolving into objects of intelligent interconnection. Vehicle-to-Vehicle (V2V) communications enable the interconnection between vehicles, while also leading to new electromagnetic exposure scenarios. This paper integrates a monopole array antenna into a shark-fin antenna on the car roof for V2V communications and evaluates the specific absorption rate (SAR) and temperature rise of a human body in a smart mobility communication scenario operating at 5.9 GHz. The V2V antenna is modeled and placed on a 3D vehicle model using COMSOL Multiphysics (v.6.2) to numerically estimate the SAR in the head and body regions of the human body model (adult male) inside the vehicle. Both the localized and whole-body 30 min average SAR are lower than the International Commission on Non-Ionizing Radiation Protection (ICNIRP) occupational restrictions for electromagnetic field exposure from 100 kHz to 6 GHz, being equal in the worst-case scenario to 0.981 W/kg (for the head), which is 9.81% of the ICNIRP limit (10 W/kg), and 0.008728 W/kg (for the whole-body average), which is 2.18% of the ICNIRP limit (0.4 W/kg). The 30 min average human core temperature rise is 0.055 degrees C, which is 5.5% of the ICNIRP limit. This indicates that, in typical automotive scenarios, the electromagnetic exposure from a monopole array antenna for V2V communications does not pose threat to the human body. This study provides knowledge related to emerging exposure scenarios in intelligent mobility communication, which is beneficial for evaluating possible health impacts and designing public health management policies. https://doi.org/10.3390/s25103247

Toxicité

Electromagnetic fields modulate neuronal membrane ionic currents through altered cellular calcium homeostasis,
Bertagna, F., Ahmad, S., Lewis, R., Silva, S. R. P., Mcfadden, J., Huang, C. L. H., Matthews, H. R. and Jeevaratnam, K., *Annals of the New York Academy of Sciences*, 2025.

The biological effects of electromagnetic fields (EMFs) on the central nervous system (CNS) have been widely reported in the literature. Their nature and extent are thought to depend on parameters such as field intensity and frequency. Of these, extremely low-frequency (50 Hz) fields have been reported to influence neuronal firing in CNS regions, including the hippocampus. We applied the loose patch clamp technique to study the effects of 1 mT exposures of such fields over the course of 60 min on cornus ammonis 1 (CA1) pyramidal neuron membranes in coronal hippocampal slices. Such exposure decreased both inward and transient outward currents. Pharmacological blockers of ryanodine receptor (RyR)-dependent Ca2+ release (dantrolene) and endoplasmic reticular Ca2+ store reuptake (SERCA; cyclopiazonic acid) both abrogated these effects. We thus implicate Ca2+ homeostasis in an EMF-induced modulation of neuronal excitability through its regulation of voltage-gated channels. https://doi.org/10.1111/nyas.15386

Electric Field-Induced Effects in Eukaryotic Cells: Current Progress and Limitations,
Bystrov, D. A., Volegova, D. D., Korsakova, S. A., Salmina, A. B. and Yurchenko, S. O., *Tissue Engineering Part B-Reviews*, Apr 2025.

Electric fields (EFs) offer a powerful tool for manipulating cells and modulating their behavior, holding significant promise for regenerative medicine and cell biology. We provide a comprehensive overview of the effects of different types of EF on eukaryotic cells with the special focus on physical mechanisms and signaling pathways involved. Direct current EF induces electrophoresis and electroosmosis, influencing cell migration, proliferation, and differentiation. Alternating current EF, through dielectric polarization and dielectrophoresis, enables cell manipulation, trapping, and sorting. Pulsed EF, particularly high-intensity, short-duration pulses, induces reversible and irreversible electroporation, facilitating drug and gene delivery. The review covers some technological aspects of EF generation, emphasizing the importance of experimental setups, and integration with microfluidic platforms for high-throughput analysis and precise manipulations. Furthermore, the synergistic potential of combining EFs with optical tweezers is highlighted, enabling fine-tuned control of cell positioning, intercellular interactions, and measurement of biophysical properties. Finally, the review addresses limitations of EF application, such as field heterogeneity and potential side effects, and outlines the directions for future studies, including developing the minimally invasive delivery methods. Impact Statement The application of electric fields (EFs) for cell manipulation and modulation of cellular functions and behavior is a promising task in regenerative medicine and cell biology. This article provides systemized and structured information about EF parameters, induced effects in cells in vitro, and involved signaling pathways and introduces novice biomedical engineers to research in this field.
https://doi.org/10.1089/ten.teb.2025.0022

Weak Radiofrequency Field Effects on Biological Systems Mediated through the Radical Pair Mechanism,
Gerhards, L., Deser, A., Kattnig, D. R., Matysik, J. and Solov'yov, I. A., *Chemical Reviews*, 2025.

The widespread use of radiofrequency (RF) communication has increased the exposure of organisms to electromagnetic fields, sparking a debate over the potential health effects of weak RF

electromagnetic fields. While some experimental studies suggest that low-amplitude RF radiation may influence cellular metabolism or sleep patterns or even promote cancer, these claims remain controversial due to limited theoretical plausibility. Central to this debate is the radical pair mechanism (RPM), a quantum-mechanical framework proposed to mediate RF effects. Despite its role in magnetoreception and various magnetic field effects on chemical reactions, the RPM often fails to align with observations at low, nonthermal RF field strengths. This review examines these contrasting perspectives by discussing experimental findings and theoretical models that aim to explain putative biological effects of RF magnetic fields. Emphasis is placed on the challenges of reconciling theoretical predictions with empirical data, particularly in the context of weak RF exposure. Additionally, an overview of the theoretical framework used in current modeling efforts highlights the complexity of applying the RPM to biological systems and underscores the importance of critical interpretation. The goal is to clarify the state of understanding and inform future research on RPM-mediated biological effects under weak RF exposure.
https://doi.org/10.1021/acs.chemrev.5c00178

The role of excess charge mitigation in electromagnetic hygiene: An integrative review, Jamieson, I. A., Bell, J. N. B. and Holdstock, P., *Biomedical Journal*, Apr 2025, Vol. 48, no. 2.

The electromagnetic characteristics of many environments have changed significantly in recent decades. This is in large part due to the increased presence of equipment that emits electromagnetic radiation and materials that may often readily gain excess charge. The presence of excess charge can often increase the risk of infection from pathogens and the likelihood of individuals experiencing compromised performance, respiratory problems, and other adverse health issues from increased uptake of particulate matter. It is proposed that adopting improved electromagnetic hygiene measures, including optimized humidity levels, to reduce the presence of inappropriate levels of electric charge can help reduce the likelihood of ill health, infection, and poor performance arising from contaminant inhalation and deposition, plus reduce the likelihood of medical devices and other electronic devices getting damaged and/or having their data compromised. It is suggested that such measures should be more widely adopted within clinical practice guidelines and water, sanitation, and hygiene programs. https://doi.org/10.1016/j.bj.2024.100801

Effects of light, electromagnetic fields and water on biological rhythms, Martel, J., Rouleau, N., Murugan, N. J., Chin, W. C., Ojcius, D. M. and Young, J. D., *Biomedical Journal*, Jun 2025, Vol. 48, no. 3.

The circadian rhythm controls a wide range of functions in the human body and is required for optimal health. Disruption of the circadian rhythm can produce inflammation and initiate or aggravate chronic diseases. The modern lifestyle involves long indoor hours under artificial lighting conditions as well as eating, working, and sleeping at irregular times, which can disrupt the circadian rhythm and lead to poor health outcomes. Seasonal solar variations, the sunspot cycle and anthropogenic electromagnetic fields can also influence biological rhythms. The possible mechanisms underlying these effects are discussed, which include photoentrainment, resonance, radical-pair formation, ion cyclotron resonance, and interference, ultimately leading to variations in melatonin and cortisol. Intracellular water, which represents a coherent, ordered phase that is sensitive to infrared light and electromagnetic fields, may also respond to solar variations and man-made electromagnetic fields. We describe here various factors and underlying mechanisms that affect the regulation of biological rhythms, with the aim of providing practical measures to improve human health. https://doi.org/10.1016/j.bj.2024.100824

Direct measurement of non-thermal microwave effects on bacterial growth and redox dynamics using a novel high-throughput waveguide applicator,
Miles, A., Porch, A., Choi, H., Cripps, S., Brown, H. and Williams, C., *Philosophical Transactions of the Royal Society a-Mathematical Physical and Engineering Sciences*, May 2025, Vol. 383, no. 2297.

A high-throughput microwave applicator has been designed and characterized to investigate microwave interactions with biological systems. When operated in the TE10 mode, this rectangular waveguide enabled simultaneous exposure of 96 biological samples to a quantifiable electric field (E field) at 2.45 GHz. Optimized electric probe transitions efficiently couple power (up to 50 W) into and out of the waveguide, achieving a voltage transmission coefficient (S21) near unity (0 dB) and a voltage reflection coefficient (S11) below 0.01 (less than -20 dB). The growth dynamics of Staphylococcus aureus bacteria were analysed after non-thermal, microsecond-pulsed microwave exposure at 25 W r.m.s. of microwave power for 24 h. Post-exposure, S. aureus exhibited significantly higher optical density measurements and growth rates than thermal controls. Fluorescent probes directed towards key redox indicators revealed that microwave exposure altered the cellular redox state. This study provides new insights into the non-thermal effects of pulsed 2.45 GHz microwaves on S. aureus growth dynamics and characterizes a novel high-throughput platform for further exploration of fundamental microwave effects on biological systems.This article is part of the theme discussion meeting issue 'Microwave science in sustainable technologies'.
https://doi.org/10.1098/rsta.2024.0073

A comprehensive mechanism of biological and health effects of anthropogenic extremely low frequency and wireless communication electromagnetic fields,
Panagopoulos, D. J., Yakymenko, I., De Iuliis, G. N. and Chrousos, G. P., *Frontiers in Public Health*, Jun 2025, Vol. 13.

Exposure to anthropogenic electromagnetic fields (EMFs), especially those of wireless communications (WC) has increased tremendously. This is an unprecedented phenomenon throughout biological evolution because, all anthropogenic EMFs, being fully polarized, coherent, and, especially WC EMFs, highly variable, differ substantially from the natural EMFs. WC EMFs consist of Microwave (MW) carrier waves, modulated, by Extremely Low Frequency (ELF) signals, and included in on/off pulses repeated at various ELF rates. Moreover, they exhibit intense random variability, mainly in the Ultra Low Frequency (ULF) band. Thus, WC EMFs are a combination of MW and ELF/ULF EMFs. The combination of polarization/coherence and intense low-frequency (ELF/ULF) variability seems to be the key to EMF-bioactivity. Epidemiological and laboratory studies highlight a connection between ELF or WC EMF exposure and cancer, infertility, electro-hypersensitivity, and various other pathologies. Studies also find DNA damage and Oxidative Stress (OS) which explain these pathologies. While man-made EMFs cannot directly ionize molecules, they are capable of doing this indirectly in biological tissue, by triggering the biosynthesis of Reactive Oxygen Species (ROS) which can damage biomolecules, including DNA. The (over)production of ROS and the consequent OS are triggered by irregular gating of Voltage-Gated Ion Channels (VGICs) in the cell membranes as described by the Ion Forced Oscillation (IFO)-VGIC mechanism: Mobile ions within VGICs forced to oscillate by the applied ELF/ULF EMFs exert forces on the voltage sensors of the VGICs, similar to or greater than the forces that physiologically gate those channels, resulting in their irregular gating (dysfunction). Dysfunction of ion channels disrupts intracellular ionic concentrations. This triggers ROS overproduction and OS by the ROS-generating systems/enzymes in the cells, such as the electron transport chain (ETC) in the mitochondria, or the NADPH/NADH oxidases (NOXs), the Nitric Oxide synthases (NOS), etc. The IFO-VGIC mechanism and the consequent OS constitute a comprehensive mechanism that explains all known adverse biological

and health effects reported to be induced by anthropogenic EMFs. https://doi.org/10.3389/fpubh.2025.1585441

Electromagnetic fields from mobile phones: A risk for maintaining energy homeostasis?, Seewooruttuna, C., Maia, T. C., Coronaa, A., Delanauda, S., De Sezeb, R., Bacha, V., Desailloudc, R. and Pelletiera, A., *Annales D Endocrinologie*, Jun 2025, Vol. 86, no. 3.

In the world, there is a near ubiquitous presence of a low-intensity radiofrequency electromagnetic field (RF-EMF) radiation, due to telecommunications as mobile phones. However, their rapid expansion raises concerns about possible interaction with biological mechanisms. The RF-EMF safety guidelines recommended limits to protect against the thermal heating, the most recognized effect at high intensity levels with a known biophysical mechanism. Among all the effects studied, the impact of RF-EMF exposure on thermoregulation is one of the most important aspects of this research. This review aims to present the complex relationship between RF-EMF exposure and thermoregulation, at intensity levels below the threshold to produce thermal effects. In fact, most studies showed that RF-EMF exposure at 900 MHz seems to elicit physiological and biological effects similar to responses inducing by cold environment in two different rodent models. In this brief review, we will describe the effects and underlying mechanisms induced by RF-EMF exposure at low levels and discuss the potential implications for environmental health and safety. (c) 2025 Elsevier Masson SAS. All rights are reserved, including those for text and data mining, AI training, and similar technologies. https://doi.org/10.1016/j.ando.2025.101782

Effects of Mobile Electromagnetic Exposure on Brain Oscillations and Cortical Excitability: Scoping Review, Torkan, A., Zoghi, M., Foroughimehr, N., Yavari, A. and Jaberzadeh, S., *Sensors*, Apr 2025, Vol. 25, no. 9.

With the widespread adoption of smartphones, concerns about increased exposure to non-ionizing radiofrequency have emerged. This scoping review examines the effects of mobile phone exposure on neural oscillations and cortical excitability, focusing on both motor and non-motor regions of the cerebral cortex. A scoping review identified seventy-eight studies that involved healthy individuals and employed electroencephalography and only two studies that investigated transcranial magnetic stimulation as primary technical tools. The findings suggest that mobile phone exposure may affect brain oscillations and cortical excitability. However, inconsistencies in experimental methods across studies make it difficult to draw definitive conclusions. Additionally, research on fifth-generation technology, particularly mmWave exposure from next-generation mobile networks, remains limited and needs further exploration. These gaps highlight the need for more in-depth studies on how mobile phone exposure impacts brain function. https://doi.org/10.3390/s25092749

What is the effect of alarmist media and radiofrequency electromagnetic field (RF-EMF) exposure on salivary cortisol and non-specific symptoms?, Verrender, A., Wallace, N. K., Loughran, S. P., Wallace, C., Beange, J. and Croft, R. J., *Applied Psychology-Health and Well Being*, Jun 2025, Vol. 17, no. 3.

While there is consistent evidence that the symptoms reported by people who experience Idiopathic Environmental Intolerance attributed to Electromagnetic Fields (IEI-EMF) are closely associated with a nocebo effect, and that alarmist media reports may contribute to this nocebo effect, some methodological criticisms remain to be resolved. This study aimed to replicate previous findings and determine whether viewing an alarmist media report and being openly exposed to radiofrequency electromagnetic fields (RF-EMF) could induce a salivary cortisol response. A total of 144 participants

were randomly assigned to watch either an alarmist or control video before completing an open-label provocation trial where they were either exposed or not exposed to RF-EMF. Personality factors, RF-EMF risk perception (pre- and post-video), symptoms and salivary cortisol were assessed. Consistent with previous studies, participants who were aware that they were being exposed had increased symptoms compared to participants who were aware they were not being exposed. However, the current study failed to replicate an effect of viewing an alarmist media report and being openly exposed to RF-EMF on symptoms and failed to identify an effect on salivary cortisol. This suggests that awareness and belief of exposure play a more important role in symptom perception than underlying physiological processes. https://doi.org/10.1111/aphw.70044

Méthodes

Performance Evaluation and Calibration of Electromagnetic Field (EMF) Area Monitors Using a Multi-Wire Transverse Electromagnetic (MWTEM) Transmission Line,
Azaro, R., Franchelli, R. and Gandolfo, A., *Sensors*, May 2025, Vol. 25, no. 9.

The exposure levels generated by environmental electromagnetic field (EMF) sources can be measured and monitored by employing EMF area monitors. The operating spectrum of environmental EMF sources is not limited to high frequencies (f > 30 MHz) but also extends to low frequencies (f < 30 MHz), where sources associated, for example, with radio transmitters typically generate non-negligible field contributions. For this reason, professional EMF area monitors can be equipped with different field sensors, properly calibrated according to standardized procedures. Because low-frequency electric fields are very sensitive to environmental boundary conditions, equipping an EMF area monitor with electric field sensors, previously calibrated as stand-alone devices, can lead to measurement errors due to field perturbations introduced by the physical structure of the area monitor itself. This paper describes the activities carried out to assess the performance of an EMF area monitor in simulated realistic conditions and calibrate it in the 300 kHz-20 MHz frequency band. The activities were conducted using a multi-wire transverse electromagnetic (MWTEM) transmission line as a controlled electric field source, with dimensions suitable for exposure of the entire structure of the EMF area monitor. In view of using this approach to calibrate the area monitors as a whole instead of the individual sensors, the uniformity of the electric field generated by the available MWTEM transmission line was analyzed in detail both numerically and experimentally. Finally, the results of the evaluation and calibration of an area monitor are reported and discussed. https://doi.org/10.3390/s25092920

Universal Electromagnetic Reference Skin Model for APD Evaluation at 6-100 GHz,
Boriskin, A., Ziane, M., Mafamane, M., Anwar, S. M., Foged, L. J. and Zhadobov, M., *Ieee Journal of Microwaves*, May 2025, Vol. 5, no. 3, p. 543-554.

The increasing use of the upper part of the microwave spectrum for wireless communications requires appropriate methods and instrumentation for user exposure assessment. In this context, the IEC TC106 is developing a new international standard for user exposure compliance testing of the next generation 5G/6G wireless devices operating above 6 GHz. As a part of this initiative, the development of a universal reference skin model (RSM) is fundamental for definition of reference data to be included in specifications for body phantom design. In this study, we systematically analyze the impact of the human body near-surface tissue structure on the electromagnetic field (EMF) reflection from the skin surface in the 6-100 GHz range. A conventional multi-layer model is used to calculate skin reflectance as a function of the tissue thickness for the range of thicknesses corresponding to that of typical human skin and near-surface body tissues at four body sites

concerned by the 5G/6G wireless use-case scenarios, namely: head, torso, forearm, and palm. The dominant contribution from the epidermis/dermis (ED) layer to the skin reflectance is demonstrated for all body sites in the considered frequency range. A high variation in the reflectance of the palm skin at frequencies above 20 GHz is demonstrated and explained by the matching layer effect associated with a thick stratum corneum (SC). The dry skin model, represented by a semi-infinite homogeneous medium with complex permittivity equivalent to that of the ED tissue, is shown to be an appropriate RSM both for the experimental and numerical evaluation of the absorbed power density (APD) in the 6-100 GHz range. The reference data for the antenna loading and APD at the skin surface are provided for standard reference feeds at 10 GHz, 30 GHz, 60 GHz, and 90 GHz. https://doi.org/10.1109/jmw.2025.3564466

Electromagnetic Effects Analysis for Biological Tissues via Dispersive FCC-FDTD Method,
Cui, B. Y., Chen, G. Z., Wang, X. S., Yang, S. C. and Zhou, Z. F., *Ieee Transactions on Antennas and Propagation*, Jul 2025, Vol. 73, no. 7, p. 4646-4660.

A dispersive face-centered cubic finite-difference time-domain (FCC-FDTD) method is proposed for analyzing electromagnetic effects in biological tissues in this article, where biological tissues are dispersive media described by the Debye model. To simplify the derivation and improve accuracy, the auxiliary differential equation (ADE) technique is incorporated into the FCC-FDTD method updating formulas, and the convolutional perfect matched layer (CPML) for the dispersive FCC-FDTD method is developed. Then, the stability of the dispersive FCC-FDTD method is investigated for solving the four-term Debye dispersive model. Three numerical examples, pulse propagation in Debye medium, pulse propagation in multimedia, and the electromagnetic energy absorption of the four-layer spherical head phantom, are used to validate the performance of the dispersive FCC-FDTD method. Considering the dispersive properties of biological tissues, the proposed method is used to analyze the electromagnetic effects of the human brain under broadband radiation. The results show that there are differences in the absorption of electromagnetic energy for different biological tissues, and the electromagnetic effects of the human brain are influenced by age and gender. As a result, the proposed method can more accurately evaluate the effects that electromagnetic radiation causes on organisms and serve as a reference for their electromagnetic safety to make further targeted protection research. https://doi.org/10.1109/tap.2025.3547938

Novel PENELOPE geometry subroutine for patient-Specific dosimetry in the presence of electromagnetic fields,
Gayol, A., Malano, F., Scarinci, I., Pérez, P. and Valente, M., *Radiation Physics and Chemistry*, Dec 2025, Vol. 237.

Technological advancements have enabled the integration of magnetic resonance imaging with linear accelerators, introducing new dosimetry challenges arising from strong magnetic fields within the ionizing radiation field. Notwithstanding the traditional pengeom subroutine, distributed with the PENELOPE package, adequately tracks particles in the presence of external electromagnetic fields, it is limited to geometries defined by quadric surfaces. Conversely, established developments such as PenEasy, which handle voxelized geometries within the PENELOPE main code, are constrained in performing particle tracking with external electromagnetic fields. In response, the here introduced voxgeom emerges as an innovative geometry subroutine tailored to track particles within voxelized regions seamlessly integrated with the PENELOPE main code, even when accounting for external electromagnetic fields. Voxgeom considers each voxel of the geometry as a body in a 3D arrangement, whereas interfaces are treated completely analogue to the pengeom subroutine. Furthermore, allows the use of patient-specific information to establish a univocal relationship between each body and material files, and integrates the models provided by the

PENELOPE package for simulating electron/positron transport with external EM fields. Successful performance is obtained comparing voxgeom with the well-validated pengeom geometry manager both in absence and in presence of external strong magnetic fields. Differences up to 2 % and 1 % are reported between both subroutines, for the homogeneous and inhomogeneous phantom with magnetic field, respectively. Moreover, parameters such as percentage depth dose at depth of maximum dose, 10, and 20 cm are indistinguishable. Finally, promising dosimetry outputs are obtained using voxgeom to characterize dosimetry effects due to the presence of magnetic fields as happens in the Elekta Unity MR-LINAC in a representative patient-specific clinical case. https://doi.org/10.1016/j.radphyschem.2025.113027

Efficient design of electromagnetic field exposure maps with multi-method evolutionary ensembles,
Guillén-Pina, J., Pérez-Aracil, J., Chocano-Del-Cerro, R., Sánchez-Montero, R., López-Espí, P. L. and Salcedo-Sanz, S., *Environmental Research*, Aug 2025, Vol. 278.

Radio-frequency electromagnetic field (EMF) exposure is a growing concern among the population. This concern has led to a need for practical tools to contribute to an adequate risk perception. Representing spatial variations af-ter measurements from fixed sites and interpolating using different techniques is the most suitable method for obtaining EMF high-quality exposure maps. This paper uses evolutionary computation to obtain the optimal set of points to construct high-quality electromagnetic field exposure maps (minimizing an error measure with respect to a reference exposure map). A multi-method en-semble evolutionary approach, able to combine different search operators in a single population (PCRO-SL), is introduced for this particular problem, and it has been tested over actual measurements at Meco town, Madrid, Spain, obtaining good quality electromagnetic field exposure map reconstructions in terms of the differences with a reference EMF exposure map. The results obtained show that reducing the number of measurement points necessary to obtain significant exposure maps, while maintaining their representativeness, is possible. https://doi.org/10.1016/j.envres.2025.121636

SAR Analysis in an Anatomical Head Model Using CFL-Optimized Yee Cells and an Accurate Dipole Model at 700-MHz for 5G Mobile Radiation,
Jariyanorawiss, T., Kanjanasit, K., Chongburee, W. and Sornsungnoen, N., *Ieee Access*, 2025, Vol. 13, p. 82718-82731.

Electromagnetic radiation (EMR) exposure from fifth-generation (5G) mobile technology influences human health. This article proposes a numerical analysis to investigate the specific absorption rate (SAR) using an anatomical human head and accurate dipole model to examine the EMR effect at 700 MHz, a low-band frequency for 5G mobile communication. A three-dimensional (3D) digital model of a realistic human head is reconstructed using a series of magnetic resonance imaging (MRI) scans. This model encompasses various tissue types with their respective bio-material properties. The radiation from a mobile terminal is modeled using a dipole-based structure. In this study, the Unsplit-Field Finite-Difference Time-Domain (UF-FDTD) algorithm is modified for numerical analysis, with a perfectly matched layer (PML) serving as the boundary condition. The electromagnetic (EM) simulation is conducted to study the interaction between the two computational objects in the artificial absorbing environment. The Yee cell is utilized for a structured lattice in the UF-FDTD approach, characterized by its uniformity and consistent application throughout the model. The research problem involves correlating the size of the human head model with the unit cell size, which is associated with the average weight of the human brain for adults. The Yee cell is optimized based on the Courant-Friedrichs-Lewy (CFL) condition. This work enhances simulation accuracy twofold. First, the optimization of the unit cell size relative to the wavelength is

refined in comparison to other unit cells without a phase error. This optimization leads to an accurate time-step parameter via the CFL criterion, ensuring the stability of the computer simulation. Second, the optimized grid structure of the UF-FDTD algorithm closely approximates the infinitesimal feeding gap, ensuring precise alignment with the exact dimensions of the feed-gap point in the dipole antenna configuration and accurately reflecting the effects of input impedance characteristics. The SAR 1-g and SAR 10-g are reported in association with the IEEE standard and ICNIRP guidelines. The total average absorbed power at a gap distance of 1.12 cm is correlated with the radiated power, given by P-avg/P-r, with a resulting value of approximately 189.556. The resulting SAR 1-g value is reported as 0.556 W/kg. This investigation contributes to understanding the dosimetry of EMR exposure from 5G mobile technology in the 700 MHz band.
https://doi.org/10.1109/access.2025.3568603

Uncertainty assessment of electromagnetic exposure safety for human body with intracranial artery stent around EV-WPT based on K-GRU surrogate model,
Liu, J. X., Zhao, K. F., Yu, Q. Y., Zhou, H. W., Wang, T. H. and Chi, Y. D., *Alexandria Engineering Journal*, Jun 2025, Vol. 125, p. 624-635.

As electric vehicles (EVs) continue to gain popularity and wireless power transfer (WPT) advances, protecting human health from electromagnetic exposure during EV-WPT operation has become a critical research priority. Given the rising number of patients with metallic medical devices implanted, this article presents a human model of an adult male with an intracranial arterial stent exposed to electromagnetic field leakage from WPT. Considering uncertainties in WPT manufacturing errors and human positioning relative to WPT, this article employs a modified Gate Recurrent Unit (GRU) architecture based on the Kolmogorov-Arnold Network (K-GRU) to quantify these uncertainties in electromagnetic safety assessment. Compared to the Monte Carlo (MC) method, the K-GRU proxy modeling approach reduces assessment time to just 5% of that required by MC. The findings indicate intracranial artery stent implantation significantly influences the distribution of the induced electric field within the human body. Specifically, there is a 96% probability that the induced electric field exceeds the limits set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines at the EV's outer side, and a 71.5% probability at the rear. These findings suggest that for patients with intracranial arterial stents, maintaining appropriate safety distances and implementing power restrictions in EV-WPT systems may be necessary to ensure compliance with electromagnetic exposure limits.
https://doi.org/10.1016/j.aej.2025.03.112

Comparison Between Broadband and Personal Exposimeter Measurements for EMF Exposure Map Development Using Evolutionary Programming,
Nájera, A., Sánchez-Montero, R., González-Rubio, J., Guillén-Pina, J., Chocano-Del-Cerro, R. and López-Espí, P. L., *Applied Sciences-Basel*, Jul 3 2025, Vol. 15, no. 13.

In this study, we provide a comparison of radiofrequency electromagnetic field exposure level maps as determined using two approaches: a broadband meter (NARDA EMR-300) equipped with an isotropic probe in the range of 100 kHz to 3 GHz, and a Personal Exposimeter (Satimo EME Spy 140) in the range of 88 MHz to 5.8 GHz. The aim of this research was to determine the necessary adjustments to the measurements made with personal exposimeters to obtain RF-EMF exposure maps equivalent to those made with broadband meters. We evaluated different possibilities to obtain the best equivalence of measurements between both devices. For this purpose, the datasets obtained in both cases were analyzed, as well as the possible correction factors. First, the possibility of establishing a single or double correction factor depending on the existence (or lack thereof) of a line of sight with respect to the base stations was analyzed by minimizing the average value of the

error between the values of the broadband meter and the corrected values of the personal exposure meter. Due to the differences observed in the exposure maps, a second procedure was carried out, in which a genetic algorithm was used to determine the ratio between the measurements from both methods (the broadband meter and personal exposure meter), depending on the existence (or lack thereof) of a line of sight, and we compared the exposure maps generated using kriging interpolation. https://doi.org/10.3390/app15137471

Safety Management Technologies for Wireless Electric Vehicle Charging Systems: A Review, Niu, S. Y., Jia, Q. R., Hu, Y., Yang, C. B. and Jian, L. N., *Electronics*, Jun 11 2025, Vol. 14, no. 12.

Wireless electric vehicle charging (WEVC) is rapidly advancing as an enabling technology for convenient electrified transportation. The trend toward high-power WEVC systems is accelerating, which not only enhances charging speed and user convenience but also introduces new and complex safety challenges. These challenges are particularly acute at the coupler level, where electrical, thermal, and magnetic risks often interact. This review offers a comprehensive analysis of safety management technologies that are specific to WEVC, with an exclusive focus on coupler-related risks. System-level and coupler-level hazards associated with high-power operation are first examined, followed by an in-depth discussion of recent progress in passive safety materials, such as insulation, thermal dissipation, and electromagnetic shielding. Active safety management strategies are also reviewed in detail, including foreign object detection, live body detection, misalignment detection, and multifunctional detection schemes that integrate these capabilities. Emphasis is placed on the ongoing rapid iteration of safety technologies as power levels increase and on the necessity for solutions that are comprehensive, precise, orderly, and reliable. This review concludes by highlighting future research directions, such as data-driven safety management, intelligent sensor integration, regulatory evolution, and user-centered system design, aiming to support the safe and scalable deployment of WEVC in next-generation mobility.
https://doi.org/10.3390/electronics14122380

Cluster Analysis of RF-EMF Exposure to Detect Time Patterns in Urban Environment: A Model-Based Approach,
Pasquino, N., Solmonte, N., Djuric, N., Kljajic, D. and Djuric, S., *Ieee Access*, 2025 2025, Vol. 13, p. 118724-118732.

The increase in human exposure to electromagnetic fields (EMFs), driven by advancements in telecommunication systems like the 5G mobile system, highlights the need for continuous EMF monitoring. Advanced techniques for data analysis, based on machine learning like clustering, can decompose daily variations in EMF exposure into distinct patterns, providing a clearer understanding of how exposure fluctuates over time. Although several exposure monitoring systems exist in Europe, only a few studies have thoroughly examined the time variability. This study addresses the gap by applying model-based clustering techniques to analyze the temporal patterns. Specifically, the study focuses on characterizing fluctuations in field strength during workdays and holidays, thereby contributing to a deeper understanding of time-distributed exposure. Continuous monitoring data, collected through the Serbian EMF RATEL network's sensors installed in Novi Sad, were processed and analyzed using the Log-Normal Mixture Model (LNMM), a model-based clustering algorithm resorting to mixture distributions. The analyses reveal that the LNMM can separate night and day exposure values and identify periods when values persist longer over the day. This suggests that model-based clustering can be useful for understanding the temporal patterns of local EMF exposure. https://doi.org/10.1109/access.2025.3586905

Design and Validation of a Low-Cost Triaxial 5G RF-EMF Exposure Sensor,
Van Der Straeten, J., Van Bladel, H., Deprez, K., Joseph, W. and Vermeeren, G., *Ieee Sensors Journal*, May 2025, Vol. 25, no. 9, p. 16050-16060.

A low-cost monitoring network, to measure radio frequency (RF) electromagnetic field (EMF) exposure induced by 5G, is required for risk communication and to support research into long-term health and ecological effects related to 5G technologies. A low-cost triaxial fifth generation (5G) RF-EMF exposure sensor was designed, calibrated, and validated in the field, using a commercial network. The sensor uses a triaxial antenna-based measurement design and is able to measure the exposure induced by 5G communication in the n78 (3300-3800 MHz) and the n77 (3300-4200 MHz) frequency band up to 3900 MHz. The sensitivity of the simultaneous analog-to-digital converter (ADC)-based triaxial sensor is 0.06 V/m, while having a combined uncertainty u(c) of 3.12 dB. The sensor was tested indoor and in two outdoor environments (private and commercial 5G networks). The maximum measured electric-field level induced by 5G (n77 band) was 0.89 V/m [500 m from a commercial base station (BS)] and 2.87 V/m (60 m from a private BS), which are 1.5% and 4.8% of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines, respectively. A second measurement campaign was used to compare the values of the electric field captured by the novel triaxial 5G sensor and commercial measurement equipment (SRM-3006). The average values of the electric field registered by the triaxial 5G sensor differ on average 2.8 dB from the values of the SRM-3006, which is within the measurement uncertainty of the SRM-3006.
https://doi.org/10.1109/jsen.2025.3549631

Experimental Platform for Investigation of Low-Frequency Magnetic Field Effects on Cells,
Viet, H. V., Kremnicky, L., Bereta, M. and Teplan, M., *Measurement Science Review*, Apr 2025, Vol. 25, no. 2, p. 83-92.

This study presents a novel experimental platform designed to systematically investigate the effects of low-frequency (LF) magnetic fields (MFs) on biological systems. By overcoming key methodological challenges, including variability in environmental conditions and poor reproducibility, this platform sets a new standard for experimental reliability. It integrates precise temperature regulation, high MF homogeneity, and a modular structure, that ensures adaptability to diverse experimental setups. The platform was validated using Saccharomyces cerevisiae CCY 21-4-99 as a model organism, cultivated under controlled conditions with and without MF exposure. The minimal growth variations observed between chambers confirm the ability of the platform to maintain reproducible conditions and support statistically robust experimental designs. The platform can be applied to diverse biological systems and can be technically adapted to different experimental requirements, including different electromagnetic field sources. It provides a highly controlled environment for investigating the cellular and subcellular effects of LF MF, creating a solid foundation for future research into its biological mechanisms and potential applications.
https://doi.org/10.2478/msr-2025-0011

Realistically Poseable Mouse Model for Assessing Exposures to Magnetic Field in the Intermediate Frequency Band,
Wasoontarajaroen, S., Ishiwata, H., Chakarothai, J., Ohtani, S., Ushiyama, A., Hattori, K., Wada, K., Ikehata, M. and Suzuki, Y., *Ieee Access*, 2025, Vol. 13, p. 86528-86541.

Recently, a mouse model was used to quantify electromagnetic (EM) dosimetry in an investigation of the biological effects of an EM field in the intermediate-frequency band (300 Hz to 10 MHz). However, it did not reflect the realistic postures observed during exposure experiments; thus, the data obtained were not accurate. In this study, a poseable mouse mesh model was developed using

photogrammetry techniques; its pose was changed to mimic ten realistic postures observed during exposure experiments. The mouse model was composed of ten different tissues and organs: the eyes, brain, skull, bone, liver, lungs, heart, spleen, glands, and skin. The dosimetry evaluation was performed on the mouse model under a uniformly applied magnetic field intensity. The reliability and accuracy of the EM solver used in the evaluation were validated by performing a dosimetry evaluation on a homogeneous sphere and ellipsoid exposed to a uniform magnetic field; the results were compared with those obtained by the analytical method. Dosimetric quantification was performed using several metrics. The metrics included the whole-body average (E-WBA), 99th percentile (E-99), 99.9th percentile (E-99.9), and maximum (E-max) values of the induced electric field intensity inside the mouse body. For an applied magnetic field density of 1 mT at 100 kHz, the E-WBA, E-99, E-99.9, and E-max values for the poseable mouse in the standing, upright, and curled-up positions were derived and discussed. The developed poseable mouse model potentially provides accurate exposure data for animal experiments under freely roaming conditions. https://doi.org/10.1109/access.2025.3569330

The Parametrization of Electromagnetic Emissions and Hazards from a Wearable Device for Wireless Information Transfer with a 2.45 GHz ISM Band Antenna,
Zradzinski, P., Karpowicz, J. and Gryz, K., *Applied Sciences-Basel*, Jun 12 2025, Vol. 15, no. 12.

The parameters of electromagnetic emissions from the antenna of a wearable radio communication module (parameterizing device functionality) were investigated at different positions near the body where an antenna is located. The specific absorption rate (SAR) coefficient was also investigated as a way of parameterizing the absorption of electromagnetic radiation in the user's body adjacent to the antenna in various locations. The modeled exposure scenarios concerned a body-worn device with a 2.45 GHz ISM band antenna (used, e.g., for Wi-Fi 2G/Bluetooth applications). The antennas were modeled as follows: (1) located directly on the body (considered to be a model of a disposable, adhesive device) or (2) next to the body (considered to be a model of a classic, reusable, wearable electronic device located inside a plastic housing). Several body sections adjacent to the antenna were considered: head, arm, forearm, and chest (simplified and anatomical body models were used). The numerical models of the exposure scenarios were verified by relevant laboratory tests using physical models. It was found that the use of simplified models of the human body (numerical or physical) may be sufficient when analyzing antenna performance and SAR in a user's body, such as in studies regarding microwave imaging and sensing, wireless implantable devices, wireless body-area networks or SAR estimation. https://doi.org/10.3390/app15126602

Toxicité sur les animaux

The influence of Wi-Fi on the mesonephros in the 9-day-old chicken embryo,
Almásiová, V., Andrasková, S., Karaffová, V., Hudaková, P., Molnár, J., Tóth, S. and Holovská, K., *Veterinary Research Communications*, Aug 2025, Vol. 49, no. 4.

The use of wireless devices has increased rapidly in recent times, especially in developed countries. As a result, all living systems are to some extent permanently exposed to this artificial electromagnetic non-ionizing radiation (NIR). These modern devices provide countless benefits to the users, but the disadvantage of their excessive use is the production of electrosmog. This physical pollutant of the environment can be particularly dangerous especially during the developmental period of the individual. The aim of the current study was to elucidate the effect of Wi-Fi radiation on the mesonephros development in the chicken embryo on day 9 of incubation. Continual 9-day

application of radiation with a frequency of 2.4 GHz and a power density of 200-500 mu W/m2 had no adverse effect on the general development of the mesonephros, however moderate diffuse degenerative changes were found in the developing mesonephric corpuscles and tubules. Also congested blood vessels were present in the surrounding interstitium, but no signs of inflammatory infiltrate were detected. In the Wi-Fi group, we also noted a significantly increased number of apoptotic and proliferating cells as well as a significant up-regulation of caspase-1 gene expression. The results indicated that non-ionizing radiation at the frequency and power density used in the study can interfere with the key regulatory mechanisms involved in the normal development of tissues and organs. https://doi.org/10.1007/s11259-025-10777-x

Protective effects of quercetin against 3.5 GHz RF radiation-induced thyroid dysfunction and oxidative stress in rats,
Bektas, H., Akgun, B. B. B., Cakir, S., Dogu, S. and Ahnas, B., *Electromagnetic Biology and Medicine*, 2025.

The global expansion of 5 G communication networks has heightened concerns about the biological effects of high-frequency radiofrequency (RF) radiation, particularly on endocrine organs such as the thyroid gland. This study investigated the effects of 3.5 GHz RF radiation on thyroid hormone levels and oxidative stress markers in male Wistar rats and assessed the potential protective role of quercetin, a natural antioxidant. Twenty-eight rats were randomly assigned to four groups: Sham, RF, Quercetin, and RF + Quercetin. RF exposure was administered at 3.5 GHz (2 W) for 2 hours/day, 5 days/week, for 30 days. Quercetin (20 mg/kg) was administered intraperitoneally. Serum levels of T3, T4, and TSH, as well as thyroid tissue levels of TAS, TOS, GSH, and MDA, were analyzed using ELISA. RF exposure significantly decreased T3 and T4, increased TSH, elevated MDA and TOS, and reduced TAS and GSH levels. Quercetin treatment showed trends toward reversing some of these effects, although not all changes reached statistical significance. SAR simulations confirmed higher energy absorption in the thyroid region (average SAR: 1.128 W/kg). These findings suggest that 3.5 GHz RF radiation may impair thyroid function and redox homeostasis, and that quercetin may exert limited biochemical protection, though further studies are needed to confirm its efficacy. Further long-term molecular studies are warranted to elucidate the mechanisms involved.
https://doi.org/10.1080/15368378.2025.2528732

The effects of short-term and long-term 2100 MHz radiofrequency radiation on adult rat auditory brainstem response,
Er, H., Basaranlar, G., Derin, N., Kantar, D. and Ozen, S., *Open Chemistry*, Jul 3 2025, Vol. 23, no. 1.

Although mobile phones that work with RFR provide very important benefits for our lives, they may have negative effects. Namely, side effects, such as headaches, sleep disorders, dizziness, lower sperm quality, changes in brain potentials, an increase in oxidative stress levels, and a decrease in antioxidant parameters, have been reported due to mobile phone use. Accordingly, the aim of this research is to investigate the effects of acute and chronic 2100 MHz radiofrequency radiation (RFR) exposure on the auditory brainstem response (ABR) in adult rats. Study groups (n = 10 rats): Sh-1: sham for 1 week; Sh-10: sham for 10 weeks; 2100-1: 2100 MHz for 1 week; and 2100-10: 2100 MHz for 10 weeks. RFR groups were applied for 2 h/day (5 day/week) 2100 MHz RFR, whereas sham groups were kept under identical circumstances without RFR. ABR were recorded, and biochemical and ultrastructural examinations in the rat brain were carried out. In the acute RFR group, the latencies of all ABR waves were prolonged compared to the sham group. In the acute RFR group, brain 4-hydroxynonenal, thiobarbituric acid reactive substances, and protein carbonyl content levels increased and catalase and superoxide dismutase activities decreased compared to the acute sham group. Edema in acute RFR group neurons, astrocytes, astrocytic end-feet, and mitochondrial

damage in astrocytes were observed. Our data imply that acute exposure to 2100 MHz RFR may have adverse impacts on the auditory system, while chronic exposure with certain rest days has no harmful effects. https://doi.org/10.1515/chem-2025-0173

Microwave exposure induced ferroptosis by inhibiting the Nrf2 pathway and affected reproductive function in male mice,
Gao, J. C., Li, X. Y., Hou, Y. Z., Li, Y. Y., Pang, Y. Y., Wu, X. R., Zhao, L., Zhang, J., Wang, H. Y., Wang, H., Dong, J., Xu, X. P., Peng, R. Y., Wang, Y. and Yao, B. W., *Ecotoxicology and Environmental Safety*, Aug 2025, Vol. 301.

The mechanisms underlying the negative health effects of microwave exposure on male reproduction remain unclear. Thus, this study aimed to explore the role and regulatory mechanisms of ferroptosis in microwave-induced reproductive damage. The exposure of male C57 mice to 2.856 GHz of microwave radiation at 0, 10 and 20 mW/cm2 for 30 min decreased sperm motility, induced morphological changes, damaged testicular tissue and mitochondrial morphology, increased malondialdehyde (MDA) contents and decreased the GSH/GSSG ratio. Simultaneously, the Fe2+levels increased and SLC7A11 and GPX4 protein expressions decreased, causing oxidative stress. After 30 min of mouse spermatocyte (GC-2) irradiation, the cell viability of the Fer-1 inhibitor group and the GSH/GSSG ratio increased, while the reactive oxygen species, MDA and ferrous iron contents decreased. Furthermore, the depolarisation of membrane potential improved. Western blotting revealed that Nrf2, Keap1, SLC7A11, GPX4 and HO-1 expressions were down-regulated by microwave exposure and significantly up-regulated following the addition of the Fer-1 inhibitor. The results confirmed that the Nrf2 signalling pathway can regulate ferroptosis of oxidative stress. This study demonstrates that microwave exposure affects mouse reproductive function by enhancing oxidative stress, inducing ferroptosis by inhibiting the Nrf2 signalling pathway and reducing SLC7A11 and GPX4 protein expressions. https://doi.org/10.1016/j.ecoenv.2025.118523

Effects of 2100 MHz radio-frequency fields on brain tissues and plasma of normal rats and obese rats,
Günay, S., Delen, K., Özkan, E. T., Aksoy, D. K. and Aral, B. S., *Electromagnetic Biology and Medicine*, Jun 2025.

The use of mobile phones, one of the popular recent sources of radio-frequency fields (RFF), is increasing. It has been shown thatRFF exposure can increase free radical levels and oxidative stress.Obesity is an important risk factor for many diseases such as cancer, cardiovascular diseases, and diabetes, and has been shown to increase oxidative stress. In this study, rats were exposed to 2100 MHz RFF(electric field 15 V/m) for 15 minutes daily and 4 hours daily for 3 weeks. It aims to investigate the effects of 2100 MHz RFF on brain tissue and plasma of normal and obese rats. The rats were divided into eight groups (n = 6):control, Sham1, Sham2, RFF1, RFF2, High Fat Diet (HFD), Sham+HFD, andHFD+RFF. The inflammatory and oxidative effects on brain tissue and plasma were analyzed using the GraphPad 9 macOS package program. WhenTOS levels in brain tissue were compared between Sham2 and RFF1 andall groups, a significant difference was found in the RFF2 group. TASlevel was significantly different in the HDF+RFF group compared to the control group, Sham and all groups. When pro-inflammatory and anti-inflammatory parameters were evaluated in brain tissue, significant differences were found in different exposure groups. Inplasma, TOS levels were significantly different in the RFF2 groupcompared to Sham2 and RFF1, but TAS levels were not different.According to the data obtained, obesity may be protective against the oxidative and inflammatory effects of RFF. https://doi.org/10.1080/15368378.2025.2513903

Carcinogenicity of extremely low-frequency magnetic fields: A systematic review of animal studies,
Luukkonen, J., Roivainen, P., Nieminen, V., Naarala, J., Mustafa, E. and Juutilainen, J., *Environmental Research*, Aug 2025, Vol. 279.

Possible carcinogenicity of extremely low frequency (ELF) magnetic fields (MFs), associated with the use and transmission of electricity, has been under scientific and public debate for decades. This review aims to provide an update on studies testing carcinogenicity of ELF MFs in experimental animals. Emphasis was placed on identifying possible connections between study characteristics and the results obtained. This review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement, and the methodological quality of the studies was evaluated using the Risk of Bias Rating Tool for Human and Animal Studies developed by the National Toxicology Program's Office of Health Assessment and Translation (OHAT). Publication bias was assessed using the caliper test. Fifty-four eligible studies were identified. Despite poor ratings in certain aspects of the risk of bias evaluation, the quality of the studies was generally relatively good, with only four studies receiving the weakest rating. Overall, there was very little evidence that ELF MFs alone are carcinogenic. Evidence of co-carcinogenicity, from studies that have used ELF MFs in combination with other agents, remains inconclusive. A clear indication of publication bias was observed, though it is unlikely that this bias alone explains all reported MF-modified effects. Based on the current literature, future studies on cocarcinogenicity of ELF MFs should employ approaches other than classical initiation-promotion models. Additionally, well-designed studies to better understand the reported effects of ELF MFs and the underlying mechanisms are warmly welcomed. https://doi.org/10.1016/j.envres.2025.121819

Effects of radiofrequency electromagnetic field exposure on cancer in laboratory animal studies, a systematic review☆,
Mevissen, M., Ducray, A., Ward, J. M., Kopp-Schneider, A., Mcnamee, J. P., Wood, A. W., Rivero, T. M. and Straif, K., *Environment International*, May 2025, Vol. 199.

Background: More than ten years ago, the World Health Organization's (WHO) International Agency for Research on Cancer (IARC) published a monograph concluding there was limited evidence in experimental animals for carcinogenicity of Radio Frequency Electromagnetic Field (RF EMF). Objective: The objective of this review was to systematically evaluate the effects of RF EMF exposure on cancer in experimental animals. Methods: Eligibility criteria: Based on pre-established Populations, Exposures, Comparators, Outcomes, and Study Type (PECOS) criteria, studies in experimental animals of the following study types were included: chronic cancer bioassays, initiation-(co-)promotion studies, and studies with tumor-prone animals. Information sources: MEDLINE (PubMed), Science Citation Index Expanded and Emerging Sources Citation Index (Web of Science), and the EMF Portal. Data abstraction and synthesis: Data are publicly available online as interactive visuals with downloadable metadata. We adapted the risk-of-bias (RoB) tool developed by Office of Health Assessment and Translation (OHAT) to include considerations pertinent to the evaluation of RF EMF exposure and cancer bioassays. Study sensitivity was assessed with a tool adopted from the Report on Carcinogens (RoC). We synthesized studies using a narrative approach. Effect size was calculated as the 1% Bayesian Average benchmark dose (BMD) of a respective study when dose-response or a trend was identified (see BMDAnalysisSupplementaryMaterial) (Supplement 1). Evidence Assessment: Certainty of the evidence (CoE) was assessed using the Grading of Recommendations, Assessment, Developing and Evaluations (GRADE) approach, as refined by OHAT. Evidence from chronic cancer bioassays was considered the most directly applicable to evaluation of carcinogenicity. Results: We included 52 studies with 20 chronic bioassays No studies were excluded based on risk of bias concerns. Studies were not considered

suitable for meta-analysis due to heterogeneity in study design, species, strain, sex, exposure characteristics, and cancer outcome. No or minimal evidence of RF EMF exposure-related cancer outcomes was found in most systems or organs in any study (these included gastrointestinal/digestive, kidney, mammary gland, urinary, endocrine, musculoskeletal, reproductive, and auditory). For lymphoma (18 studies), with 6 chronic bioassays (1,120 mice, 1,780 rats) inconsistency between two chronic bioassays was not plausibly explainable, and the CoE for lymphoma was rated 'moderate'. For brain tumors (20 studies), including 5 chronic bioassays (1,902 mice, 6,011 rats), an increase in glial cellderived neoplasms was reported in two chronic bioassays in male rats. The CoE for an increased risk in glioma was judged as high. The BMD analysis was statistically significant for only one study and the BMD was 4.25 (95% CI 2.70, 10.24). For neoplasms of the heart (4 chronic bioassays with 6 experiments), 3 studies were performed in rats (2,165 animals), and 1 in mice (720 animals). Based on 2 bioassays, statistically significant increases in malignant schwannomas was judged as high CoE for an increase in heart schwannomas in male rats. The BMDs from the two positive studies were 1.92 (95 %CI 0.71, 4.15) and 0.177 (95 %CI 0.125, 0.241), respectively. Twelve studies reported neoplasms in the adrenal gland (5 chronic bioassays). The CoE for an increased risk in pheochromocytoma was judged as moderate. None of these findings were dose-dependent when compared to the sham controls. Sixteen studies investigated tumors of the liver with 5 of these being chronic bioassays. The CoE was evaluated as moderate for hepatoblastomas. For neoplasms of the lung (3 chronic bioassays), 8 studies were conducted in rats (1,296 animals) and 23 studies in mice (2,800 animals). In one chronic bioassay, a statistically significant positive trend was reported for bronchoalveolar adenoma or carcinoma (combined), which was rated as moderate CoE for an increase in lung neoplasms with some evidence from 2 initiation-(co-)promotion studies. Discussion: Meta-analysis was considered inappropriate due to the heterogeneity in study methods. The GRADE/ OHAT CoE framework has not been frequently applied to animal studies and experience to date suggests refinements are needed. We referred to standard methods in environmental health where CoE is framed in the context of strength of the evidence providing positive support for carcinogenicity. High CoE can be interpreted as the true effect is highly likely to be reflected in the apparent relationship. Moderate CoE indicates the true effect may be reflected in the apparent relationship. Cancer bioassays conducted in experimental animals are commonly used to identify potential human carcinogens. We note that the two tumor types with high CoE in animals in this systematic review are the same as those identified with limited evidence in humans by the IARC Working Group. However, even in cases where the animal evidence demonstrates high CoE, the extrapolation of risk from cancer bioassays to humans is particularly complex for RF EMF. Without a better understanding of the mechanism of the carcinogenicity of RF-EMF, the choice of exposure metric for risk extrapolation (whole body versus localized), intensity or cumulative exposure, whether or not a monotonic dose-response holds for carcinogenic effects, and whether SAR is the appropriate dose metric for adverse effects induced by RF-EMF, may be critical. Other: This review was partially funded by the WHO radioprotection programme. The protocol for this review was registered in Prospero reg. no. CRD42021265563 and published in Environment https://doi.org/10.1016/j.envint.2025.109482

Mitigation of 3.5 GHz Electromagnetic Field-Induced BV2 Microglial Cytotoxicity by Polydeoxyribonucleotide,
Pachhapure, S., Mufida, A., Wei, Q., Choi, J. S. and Jang, B. C., *Current Issues in Molecular Biology*, May 22 2025, Vol. 47, no. 6.

Emerging evidence highlights the biological risks associated with electromagnetic fields (EMFs) generated by electronic devices. The toxic effects and mechanisms induced by exposure to EMFs on microglial cells and natural substances that inhibit them are limited to date. Here, we investigated whether exposure to 3.5 GHz EMF radiation, potentially generated by smartphones working in 5G

communication or cooking using microwave ovens, affects the growth of BV2 mouse microglial cells and polydeoxyribonucleotide (PDRN), a DNA preparation derived from salmon sperm, inhibits it. Of note, exposure to 3.5 GHz EMF radiation for 2 h markedly inhibited the growth and triggered apoptosis in BV2 cells, characterized by the reduced number of surviving cells, increased genomic DNA fragmentation, increased reactive oxygen species (ROS) levels, and altered phosphorylation and expression levels of JNK-1/2, p38 MAPK, ERK-1/2, eIF-2 alpha, and procaspase-9. Pharmacological inhibition studies revealed that JNK-1/2 and p38 MAPK activation and ROS generation were crucial for 3.5 GHz EMF-induced BV2 cytotoxicity. Of interest, PDRN effectively countered these effects by inhibiting the activation of JNK-1/2, p38 MAPK, and caspase-9, and the production of ROS, although it did not affect eIF-2 phosphorylation. In conclusion, this study is the first to report that PDRN protects against 3.5 GHz EMF-induced toxicities in BV2 microglial cells, and PDRN's protective effects on 3.5 GHz EMF-induced BV2 cytotoxicity are mediated primarily by modulating ROS, JNK-1/2, p38 MAPK, and caspase-9. https://doi.org/10.3390/cimb47060386

An 1800 MHz Electromagnetic Field Affects Hormone Levels, Sperm Quality, and Behavior in Laboratory Rats (Rattus norvegicus),
Pawlak, K., Bojarski, B., Jagusiak, W., Wojnar, T., Nieckarz, Z., Arent, Z., Ludwiczak, M. and Lasko, M., *Applied Sciences-Basel*, May 2025, Vol. 15, no. 9.

In addition to natural electromagnetic fields (EMFs), so-called artificial electromagnetic fields exist in the biosphere, with mobile communications being one of their main sources. This study aimed to determine the impact of EMF at a frequency of 1800 MHz on the concentrations of selected hormones, sperm motility, viability, morphology and behaviors in laboratory rats. We used 28 rats divided into two equinumerous groups: control (n = 14) and experimental (n = 14). The rats in the experimental group were exposed to EMF for 12 weeks (for 10 min, four times daily); at the same time, the control specimens were kept in standard conditions. After 12 weeks, half of each group was killed, while the other half was maintained for another 4 weeks with no EMF emission. Elevated corticosterone levels and decreased thyroid-stimulating hormone levels were observed in the experimental specimens, which persisted for 2 weeks after the cessation of EMF emission. Exposure to EMF also resulted in decreased sperm motility and viability, as well as increased rat anxiety. This study shows that exposure to EMF (1800 MHz) may affect the endocrine status of the body and the behavior and reproductive functions of animals. However, hormonal disorders appear to be reversible. https://doi.org/10.3390/app15095160

Effects of non-ionizing radiation on the thyroid gland in rats,
Sarhad, Z. S., Ebrahimbabaei, A., Tavassoli, A. and Shojaeifard, M., *Bmc Research Notes*, May 2025, Vol. 18, no. 1.

Objectives This study evaluated the effects of non-ionizing electromagnetic radiation on rat thyroid function and histopathology. Forty female and thirty male Sprague-Dawley rats (200-220 g, 2 months old) were exposed to 2.45 GHz Wi-Fi, mobile jammer radiation, or a sham condition. In Group A, male rats were exposed to Wi-Fi or mobile jammers for 2 h daily for two weeks. The devices were located within a one-meter radius of the animal cage, either on or off. In the Sham group, the experimental setup was like the other groups, but the irradiating devices were turned off. Group B included non-pregnant females, pregnant (exposed and control subgroups), and their offspring. Thyroid hormones in the serum were measured, and the histology was microscopically analyzed, focusing on areas of colloid and epithelium in the thyroid follicles. Results Compared to the control group, T4 hormone levels were significantly different in male rats exposed to mobile jammer radiation (p-value = 0.037). In group B, significant differences were found solely in the male offspring regarding T3 levels due to jammer exposure (average = 109.00 for male offspring in the

experiment vs. average = 65.50 for those in the control, p-value < 0.001). Additionally, histopathological findings indicated significant differences as well. These results highlight a potential link between exposure to electromagnetic radiation and changes in thyroid endocrine and histological parameters. Our findings suggest that ongoing assessment of existing safety guidelines on non-ionizing radiation exposure is necessary, especially concerning its effects on thyroid hormone levels and follicular histology. https://doi.org/10.1186/s13104-025-07297-x

Effect of short-term extremely low-frequency electromagnetic field on respiratory functions, Sirinyildiz, F., Cesur, G., Elmas, O., Elmas, S., Comlekci, S., Yazici, O., Keskin, A. and Keskin, H. E., *Revista Da Associacao Medica Brasileira*, 2025, Vol. 71, no. 4.

OBJECTIVE: Exposure to extremely low-frequency electromagnetic fields can cause harmful or beneficial effects on living organisms. The aim of this study was to examine the potential effects of extremely low-frequency electromagnetic fields on respiratory physiology by investigating possible changes in respiratory function parameters during and after short-term extremely low-frequency electromagnetic field exposure. METHODS: Twenty Wistar albino rats were included in the study, and these rats were randomly divided into two groups: control and electromagnetic field. A noninvasive head-out plethysmography technique was used to accurately assess lung function in rats. Rats in the electromagnetic field group were exposed to electromagnetic field at a frequency of 50 Hz and a magnetic flux density of 0.3 mT for 2 min. Respiratory function parameters of both groups were recorded in three separate periods before, during and after electromagnetic field exposure. Respiratory rate, respiratory cycle duration, inspiration time, expiration time, tidal volume, minute volume, peak inspiratory flow, and peak expiratory flow were measured in these periods. RESULTS: There was no significant difference in the parameters measured before electromagnetic field exposure between the groups. During the electromagnetic field exposure period, the mean respiratory rate measured in the electromagnetic field group was lower compared to the control group data, while the mean respiratory cycle duration, inspiration time, and tidal volume measured in the electromagnetic field group were higher compared to the control group data. There was no significant difference in the parameters measured after electromagnetic field exposure between the groups. CONCLUSION: Short-term extremely low-frequency electromagnetic field exposure decreases respiratory rate and increases respiratory cycle duration, inspiration time, and tidal volume. https://doi.org/10.1590/1806-9282.20241812

The effect of 50 Hz magnetic fields on cellular sensitivity of mouse spermatogenic cell lines to hydrogen peroxide,
Wei, X. X., Zhu, L. T., Zhu, Y., Zhao, X. Y., Sun, C. and Chen, G. D., *Toxicology Research*, Jun 2025, Vol. 14, no. 3.

With the widespread application of electromagnetic technology, electromagnetic fields (EMFs) emitted from various electric and electronic devices have significantly altered the electromagnetic environment. This has raised concerns about the potential health impacts of EMFs. Previous studies have indicated that EMFs may influence male infertility, with oxidative stress proposed as a key factor; however, the underlying mechanisms remain unclear. In this study, we aimed to determine whether EMFs enhance the impact of oxidative stress on male infertility. We investigated the effects of 50 Hz magnetic fields (MFs) on the sensitivity of mouse spermatogenic cell lines (GC-1 spg and GC-2 spd) to low-dose hydrogen peroxide (H2O2, 5 and 10 mu M). Our findings revealed that pre-exposure to 2.0 mT 50 Hz MFs for 24 h increased the sensitivity of GC-2 spd cells to low-dose H2O2 in terms of gamma H2AX foci formation, a marker for DNA damage repair. However, no significant changes were observed in DNA fragmentation, cell viability, or cell cycle progression in either GC-1 spg or GC-2 spd cells. In conclusion, our results suggest that 50 Hz MFs do not significantly enhance

the sensitivity of mouse spermatogenic cell lines to low-dose H2O2.
https://doi.org/10.1093/toxres/tfaf059

Actualité, société et mesures de prévention

Electrohypersensitivity: what is belief and what is known?,
De Vocht, F. and Röösli, M., *Frontiers in Public Health*, May 2025, Vol. 13.

Electrohypersensitivity (EHS), or idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF), is a condition with fluid and transient symptoms associated to exposure to non-ionizing radiation by people claiming to suffer from it. However, the scientific evidence linking the exposure to the reported effects to datwe has eluded researchers, and may not even exist. In the current perspective we outline what is objectively known about EMF as the cause for EHS and what is based on anecdotal information only. We discuss why randomized provocation trials were considered the most appropriate research methodology to elucidate causal links between EMF exposure and effects in a scientifically robust manner, what the main arguments against such studies are, and whether these criticisms are valid. Finally, we synthesize the evidence and beliefs around EHS and provide future directions of research and practice.
https://doi.org/10.3389/fpubh.2025.1603692

Epidemiological criteria for causation applied to human health harms from RF-EMF exposure: Bradford Hill revisited,
Frank, J. W., *Frontiers in Public Health*, May 2025, Vol. 13.

Purpose This paper reviews the applicability of standard epidemiological criteria for causation, to the multidisciplinary studies of RF-EMF exposure and various adverse biological and health effects, with the aim of demonstrating that these criteria, although 60 years old, are still helpful in this context-albeit in some cases not entirely straightforward to apply.Methods This is a commentary, based on Bradford Hill's criteria for assessing evidence of causation, applied to recent primary studies and systematic reviews of the RF-EMF/health-effects literature. Every effort has been made to use non-epidemiological language to reach a wide readership of biologists, physicists, and engineers now active in this field.Results A rapidly growing number of human observational epidemiological studies have assessed the association of diverse adverse health effects with RF-EMF exposures. However, existing systematic reviews and meta-analyses of these primary studies have substantially diverged in their conclusions. The application of Bradford Hill's epidemiological criteria for assessing evidence of causation, originally designed for use in occupational and environmental health, casts light on some of reasons for this divergence, mostly reflecting the key weaknesses in the primary literature, which are discussed in detail. As a result of these threats to their validity-particularly the facts that (1) exposure measurement is typically subject to substantial error, and (2) insufficient time has elapsed, since modern cell phone use began in earnest, to allow tumors of longer latency to develop-most primary studies to date, and therefore many published systematic reviews of them, probably underestimate the true potential for causation, if in fact this association is causal.Conclusion and recommendations In view of these findings, international experts representing professional and scientific organizations in this field should convene an independent Guidelines development process to inform future epidemiological studies of associations between RF-EMF exposures and human health outcomes. Wide dissemination of such Guidelines could help researchers, journals and their reviewers in this field to execute, review and publish higher-quality studies to better inform evidence-based policy. https://doi.org/10.3389/fpubh.2025.1559868

Electromagnetic emission-aware Machine Learning enabled scheduling framework for Unmanned Aerial Vehicles,
Jamshed, M. A., Nauman, A., Althuwayb, A. A., Pervaiz, H. and Kim, S. W., *Computer Networks*, Jul 2025, Vol. 267.

Recently, there has been a notable increase in the number of User Proximity Wireless Devices (UPWD). This growth has significantly raised users' exposure to Electromagnetic Field (EMF), potentially leading to various physiological effects. The use of Non-Terrestrial Networks (NTN) has emerged as an optimistic solution to improve wireless coverage in rural areas. NTN mainly consist of satellites, with High Altitude Platform Stations (HAPS) and Unmanned Aerial Vehicles (UAV) considered special use cases. It is well established that optimizing exposure over time (Dose), rather than dealing with a fixed value, plays a crucial role in reducing uplink EMF exposure levels. In this paper, for the first time, we showcase that the combined use of UAV and the Dose metric can help keep the regulated uplink EMF exposure level well below the required threshold. This paper employs a combination of Non-Orthogonal Multiple Access (NOMA), UAV technology, Machine Learning (ML), and the Dose metric to optimize EMF exposure in the uplink of wireless communication systems. The ML based technique consists of a combination of k-medoids-based clustering and Silhouette analysis. To further reduce uplink EMF exposure, a power allocation policy is developed by transforming a non-convex problem into a convex one for solution. The numerical results indicate that the proposed scheme, which integrates NOMA, NTN, and ML, achieves at least a 89% reduction in EMF contrast to existing methods. https://doi.org/10.1016/j.comnet.2025.111311

A Study on the Social Perception of Risks From Electromagnetic Wave-Focusing on Big Data-Based Text Mining Analysis,
Kim, D. H. and Kim, B. H., *Sage Open*, Apr 2025, Vol. 15, no. 2.

This study aimed to analyze the social perceptions of risks and harm to the human body from electromagnetic waves, which have increased due to the era of the fourth Industrial Revolution and the development of information and communication technology (ICT), and to suggest alternatives. This study applied big-data-based text-mining analysis techniques to collect and analyze 10,681 Korean media reports and portal big data over the last 10 years. As a result, social perceptions shown in the media and portal big data recognized that national policies, such as THAAD, nearby facilities, electronic products used in daily life, and smartphone electromagnetic waves harm the human body and health. Therefore, to establish proper perceptions of electromagnetic waves, this study suggests policy implications, such as strengthening publicity activities for the public on electromagnetic wave safety, expanding the provision of relevant information on electronic products, and establishing a specialized organization for electromagnetic waves.
https://doi.org/10.1177/21582440251340132

Eco-Management of Wireless Electromagnetic Fields Involved in Smart Cities Regarding Healthcare and Mobility,
Razek, A., *Telecom*, Mar 2025, Vol. 6, no. 1.

The everyday comfort and security of the present society are intimately associated with the assistance of different tools that function by means of diverse sources linked to the transfer and conversion of electromagnetic (EM) energy. The use of these devices exhibits expected outcomes, which are regularly coexistent with unwanted side effects. A laudable intention of an administration is to strengthen the anticipated results and lessen the unsolicited effects. This paper's goal, in the framework of such an organization, is to evaluate the significance of the methodologies of

responsible attitude (RA) and one health (OH) in the everyday exercise of the involved wireless EM energy tools in the environment of a smart city (SC). The approach of RA is linked to a tool's eco-design, while the concept of OH is linked to the protection of an SC's biodiversity and ecosystem. The unwanted side effects of these wireless devices could be implicated as occurrences of straying or radiated EM fields on devices or living tissues. The investigation intends to assess the enhancement of projected outcomes and the reduction of unwanted effects in the quotidian exercise of wireless EM energy transfer and transmission tools in the SC environment. The challenges are associated with the sources and the emissions of wireless EM technologies available today, and their impacts on the health of living tissues, biodiversity, and the ecosystem. The paper centered particularly on two cases engaged in the SC environment. The first involves the disrupting effects of EM exposure of onboard or near-living tissues from sensing and assistance medical tools. The second is linked to the adverse biological effects resulting from wireless inductive power transfer used for charging the batteries inside electric vehicles while motionless or running in SCs. The inquiries followed in the paper are supported by instances in the literature. https://doi.org/10.3390/telecom6010016

Multifunctional Hydrogen-Bond-Cross-Linked PDMS/MXene/Fe3O4-NH2/Cotton Fabric for Male Reproductive Electromagnetic Protection,
Zhang, L., Chen, H. T., Wei, D., Yuan, J. R., Zhang, X. M., Shang, S. H., Ji, H. J., Zheng, W. X., Liu, K. P., Wang, J. M., Zhu, Z., Chen, M. Y. and Yuan, J. L., *Acs Applied Electronic Materials*, May 2025, Vol. 7, no. 11, p. 5290-5303.

With the increasing exposure to electromagnetic radiation (EMR) and its detrimental effects on male reproductive health, there is an urgent demand for advanced protective materials. This study presents a multifunctional hydrogen-bond-cross-linked PDMS/MXene/Fe3O4-NH2/cotton fabric (PMFC) designed for male reproductive electromagnetic protection. The composite fabric integrates MXene nanosheets and Fe3O4-NH2 nanoparticles via layer-by-layer assembly, enhanced by hydrogen bonding and hydrophobic PDMS coating. Remarkably, PMFC achieves an exceptional electromagnetic interference shielding efficiency of 56.4 dB at 0.35 mm thickness, outperforming existing materials. Its ultralow infrared emissivity (0.33) enables effective thermal stealth, while programmable Joule heating (up to 109.9 degrees C at 4.5 V) ensures adaptability to diverse environments. Furthermore, PMFC retains cotton's inherent breathability, moisture permeability, and softness, coupled with superhydrophobicity (water contact angle: 147.7 degrees) and mechanical durability. This work not only addresses the critical challenge of electromagnetic protection for male reproductive health but also pioneers a versatile textile platform for multifunctional wearable applications https://doi.org/10.1021/acsaelm.5c00711