Bulletin de veille
Champs électromagnétiques
N°13 – Novembre/Décembre 2025

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

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

Exposition professionnelle

Recommendation of occupational exposure limits (2025-2026),
Environ Occup Health Pract, 2025, Vol. 7, no. 1, p. Roel2025.

The Japan Society for Occupational Health (JSOH) recommends the Occupational Exposure Limits (OELs) as reference values for preventing adverse health effects on workers caused by occupational exposure to chemical substances, continuous or intermittent noise, impulsive or impact noise, heat stress, cold stress, whole-body vibration, hand-arm vibration and time-varying electric, magnetic and electromagnetic fields and ultraviolet and ionizing radiation.
https://doi.org/10.1539/eohp.ROEL2025

Personal radio use and risk of cancers among police officers in Great Britain: Results from the airwave health monitoring study,
Di Gravio, C., Elliott, P. and Muller, D. C., *International Journal of Cancer*, 2025.

Exposure to radiofrequency electromagnetic fields (RF-EMF) from mobile phones and other wireless devices has been classified as possibly carcinogenic to humans. With data from 48,457 police

officers and staff enrolled in the Airwave Health Monitoring Study, we investigated associations between personal radio use and the risk of developing cancer using Cox proportional hazard regressions. Personal radio use and duration of use were derived by combining objective data on call duration provided by the Home Office and participants' self-reported data via gradient boosting methods. Across a median follow-up time of 11 years, there were 1502 incident cancer cases of which 146 were cancers of the head, neck and central nervous system (CNS). There was no association between personal radio use, all cancers (hazard ratio [HR] = 0.96, 95% confidence interval [CI]: 0.79, 1.15) and head, neck, and CNS cancers (HR = 0.74, 95% CI: 0.39, 1.38). Doubling minutes of call duration via personal radio use was not associated with increased hazard of developing all cancers (HR = 1.00, 95% CI: 0.96, 1.04) or head, neck and CNS cancers (HR = 1.09, 95% CI: 0.97, 1.22). Results were similar when considering exposure to RF-EMF via mobile phone use as well as when restricting the analyses to police officers only. https://doi.org/10.1002/ijc.70255

Investigating the Effects of Occupational Noise and Extremely Low-Frequency Electromagnetic Field Exposure on Oxidative Response in Power Plant Workers,
Jafarimanesh, S., Ehsani, H., Shaki, F., Moosazadeh, M. and Samaei, S. E., *Bioelectromagnetics*, Oct 2025, Vol. 46, no. 7.

Occupational noise and extremely low-frequency electromagnetic fields (ELF-EMF) are common in power plants and represent important risk factors that may contribute to oxidative stress. This study examined how simultaneous exposure to these hazards affects oxidative stress biomarkers in workers under real-world conditions. Participants were assigned to one of four exposure groups: Control (C), Noise (N), ELF-EMF (E), or a combined Noise and ELF-EMF group (NE). Occupational noise and ELF-EMF exposures were measured according to ISO 9612 and IEEE Std C95.3.1, respectively. To assess oxidative stress, venous blood samples were collected from all participants, and plasma levels of malondialdehyde (MDA), glutathione (GSH), superoxide dismutase (SOD), and total antioxidant capacity (TAC) were analyzed using validated biochemical assays. The NE group showed the highest MDA levels, indicating elevated lipid peroxidation compared with controls ($p < 0.001$). GSH concentrations were lower in NE relative to controls ($p < 0.001$). SOD activity was significantly reduced in both the N and NE groups compared with the control group ($p < 0.005$). TAC was lowest in the NE group, showing a significant decrease compared with both the control and Noise-only groups ($p < 0.05$). While these findings suggest that concurrent exposure to noise and ELF-EMF can influence oxidative stress biomarkers, they do not provide direct evidence to mandate specific workplace monitoring or interventions. Further studies are needed to clarify potential health risks and to guide evidence-based occupational safety measures.
https://doi.org/10.1002/bem.70027

Human Responses to Magnetic and Hypomagnetic Fields: Available Evidence and Potential Risks for Deep Space Travel,
Kaspranski, R. R., Binhi, V. N. and Koshel, I. V., *Life-Basel*, Nov 18 2025, Vol. 15, no. 11.

The growing body of biomedical research reveals that many biological processes are governed by quantum physical principles, including the effects of weak magnetic fields (MFs) at or below geomagnetic strength. Given that life evolved within the geomagnetic field, its significant decrease-the hypomagnetic field (hypoMF)-may disrupt fundamental biological processes. This is particularly relevant for interplanetary missions, where astronauts will encounter prolonged hypoMF conditions alongside other spaceflight stressors. This mini-review synthesizes current knowledge on hypoMF effects, comparing terrestrial and extraterrestrial MF conditions and evaluating evidence from human studies. The initial database search identified 645 records. After most were excluded for various reasons, only 44 publications on the effects of MFs on the entire human body were included

in the review. An effect of the hypoMF was reported in 10 of these studies and was absent in 4. Despite some methodological limitations in the available research, the evidence suggests that the human body is not indifferent to hypoMF exposure. We also discuss leading mechanistic molecular hypotheses-particularly the radical pair mechanism. Finally, we identify urgent research priorities to elucidate hypoMF's biological role and develop countermeasures for future deep space exploration. Addressing these gaps is essential for safeguarding astronaut health and advancing magnetobiology as a frontier discipline in biophysics. https://doi.org/10.3390/life15111766

The Influence of MRI, X-ray, and Nano-Scale Effects on Hospital Workers' Health,
Khilf, H. M., Hussein, M. U. and Oueslati, A., *Journal of Nanostructures*, Win 2026, Vol. 16, no. 1, p. 27-35.

The technique of taking visual images of the human body's interior for diagnostic and therapeutic reasons is known as medical imaging. Medical imaging comes in several forms, the most often used being nuclear medicine, magnetic resonance imaging, ultrasound, and radiography. Medical imaging technologies have brought about a revolution in healthcare, resulting in better patient outcomes and public health benefits. Electromagnetic radiation is used in radiography to create internal body pictures. The most popular type of radiography is x-rays, which use high-energy waves to scan the body and detect the waves' reflections off of hard tissues like bones to produce a picture. The way of working and studying, the study included (402) patients who were visited to the diagnostic radiology department for periodic examinations of them; and in various hospitals of his/her area, the areas and center of Al Anbar-Iraq, in (Al-Ramadi Teaching Hospital), patients with blood disorders and those undergoing open heart surgery and receiving anticoagulant factors were excluded, and diabetics and chronic pressure who are previously receiving surgical treatment were also excluded. The study was divided into two groups comprising (222 male), (180 female), and then divided into the same group by age into three subgroups, the first (22-35 years) which are group A, the second (36-45 years old) which is group B, the third (46-55 years old) which is group c. Samples of blood (white blood cells WBC, red blood cells RBC), blood platelets PLTu HGB blood hemoglobin) have been examined for patient loyalty in two stages, first stage before exposure to (X-Ray and MRI) and the exposure when time and intensity of the magnetic field changes is considered in proportion to the magnetic resonance in addition to the sort of test, such as an X-Ray, and then repeat the same steps after a duration of three months. https://doi.org/10.22052/jns.2026.01.003

Radiofrequency Electromagnetic Field (RF-EMF) Exposure Assessment at a Nuclear Facility: Safety Monitoring and Public,
Omar, R. S., Nor, N., Yunoh, W. S. W., Hidzir, N. M., Mohamed, F., Ibrahim, N. M., Zainal, N. A., Samah, M. S. A. and Tukimin, R., *Sains Malaysiana*, Nov 2025, Vol. 54, no. 11, p. 2745-2756.

The widespread adoption of 5G technology has brought numerous benefits; however, it has also raised public concerns regarding potential health risks associated with exposure to radiofrequency electromagnetic fields (RF-EMF). To address these concerns, this study evaluated RF-EMF levels at the Malaysian Nuclear Agency (Nuclear Malaysia) to ensure compliance with international safety standards. A key standard examined was the guidelines established by the International Commission on Non-Ionising Radiation Protection (ICNIRP 2020). To conduct the assessment, a NARDA broadband area monitor was used to measure the RF-EMF electric field strength (E) at eight primary locations within Nuclear Malaysia over 24 h. NARDA is a brand of Narda Safety Test Solutions (Narda STS), a global leader in developing and manufacturing measurement technology for RF-EMF. Data was gathered at six-minute intervals, resulting in 240 measurement points per site. These measurements were compared to the public exposure limit of 36.38 V/m at the 700 MHz frequency band. The results showed that all recorded RF-EMF levels were below the established

safety thresholds. The study found a significant correlation between location and exposure levels; laboratory blocks (Block 11) recorded the lowest readings, while administrative offices, near the external telecommunication mast (Block 28), had the highest readings. The maximum exposure measured at Block 28 represented only 3.88% of the ICNIRP (2020) guidelines limit at 1.41 V/m. Additionally, these findings indicated that workers and the public faced minimal risk due to safe RF-EMF exposure levels at Nuclear Malaysia. Consequently, the transparent communication of these results can help improve public confidence in 5G technology within sensitive environments. This study also effectively presented the inaugural empirical mapping of RF-EMF exposure in a Malaysian nuclear research facility through real-time monitoring and public safety assessments. The overall process offers several benefits, including safeguarding public health, promoting responsible growth of digital infrastructure, and providing a scalable model for environmental safety. https://doi.org/10.17576/jsm-2025-5411-14

Radio Frequency Exposure in Military Contexts: A Narrative Review of Thermal Effects and Safety Considerations,
Risling, M. and Günther, M., *Military Medicine*, 2025.

Introduction Radiofrequency (RF) exposure has been extensively studied for potential health risks. Unlike ionizing radiation, RF fields primarily cause thermal health effects, the only established mechanism of biological harm. Regulatory bodies, including the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Institute of Electrical and Electronics Engineers (IEEE), set limits to prevent excessive heating. This review examines the relationship between RF exposure, heat generation, and physiological responses, with relevance to civilian and military safety.Methods A narrative review of peer-reviewed literature, regulatory reports, and experimental studies was conducted using PubMed, IEEE Xplore, Google Scholar and Scopus. Emphasis was placed on Specific Absorption Rate (SAR) and Cumulative Equivalent Minutes at 43 degrees C (CEM43). Studies on thermal effects and exposure scenarios were prioritized; speculative non-thermal mechanisms were excluded.Results Thermal effects depend on frequency, tissue composition, and environmental conditions. Whole-body SAR limits (<= 4 W/kg) generally prevent core temperature increases, but localized heating remains a concern. CEM43 provides a temperature-based metric but is difficult to apply in transient exposures. Penetration depth across NATO frequency bands shows variability because of differences in tissue models and measurement methods. This variability is clinically relevant, as localized heating of the skin, eye, or superficial nerves may occur even when whole-body exposure is within limits.Conclusion Current guidelines prevent systemic overheating but may not fully address localized risks. Combining SAR and CEM43 with refined penetration depth data could improve risk assessment. Future work should refine dose-response thresholds and methods for detecting and modeling localized heating, especially under military conditions where thermoregulation may be impaired. https://doi.org/10.1093/milmed/usaf613

Dose Estimation for Indoor Radon, Occupational Radiation, and Electromagnetic Field Exposure in a Nuclear Medicine Department in Turkiye,
Sahmaran, T., Nur, S., Atılgan, H. I. and Peker, H., *Health Phys*, Jun 1 2025, Vol. 128, no. 6, p. 449-456.

In this study, the occupational radiation dose, radon gas, and non-ionizing radiation doses originating from electromagnetic fields (EMF) to which radiation workers are exposed were monitored and evaluated for 1 y. Using electronic personnel dosimeters (EPD), average daily radiation doses based on the number of patients and annual average effective dose results of radiation workers were obtained over a period of 1 y. Also, the annual effective dose and risk values were calculated for 8 h and 24 h by taking radon gas measurements at 2-mo intervals in the nuclear

medicine department. Finally, electric field measurements were made one day a week in the selected areas. All the results obtained were compared with national and international dose limits. The results obtained as a result of EPD, radon gas, and EMF measurements made in the nuclear medicine department were found to be far below the international and national legal dose limits.
https://doi.org/10.1097/hp.0000000000001934

Factors Influencing the Health-Promoting Impact of Buildings,
Siewczynska, M., Rzeszut, K. and Kucz, M., *Sustainability*, Nov 18 2025, Vol. 17, no. 22.

Buildings have a significant impact on the health and well-being of their occupants through factors such as thermal comfort, humidity, air quality, access to natural light, acoustics, and radiation protection. The purpose of this study was to identify factors that contribute to healthy construction and to define the competencies needed in technical education to support the design and operation of health-promoting buildings. The study utilised expert brainstorming, an analysis of legal regulations in partner countries, a review of educational programmes, and a systematic review of the scientific literature. The research confirmed the positive impact of green buildings (e.g., LEED Certification) on occupant health. Gaps in technical education programmes were identified, particularly in the practical teaching of modern technologies and health-promoting design solutions. A competence matrix was developed, divided into educational levels, encompassing knowledge, skills, and social competencies related to the health-promoting aspects of buildings. Knowledge about healthy construction should include indoor environmental parameters, universal and ecological design, and conscious operating practices. The prepared competence matrix provides a foundation for further educational development and guides further research in this area.
https://doi.org/10.3390/su172210304

Assessment for occupational hazards to cardiac implantable electronic devices due to electric field exposure at power frequency within the framework of European standards,
Zhou, M., Kourtiche, D., Claudel, J., Nadi, M., Roth, P., Magne, I. and Deschamps, F., *Radioprotection*, Dec 15 2025, Vol. 60, no. 4, p. 373-381.

Workers with cardiovascular implantable electronic devices (CIEDs) may face interference hazards from electromagnetic fields emitted by industrial electrical apparatus, which may compromise device functionality and safety, leading to significant occupational risks. A risk assessment approach was proposed for the non-clinical investigation in the process of specific assessing within the framework of the European standards EN 50527. An exposure system, the voltage injection system (VIS), was introduced to experimentally investigate the interference thresholds and the induced voltages of CIEDs exposed to electric fields (EFs) at power frequency (50 Hz) by in vitro testing. A thorough risk assessment was performed on four CIEDs in two exposure scenarios, as an application illustration of VIS assessment. Correspondence between in vitro testing and real-case exposure was founded based on the study of induced voltages under EF exposures to establish VIS assessment. In the risk assessment for CIEDs, severe interference was observed in some cases with maximum sensitivity and in ICDs with nominal sensitivity at the high Action Level specified in the Directive 2013/35/EU (20 kV/m). The VIS assessment proposed in this work provides an efficient, easy-to-setup, on-site solution to evaluate the EF exposures at power frequency of workers with CIEDs in the workplace. The findings highlight the importance of conducting risk assessment for specific cases.
https://doi.org/10.1051/radiopro/2024060

Etudes épidémiologiques

A Cohort Study on Alzheimer's Disease in Relation to Residential Magnetic Fields From Indoor Transformer Stations,
Liimatainen, A., Roivainen, P., Juutilainen, J., Höytö, A. and Naarala, J., *Bioelectromagnetics*, Dec 2025, Vol. 46, no. 8.

Meta-analyses of epidemiological studies have suggested that Alzheimer's disease (AD) may be linked with exposure to extremely low frequency (ELF) magnetic fields (MF). This is the first study investigating the association of AD with exposure to residential ELF MFs from indoor transformer stations, using a study design that avoids shortcomings of previous studies. All cohort members had lived in buildings with indoor transformer stations. MF exposure was assessed based on the location of their apartment in relation to the transformer room. AD patients were identified from Drug Purchase Register and Drug Reimbursement Register. Out of the 155,562 individuals, 5652 (111,357 person-years of follow-up) living in apartments next to transformer stations were considered as exposed, while 115,772 (2,289,526 person-years of follow-up) individuals living on higher floors of the same buildings were considered as referents. Associations between MF exposure and AD were examined using Cox proportional hazard models. The hazard ratio (HR) was 1.02 (95% confidence interval: 0.85-1.22), indicating that the risk of AD is not associated with residential ELF MFs present in apartments next to transformer stations. The duration of residence did not essentially change the HR. The risk of AD was slightly but not statistically significantly higher (HR 1.22, 95% confidence interval: 0.94-1.57) for those whose residence started before the age of 50 years. The results did not support positive findings from previous studies that have reported a link between AD and occupational or residential MF exposure. Bioelectromagnetics. 00:00-00, 2025.
https://doi.org/10.1002/bem.70031

Residential exposure to magnetic field due to high-voltage power lines and childhood leukemia risk in mainland France - GEOCAP case-control study, 2002-2010,
Mancini, M., Hémon, D., Faure, L., Clavel, J. and Goujon, S., *Environ Res*, Aug 1 2025, Vol. 278, p. 121638.

BACKGROUND: Environmental exposure to extremely low frequency magnetic fields (ELF-MF) is suspected of being a risk factor of childhood acute leukemia (AL) and classified as possible carcinogen. Results of recent epidemiological studies remain however heterogeneous. OBJECTIVE: The present study aimed to evaluate AL risk in children exposed to ELF-MF by living close to high-voltage overhead power lines (HVOL) in France. METHODS: We included 4117 AL cases under the age of 15 diagnosed in 2002-2010 and 44,838 contemporary controls representative of the French pediatric population, drawn from the national registry-based GEOCAP study. The distance between the geocoded address of residence and the closest 63-400 kV HVOL, and the closest 225-400 kV HVOL, were evaluated. ELF-MF exposure was also calculated at the geocoded addresses considering the characteristics of the neighboring HVOLs. Logistic regression models adjusted for age were used to estimate odds-ratios (OR) and 95 % confidence intervals. Sensitivity analyses were carried out to account for geocoding error and potential confounders. RESULTS: 0.7 % of the controls lived within 50 m of HVOL and 0.3 % were exposed to more than 0.3 µT. Living within 50 m of HVOL was associated with an increased risk of AL for children under 5 (OR = 1.6 (1.0-2.7)), an association more marked when restricting to the high-quality geocoded addresses (OR = 3.2 (1.3-7.9)). ELF-MF was not associated with AL risk (≥0.3 µT, OR = 0.6 (0.3-1.3)). The results remained stable in all the sensitivity analyses. CONCLUSION: Our study brings new evidence that ELF-MF are probably not associated with AL risk, and cannot explain an association with distance to HVOL.
https://doi.org/10.1016/j.envres.2025.121638

Millimeter-wave high frequency 5G (26 GHz) electromagnetic fields do not modulate human brain electrical activity,
Michelant, L., Baz, T., Carrie, A., Hugueville, L., Lévêque, P. and Selmaoui, B., *Environmental Research*, Jan 15 2026, Vol. 289.

The deployment of 5G networks utilizing millimeter-wave frequencies such as 26 GHz has raised concerns about potential neurophysiological effects. However, no controlled studies have investigated the impact of 26 GHz exposure on human brain electrical activity. We conducted a randomized, triple-blind crossover study in 31 healthy young adults (18 men, 14 women, mean age 26.1 +/- 5.2 years). Participants underwent two sessions (real and sham exposure) separated by one week, with 26.5-min exposure to 26 GHz electromagnetic fields at 2 V/m. EEG activity was recorded before, during, and after exposure. Power spectral density was computed for delta (1-4 Hz), theta (4-8 Hz), alpha (8-12 Hz), and beta (12-35 Hz) frequency bands. Statistical analysis employed mixed-effects models with baseline correction, examining exposure effects across temporal phases and electrode clusters. No significant modulation of EEG frequency bands was observed during eyes-closed conditions following 26 GHz exposure. Mixed-effects modeling revealed no significant main effects or interactions for exposure conditions across all frequency bands and electrode clusters. This first controlled investigation of 26 GHz 5G effects on human EEG activity found no detectable alterations in brain electrical activity under regulatory-compliant exposure conditions. These findings contribute important preliminary safety data for 5G millimeter-wave technology deployment, though further research across diverse populations and exposure scenarios remains warranted. https://doi.org/10.1016/j.envres.2025.123349

Occupational exposure to extremely low-frequency magnetic fields (ELF-MF) and postmenopausal breast cancer risk,
Moayedi-Nia, S., Almadin, C., Labrèche, F., Goldberg, M. S., Richardson, L., Cardis, E. and Ho, V., *J Occup Environ Med*, Oct 1 2025.

OBJECTIVE: Estimate the association between occupational exposures to extremely low-frequency magnetic fields (ELF-MF) and postmenopausal breast cancer. METHODS: Lifetime job histories from a population-based case-control study (2008-2011) of histologically-confirmed breast cancer in Montréal, Canada were linked to a job-exposure matrix to assign geometric mean ELF-MF exposure/workday. Logistic regression estimated odds ratios (OR) and 95% confidence intervals (CI) for cumulative, average, maximum, and duration of maximum exposure to ELF-MF (per interquartile range increase), adjusting for individual-level and ecological covariables. RESULTS: Data from 663 cases and 592 controls revealed no association between occupational ELF-MF exposure and postmenopausal breast cancer, though restricting exposures to 0-10 years before interview and to those during breast development, some positive associations was observed, particularly for ER+/PR+ tumours. CONCLUSIONS: Our findings suggest no association between occupational ELF-MF exposure and postmenopausal breast cancer risk. https://doi.org/10.1097/jom.0000000000003564

Radiofrequency radiation from mobile phones and the risk of breast cancer: A multicenter case-control study with an additional suspected comparison group,
Tahmasebi, S., Mortazavi, S. M. J., Pourghayoomi, M., Sheikhzadeh, P., Welsh, J. S., Seif, F., Bayatiani, M. R., Nematollahi, S., Zohdparast, P., Khoskhati, F., Ghahramani, Z., Allahveisi, F., Fadavi, P., Zadeh, A. J., Nejad, S. R., Zaker, F., Beigi, M., Bagherzadeh, S., Khosroabadi, M., Yarahmadi, M., Haghani, M., Nikzad, S., Bahaeddini, N., Arshadi, M., Rahimi, S., Eslami, J., Fallah, A., Safdari, M., Makarempour, F., Amirinejad, M., Mortazavi, A. and Mortazavi, S. a. R., *Journal of Research in Medical Sciences*, Nov 2025, Vol. 30, no. 1.

Background:The rapid global increase in mobile phone use has raised concerns about the potential long-term health effects of radiofrequency electromagnetic fields. While most studies have focused on brain tumors, evidence regarding breast cancer remains limited. The objective of the study is to examine the association between mobile phone use and breast cancer risk among women in Iran.Materials and Methods:In this multicenter case-control study, 226 women were recruited from diagnostic, mammography, and radiotherapy centers across Iran and classified as controls (no history of breast cancer, n = 97), suspected cases (advised to undergo mammography due to breast-related complaints or physician recommendation, n = 52), and confirmed cases (histologically verified invasive breast cancer, n = 77). Structured questionnaires collected demographic, reproductive, lifestyle, and environmental data, including mobile phone call duration, screen time, and phone placement. Associations were analyzed using multinomial logistic regression, adjusting sequentially for demographic, reproductive, environmental, and lifestyle variables.Results:In fully adjusted models, women reporting more than 60 min of daily mobile phone conversations had higher odds of confirmed breast cancer (odds ratio [OR] = 3.49, 95% confidence interval [CI]: 1.02-11.97) and suspected status (OR = 10.84, 95% CI: 2.29-51.41) compared with those using phones <10 min daily. Longer screen time (>4 h/day), later age at menarche, lower education level, and exposure to environmental pollutants were also associated with increased odds.Conclusion:Prolonged mobile phone use was associated with higher odds of breast cancer, but this does not imply causation. Given self-reported exposures and potential residual confounding, findings should be interpreted cautiously. Larger prospective studies with objective exposure assessment are warranted. https://doi.org/10.4103/jrms.jrms_679_25

The Effect of 5G Mobile Phone Electromagnetic Exposure on Corticospinal and Intracortical Excitability in Healthy Adults: A Randomized Controlled Pilot Study,
Torkan, A., Zoghi, M., Foroughimehr, N. and Jaberzadeh, S., *Brain Sciences*, Oct 22 2025, Vol. 15, no. 11.

Background: Research on the impact of 5G mobile phone electromagnetic exposure on corticospinal excitability and intracortical mechanisms is still poorly understood. Objective: This randomized controlled pilot study explored the effects of 5G mobile phone exposure at 3.6 GHz (power density: 0.0030 W/m(2)) on corticospinal excitability and intracortical mechanisms in healthy adults. Methods: Nineteen healthy participants (mean age: 36.5 years) were exposed to 5G mobile phone exposure for 5 and 20 min, approximating the typical duration of a phone call. Corticospinal excitability, intracortical facilitation, short intracortical inhibition, and long intracortical inhibition using single- and paired-pulse transcranial magnetic stimulation assessed before and immediately after exposure were performed. Results: A two-way repeated-measures ANOVA revealed no significant interactions between exposure condition (5 min, 20 min, sham) and time (pre vs. post) for CSE, ICF, SICI, or LICI (all p > 0.15). Bayesian analyses yielded Bayes factors close to 1, indicating inconclusive evidence for both the null and alternative hypotheses. Conclusion: Short-term exposure to 5G mobile phone electromagnetic fields did not produce detectable changes in corticospinal or intracortical excitability. Bayesian evidence was similarly inconclusive (Bayes factors approximate to 1), suggesting that the data provide limited support for either the presence or absence of a detectable effect. Any potential influence of 5G exposure on neural function is therefore likely to be subtle with the present methods. As a pilot study, these findings should be interpreted cautiously and underscore the need for further research using more sensitive outcome measures, extended exposure durations, and vulnerable populations. https://doi.org/10.3390/brainsci15111134

Evaluation de l'exposition

RF-EMF Exposure Assessment: Comparison of Measurements in Airports and Flights with and Without Wi-Fi Service,
Arribas, E., Escobar, I., Martinez-Plaza, A., Rufo-Pérez, M., Jimenez-Barco, A., Paniagua-Sánchez, J. M., Marín, P. and Ramirez-Vazquez, R., *Sensors*, Nov 3 2025, Vol. 25, no. 21.

Highlights What is the main findings? Personal exposure to RF-EMF from Wi-Fi on four international flights. What is the implication of the main finding? Measurement inside an airplane with and without Wi-Fi connection using personal exposimeters.Highlights What is the main findings? Personal exposure to RF-EMF from Wi-Fi on four international flights. What is the implication of the main finding? Measurement inside an airplane with and without Wi-Fi connection using personal exposimeters.Abstract This paper presents the results of personal exposure measurements to Radiofrequency Electromagnetic Fields from 2.4 GHz and 5.85 GHz Wi-Fi frequency bands. Measurements were taken in several specific scenarios: within international airports terminals, during takeoff, inside airplanes while flying with and without onboard Wi-Fi service (including while actively using a Wi-Fi connection), and during landing. Data were recorded onboard four international flights (two-round trip flights), from Spain to Mexico, and from Spain to Belgium. Two personal exposimeters, EME SPY 140 and EME Spy Evolution, were used to collect intensity level measurements in each scenario. During the outbound, the mean exposure value inside the airplane flight was 93.9 mu W/m2 in the 2.4 GHz Wi-Fi frequency band and 46.4 mu W/m2 in the 5.85 GHz Wi-Fi band (Spain to Mexico), and 7.29 mu W/m2 in the 2.4 GHz Wi-Fi band and 2.40 mu W/m2 in the 5.85 GHz Wi-Fi band (Spain to Belgium). For the return flight, the average value was 26.7 mu W/m2 in the 2.4 GHz Wi-Fi band and an average of 9.87 mu W/m2 in the 5.85 GHz Wi-Fi band (Mexico to Spain), and 3.24 mu W/m2 in the 2.4 GHz Wi-Fi band and 1.23 mu W/m2 in the 5.85 GHz Wi-Fi band (Belgium to Spain). Personal exposure levels to RF-EMFs from the Wi-Fi frequency band inside an airplane, even at the airport, are very low and well below the reference levels established by the international guidelines (10 W/m2). https://doi.org/10.3390/s25216710

In Situ Assessment of EMF Exposure Across Urban Districts of Samsun, Türkiye,
Aslan, C. A., Engiz, B. K., Kurnaz, C., Cheema, A. A. and Karadag, T., *Electronics*, Dec 23 2025, Vol. 15, no. 1.

This study offers a comprehensive in situ measurement and assessment of electromagnetic field (EMF) exposure in the central urban districts of Samsun, T & uuml;rkiye, focusing on low-frequency magnetic flux density (BLF) and radiofrequency electric field strength (ERF). Drive-test measurements were performed across Atakum, & Idot;lkad & imath;m, and Canik districts to capture spatial variability and identify primary exposure sources. Band-selective analysis revealed that downlink (DL) transmissions are the main contributors to total ERF exposure, indicating that base station emissions dominate the exposed ERF levels in the environment. Six-minute averaged BLF and ERF values account for temporal fluctuations and confirm that exposure remains well below recommended limits. A one-way ANOVA test indicated that the differences in exposure levels among the three districts were not statistically significant. These findings provide a detailed spatial evaluation of EMF exposure in a large metropolitan region, demonstrating the value of integrated BLF and ERF measurements for environmental monitoring.
https://doi.org/10.3390/electronics15010068

Analysis of Human Exposure to Electric and Magnetic Fields While Charging and Driving an Electric Vehicle

Gliga, M., Giurgiuman, A., Munteanu, C., Andreica, S., Pacurar, C., Constantinescu, C., Dusa, S. and Botezatu, M. (2024). 9th International Conference on Advancements of Medicine and Health Care through Technology-MEDITECH, Cluj-Napoca, ROMANIA.
The transition to electric vehicles is a promising strategy to reduce or eliminate harmful emissions, including carbon dioxide, nitrogen oxides, and particulate matter, from internal combustion vehicles. While electric vehicles offer environmental benefits, their operation involves the generation of electromagnetic fields (EMFs) in their immediate vicinity. Although the biological effects of EMFs have been extensively studied, the specific health risks to humans remain uncertain.In electric vehicles, occupants are exposed to artificial EMFs due to their close proximity to high-capacity electrical systems operating for extended periods. Recognizing these potential concerns, electric vehicle manufacturers have incorporated various technological solutions during the design and manufacturing processes to mitigate EMF exposure. This study will conduct experimental measurements of the electromagnetic field generated by an electric vehicle under a range of operational conditions. https://doi.org/10.1007/978-3-031-95671-3_25

Uncertainty Quantification of Human Electromagnetic Exposure From Mobile Phone Antenna Based on Migration Co-Kriging,
Huo, S. H., Song, Y. J., Duffy, A. and Bai, J. J., *Ieee Transactions on Antennas and Propagation*, Nov 2025, Vol. 73, no. 11, p. 9203-9212.

The safety of mobile phone antennas concerning electromagnetic exposure to the human body has become a prominent research focus in recent years. Uncertainties in antenna design and manufacturing processes may result in actual electromagnetic radiation levels deviating from design standards, thereby posing a potential risk of electromagnetic exposure. Finite-element simulation has emerged as a crucial tool for predicting the specific absorption rate (SAR), owing to its capability to accurately model complex structures. The effective integration of finite-element simulation with uncertainty quantification provides valuable scientific insights for optimizing design, shortening research and development cycles, and minimizing commissioning costs. This article proposes an uncertainty quantification method based on Migration Co-Kriging (MCK). This method solves the limitations of traditional Co-Kriging that cannot be achieved without a low-precision solver by calculating cross-domain correlations. A more accurate surrogate model is constructed using a smaller training set, which improves the core performance of uncertainty quantification. MCK is combined with Sobol and applied in sensitivity analysis to quantify the influence of each random variable on SAR, thereby establishing a rigorous theoretical foundation for mobile phone antenna design and electromagnetic radiation safety. https://doi.org/10.1109/tap.2025.3590080

Massive assessment of exposure to 5G electromagnetic fields in France: a 5-year synthesis,
Jawad, O., Conil, E., Sefsouf, L. and Agnani, J. B., *Annals of Telecommunications*, 2026.

This paper presents the results of a large-scale measurement campaign to assess the impact of 5G deployment on exposure levels in mainland France. The campaign consists of more than 24,000 measurements taken on the ground in direct view of 5G antennas between 2020 and 2024, subdivided into seven phases, in order to closely monitor changes in exposure. The measurements consist of accredited measurements following the ANFR protocol and exploratory measurements designed to emulate steerable-beam loading in the 3.5 GHz band. The paper also introduces a metric quantifying the rate of 5G usage. Results show that, at 5G 3500 MHz sites, the broadband exposure level increased by 0.12 V/m on average over the 5-year period, while the 3500 MHz band contribution increased by 0.34 V/m on average, reflecting the progressive adoption of 5G. Despite this increase, the 3500 MHz band remained a secondary contributor, accounting for only 10% of the main contributors in 2024, far behind historical 800/900 MHz bands. Exploratory measurements

reveal that exposure during a 1 GB download is, on average, four times higher than in idle mode, with a median 5G 3500 MHz usage rate of 17% and a mean of 26%. In the other 5G bands, exposure increased more moderately: +0.15 V/m in the 2100 MHz band and +0.14 V/m in the 700 MHz band, where pre-existing 4G signals already dominated. This unique long-term dataset provides the most extensive 5G exposure assessment published to date under real deployment conditions, quantifying the gradual contribution of 5G to overall exposure. https://doi.org/10.1007/s12243-025-01142-9

RF-EMF electromagnetic environment IN the West Bank, Palestine,
Lahham, A. and Alkhatib, M., *Radiat Prot Dosimetry*, Mar 21 2025, Vol. 201, no. 4, p. 255-260.

With the increase in the distribution of sources of electromagnetic fields in the environment, public exposure to non-ionizing radiation emitted from these sources will increase and change with time. This work aims at the evaluation of public exposure to radiofrequency electromagnetic fields in the West Bank and compares this exposure with previous studies with a time interval difference of 11 years. Measurements of exposure were conducted in the outdoor environment in 149 locations using tri-axial E-field frequency-selective personal exposure meter EME SPY 140 enabling measurements of electric field strength in 14 predefined frequency bands in the range from 80 to 6 GHz. The average field strength from all sources in all investigated locations was 1.4 Vm-1. The maximum exposure measured at any location in the country was 7.43 Vm-1 and was found in Ramallah City center. The exposure quotient corresponding to this value was about 19 times below unity. The total exposure quotient for all locations was 0.001 with FM broadcasting being the main contributor by about 36%, UMTS2100 downlink by 24%, GSM 900 downlink contributing by 17%, WiFi 5GHz by 9% GSM 1800 downlink by 5%. Seven other RF sources contributed together by only 9% including WiMax, TV, WiFi 2 GHz, and others. More than 90% of the electric field strength values were below the level of 3 Vm-1. Within 11 years the average total exposure coefficient increased by a factor of about 2. https://doi.org/10.1093/rpd/ncaf015

Associations between individual and geospatial characteristics and power of 4G signals received by mobile phones,
Laplanche, A., Guida, F., Moissonnier, M., Launay, L., Beranger, R., Lagroye, I., Orlacchio, R., Fontaine, M., Bories, S., Mazloum, T., Conil, E., Huss, A., Wiart, J., Danjou, A., Schüz, J., Dejardin, O. and Deltour, I., *Environmental Research*, Dec 1 2025, Vol. 286.

Background: The Received Signal Strength Indicator (RSSI) measures downlink signal intensity received by smartphones in 4th Generation LTE networks. Objective: This study evaluated how individual, technical, and spatial factors influenced LTE-RSSI during daily activities. Methods: Between November 2022 and October 2023, adults in France used the XMobiSensePlus Android smartphone application to record RSSI and GPS data. Distance to the operator's nearest antenna, obtained from Cartoradio, population and antenna density and urbanicity were analyzed using a geographic information system. Determinants of RSSI were assessed using an autoregressive mixed model incorporating restricted cubic splines for distance. Environmental exposures were estimated at 1800 MHz using conversion factors. Results: From 1,969,913 records of 187 participants, with measurements taken every 30 s over 7.9 days, the average LTE-RSSI was -79.3 dBm. The estimated electric field strength was 0.12 V/m, albeit with large uncertainty. The median distance to the nearest antenna was 536 m. Proximity to antennas increased RSSI. Antenna density positively influenced RSSI (overall beta = +0.37 dBm per additional antenna per km2). Lower RSSI was observed in the evening and night, particularly in urban areas. Smartphone's technical parameters (Android version and System-on-a-Chip) influenced RSSI, operators did not. Proximity to antennas had greater impact in rural areas. Conclusion: Urbanicity, distance to the nearest 4G antenna,

antenna density, time of day, and smartphone's technical parameters influenced RSSI levels in 4G networks in France, but not operator. https://doi.org/10.1016/j.envres.2025.123030

Measurement of Electromagnetic Fields Exposure to Humans from Electric Vehicles and Their Supply Equipment,
Murthy, G. P. P. and Varadarajan, G. S., *Measurement*, Jan 30 2026, Vol. 258.

Electric Vehicles (EVs) represent a progressive approach to fostering a healthy and sustainable transportation future on Earth. Intended for mitigating global warming by virtue of decarbonizing transportation sector. Besides being environmentally beneficial, electrification in transportation necessitates a study of non-ionizing Electromagnetic Fields (EMF). Despite extensive research, the health effects related to long-term exposure to EMF remain inconclusive. The main aim of this research is to share and disseminate measurement findings of EMF emission from EVs and their Electric Vehicle Supply Equipment (EVSE). The specification of the measuring instrument, methodology adhered to measurement, and observed results have been discussed. Measurements have been carried out at different EVs and EVSEs in and around Chennai city, up to 400 kHz frequency band. To analyze human exposures, Electric Field Intensity (E) and Magnetic Flux Density (B) have been measured in the vicinity of driver and passenger seats inside EVs during driving condition, furthermore fields near different positions of EVSEs during charging condition. The measured values have been compared with the ICNIRP and IEEE standard recommendations for human external body exposure level. In accordance with the findings, E & B inside EVs fall within the standard limit. The E in the vicinity of EVSE is under standard limit, but at certain places B is concurrently above general public exposure threshold (>200 mu T). In addition, a preliminary computational analysis has been done using Finite Element Method (FEM). Simulated fields are then compared with measurement readings of AC charger, where the electric and magnetic field magnitudes are relatively higher. With an ever-increasing electrification of vehicle fleets, knowledge of health impacts of long-term exposure to humans can be enhanced through more observational research. https://doi.org/10.1016/j.measurement.2025.119378

Assessment of Low Frequency Electromagnetic Fields Generated from Subsea Power Cables used in Offshore Wind Farms
Poljak, D., Cvetkovic, M. and Ieee (2025). 10th International Conference on Smart and Sustainable Technologies-SpliTech, null, CROATIA.
There has been a continuous interest of environmental impact of offshore wind farms. The present paper deals with simplified evaluation of electric and magnetic fields from undersea power cables used in offshore wind farms operating in extremely low frequency (ELF) range using analytical approaches based on standard quasi-static approximations. Possible effects to living beings in marine environment are also addressed. The obtained results are checked against relevant international guidelines and related exposure limits.
https://ieeexplore.ieee.org/document/11091678

Evaluation of Exposure Assessment Methods and Procedures for Induction Hobs,
Xi, J. T., Kühn, S., Fortunato, C., Ofli, E. and Kuster, N., *Bioelectromagnetics*, Oct 2025, Vol. 46, no. 7.

Induction hobs generate strong alternating magnetic fields to heat pots by inducing eddy currents. These fields are the strongest close to the bottom of the cookware, but stray fields at large distances can still be substantial. In general, these are higher than the reference levels defined by international electromagnetic exposure safety guidelines (ICNIRP 1998; ICNIRP 2010; IEEE 2019). That the reference levels are exceeded does not imply that the basic restrictions are also violated. In this study, we assess the exposures caused by the latest generation of induction hobs by applying

the advanced instrumentation and different methods that include the procedures developed by the International Electrotechnical Commission (IEC) for household appliances (IEC 62233) (IEC International Electrotechnical Commission 2005), the 4-tier approach developed for inductive wireless power transfer systems (IEC 63184) (IEC International Electrotechnical Commission 2021), and their derivatives. First, methods for determining the maximum exposure configuration were assessed. Then, the 3D distribution of the incident magnetic field was sampled with a scanning system and analyzed, and the contact currents assessed. Lastly, numerical dosimetric evaluations were performed in anatomical models to determine the maximum fields induced by the measured incident fields directly or by a representative coil model converted from the measured fields. The study's findings reveal significant variations in exposure across different induction hobs, with differences of up to a factor of > 20 (> 26 dB) as a function of power, coil size, and proximity to the coil. This suggests that low-exposure hobs can be designed without compromising cooking performance. Furthermore, the study strengthens the conclusions of previous studies that IEC 62233 (IEC International Electrotechnical Commission 2005) may underestimate the exposure for persons standing next to the hob by up to a factor of >30 based on testing according to the exposure limits from (ICNIRP 1998; IEEE 2019)-and thus does not ensure safety. A dosimetric analysis, the most accurate method, would be relatively costly. Alternative approaches derived from (IEC International Electrotechnical Commission, 2021) that are affordable and not overly conservative are discussed. Bioelectromagnetics. 00:00-00, 2025. (c) 2025 Bioelectromagnetics Society.
https://doi.org/10.1002/bem.70024

Toxicité

Effects of Simultaneous In-Vitro Exposure to 5G-Modulated 3.5 GHz and GSM-Modulated 1.8 GHz Radio-Frequency Electromagnetic Fields on Neuronal Network Electrical Activity and Cellular Stress in Skin Fibroblast Cells,
Hurtier, A., Patrignoni, L., Canovi, A., Orlacchio, R., Tjiou, H., Gannes, F. P. D., Garenne, A., Lévêque, P., Arnaud-Cormos, D., Lagroye, I., Lewis, N. and Percherancier, Y., *Bioelectromagnetics*, Oct 2025, Vol. 46, no. 7.

The widespread deployment of 5G wireless networks alongside existing GSM technologies has increased the need to assess potential biological effects of co-exposure to multiple radiofrequency electromagnetic fields (RF-EMF). This study evaluates the in-vitro impact of simultaneous exposure to 5G-modulated 3.5 GHz and GSM-modulated 1.8 GHz signals on neuronal electrical activity, mitochondrial reactive oxygen species (ROS) production, and cellular stress protein responses in neurons and skin fibroblasts. Primary cortical neurons and human immortalized skin fibroblasts were exposed to RF-EMF at specific absorption rates (SAR) of 1 or 4 W/kg for 15 min or 24 h, respectively. Neuronal activity was analyzed using multi-electrode arrays (MEAs), mitochondrial ROS production was measured using MitoSOX Red, and stress protein activity was assessed using bioluminescence resonance energy transfer (BRET) assays targeting RAS, PML, and HSF1 proteins. The results indicate no significant effects on the mean bursting rate (MBR) or mean firing rate (MFR) of cortical neurons, consistent with previous findings at similar SAR levels. Mitochondrial ROS production in fibroblasts also remained unaffected by RF-EMF co-exposure. BRET assays detected minor variations in the basal activity of RAS and PML and in the maximal efficacy of PMA and As2O3 to activate these pathways. However, these effects were small, near the detection threshold, and showed no consistent pattern across different tests or chemical treatments. No change was observed in HSF1 basal activity or responsiveness to MG132. These findings suggest that co-exposure to 5G- and GSM-modulated RF-EMF at SAR levels up to 4 W/kg does not produce conclusive evidence of marked biological effects under the tested conditions. Observed variations,

when present, are of low amplitude and likely to fall within the range of experimental variability. https://doi.org/10.1002/bem.70026

Review of the evidence on the influence of Wi-Fi 2.4 GHz radiation on oxidative stress and its possible relationship with Alzheimer's disease,
Laván, D., Argüelles, N., Lluncor, A., Huaman, D., Moyano, J., Ubillus, J., Peña, M., Paredes, M., Hernández, I., Guerra, A., De La Cruz-Vargas, J. and Cruz, V., *Frontiers in Neurology*, Oct 3 2025, Vol. 16.

To date, there is no scientific consensus on whether wireless communication systems, such as 2.4 and 5 GHz Wi-Fi, play a crucial role in the development of Alzheimer's disease through oxidative stress. Although numerous studies have linked oxidative stress to exposure to electromagnetic radiation from wireless systems in various biological contexts, these studies have not established a direct connection to neurodegenerative diseases. Research on Alzheimer's disease and oxidative stress is an active field in neuroscience and medicine, as oxidative stress involves an imbalance between the production of free radicals and the antioxidant system's ability to neutralize them, leading to cellular and neuronal damage. It is essential to recognize that Alzheimer's disease is multifactorial, and its development generally results from a complex interaction of genetic, environmental, and lifestyle factors. The relationship between wireless systems such as Wi-Fi and oxidative stress, as well as its possible link to Alzheimer's disease, continues to be the subject of research and debate in the scientific community. Although some studies have explored this possible association, the results have been mixed and inconclusive. While research on the health effects of wireless systems remains relevant, it is prudent not to consider this association as an established fact until solid and consistent scientific evidence is available. The study we present focuses on indirectly analyzing the relationship between genes that respond to oxidative stress upon exposure to Wi-Fi 2.4 GHz electromagnetic waves and genes associated with the development of Alzheimer's disease. Our results indicate that the modification of key genes involved in neurodegeneration, such as GSK3B and APOE, could be exacerbated by prolonged exposure to this radiation. It is essential for future research to explore this hypothesis to further clarify the potential risks associated with electromagnetic radiation and its impact on neuronal health and the progression of Alzheimer's disease. https://doi.org/10.3389/fneur.2025.1616435

Electromagnetic fields and oxidative stress: The link to the development of cancer, neurological diseases, and behavioral disorders,
Lekovic, Z., *Electromagnetic Biology and Medicine*, 2025.

BackgroundEpidemiological studies suggest an association between exposure to electromagnetic fields (EMFs) and an increased incidence of malignant, cardiovascular, and neurodegenerative diseases. This study aims to elucidate the fundamental principles and plausible mechanisms by which EMFs may influence physiological and pathological processes that lead to disease development.Materials and methodsPublished reports of oxidative stress, DNA damage, and disease risk related to EMF exposure were examined. The literature review provided the foundation for building a new conceptual model called the Electromagnetic Pathogenesis (EMP) model.MechanismsThe EMP model proposes an increase in the probability of electron tunneling through the mitochondrial electron transport chain as the primary pathophysiological mechanism triggered by non-ionizing EMFs. Induced electric fields and quantum tunneling may enhance electron leakage during mitochondrial respiration, which is a major source of free radicals.FindingsThere is a deep connection between quantum tunneling, entropy, and Heisenberg's principle. As a direct consequence of Heisenberg's principle, & iecy;lectron tunneling is essentially involved in free radical production and entropy generation in cells. Both normal aging and chronic

diseases may be considered as the biologic manifestations of increasing entropy. Heisenberg's principle underlies normal aging and sets the limit to life expectancy.Social implicationsThe human brain, particularly the structural and functional networks that support social communication, is highly vulnerable to oxidative stress associated with EMF exposure. Long-term exposure may negatively affect social and reproductive behaviors in both men and women, potentially contributing to a decline in fertility rates and the acceleration of population aging. https://doi.org/10.1080/15368378.2025.2567872

Neuroinflammatory effects of magnetic fields: insights into glia-mediated secondary cascades and mechanisms,
Luo, Y. K., Zhao, C. C., Ren, J., Tian, L. X. and Pan, Y. X., *Life Sciences*, Dec 15 2025, Vol. 383.

Neuroinflammation is an innate immune response of the central nervous system (CNS) that typically controls infection by eliminating microbes. However, it is now understood to have a dual function, either protecting or disrupting CNS homeostasis, which is significant for neural health and disease. Magnetic fields (MFs), a widespread environmental factor, have emerged as potential triggers of neuroinflammation in the brain. Despite the growing interest in the biological effects of MFs, there is still a lack of comprehensive review synthesizing the evidence for their dual role in neuroinflammation. This review fills this gap by reframing the impact of environmental MFs on the CNS from a neuroimmunology perspective, with a particular focus on the temporal dynamics of glial activation. We evaluate the key signaling pathways through which MFs may affect neuroinflammation and glia-driven secondary events leading to abnormal neural function. Furthermore, we explore the biophysical mechanisms underlying the neuroinflammatory effects of specific MFs. By integrating scattered evidence into a coherent framework, this review provides mechanistic insights for future research and suggests new ways to evaluate the public health relevance of MF exposure. https://doi.org/10.1016/j.lfs.2025.124061

Impact of electromagnetic radiation on human reproduction health: Causes, consequences, and potential therapeutic approaches,
Oladipo, A. A., Adisa, V. I., Ogunkola, B. D., Oladapo, O. M., Ajeigbe, S. B., Adedoyin, O. O., Akhigbe, T. M. and Akhigbe, R. E., *Journal of Radiation Research and Applied Sciences*, Dec 2025, Vol. 18, no. 4.
The effect of electromagnetic radiation (EMR), the propagation of wave that has both electric and magnetic radiation, on human reproduction is a rapidly growing area of public health concern due to the widespread presence of wireless technologies. Studies have shown that EMR exposure induces testicular injury, lowers circulating testosterone, and impairs sperm quality. More so, EMR exposure alters female hormonal milieu, impairs oocyte quality and embryonic growth, and induces fetal anomaly and spontaneous abortions. Mechanisms implicated include the induction of oxidative stress, disruption of hormonal milieu, and DNA fragmentation. Although the findings are yet debatable, mounting evidence highlights the pertinent need to explore the short and long term impacts of EMR on human reproductive functions and to develop mitigating strategies to curtail the potential reproductive health consequences of EMR. https://doi.org/10.1016/j.jrras.2025.102010

Short-Term Effects of Extremely Low-Frequency Electromagnetic Fields on Neurogenesis and Wnt Signaling in Amniotic Fluid Cells,
Uzun, C., Karakas, Ü., Ay, M. E., Ay, Ö., Yildiri, D. D., Erdal, N. and Erdal, M. E., *Journal of Pediatric Genetics*, 2025 2025, Vol. 14, no. 3.

Background: Extremely low-frequency electromagnetic fields (ELF-EMF) at 50 Hz are prevalent in household electrical systems. Although various studies have examined the effects of ELF-EMF on cell

proliferation and gene expression, its impact on amniotic fluid cells (AFCs) remains unclear. Objectives: This study aimed to assess the potential effects of ELF-EMFs on gene expression related to neurogenesis and the Wnt signaling pathway in AFCs. Methods: AFCs were isolated from amniotic fluid obtained via amniocentesis and divided into five groups: control, sham, and three groups exposed to different ELF-EMF intensities (1 mT, 2 mT, 3 mT for 30 minutes/day for 7 days). Expression levels of genes involved in neurogenesis (HES1, Neurog1, Neurog2, Neurod1) and Wnt signaling (SFRP2, SFRP4, SFRP5, APC1) were analyzed using real-time PCR. Results: ELF-EMF exposure did not result in significant changes in gene expression among the experimental groups compared to controls. Conclusion: Short-term exposure (Acute exposure) to ELF-EMF at moderate intensities does not significantly impact gene expression related to neurogenesis or Wnt signaling in AFCs. Future studies should explore prolonged exposure (chronic exposure) and a broader range of intensities to evaluate developmental impacts more comprehensively.
https://jpg.researchcommons.org/cgi/viewcontent.cgi?article=1021&context=journal

Effect of 3.1-THz radiation on pathological progression in Caenorhabditis elegans Alzheimer's disease model,
Wang, L., Wang, M., Zhang, X. M. and He, M. X., *Chinese Physics B*, Nov 1 2025, Vol. 34, no. 11.

Terahertz (THz) radiation, an emerging frequency band of the electromagnetic spectrum, has been widely applied across various fields. However, its ability to resonate with the energy levels of biomolecules has raised significant concerns regarding its biosafety. A growing body of research indicates that THz radiation can markedly influence the structure and function of proteins. Alzheimer's disease (AD), a neurodegenerative disorder characterized by the abnormal aggregation of amyloid proteins, has been shown in prior studies to be modulated by THz radiation in terms of amyloid aggregation. Building on this, the present study utilized the CL4176 strain of Caenorhabditis elegans as an animal model for AD. Using a self-designed and constructed radiation system based on quantum cascade lasers, the study investigated changes in the pathological progression of AD under 3.1-THz electromagnetic radiation exposure. By evaluating lifespan, motility, feeding behavior, reactive oxygen species (ROS) levels, and aging markers in the Caenorhabditis elegans model, the study highlights the potential biological risks of 3.1-THz radiation for individuals with AD. These findings provide crucial experimental evidence to support the promotion and standardization of THz technology applications. https://doi.org/10.1088/1674-1056/ade06a

Méthodes

Reducing Uplink EMF Exposure in Direct-to-Satellite Sustainable Networks: A Cooperative Space SIMO Approach
Chemingui, M., Nagrani, R., Elzanaty, A. and Ieee (2025). 2025 Conference on Computer Communications-INFOCOM-Annual, London, ENGLAND.
Uplink electromagnetic field (EMF) exposure in direct-to-satellite communication raises concerns about potential health effects due to the high transmit power needed to compensate for path loss over large distances. In this regard, we propose an EMF-aware architecture where multiple Low-Earth orbit (LEO) satellites cooperatively serve each user to reduce uplink EMF exposure while meeting users' data rate requirements. Considering limited resources at the satellites, a proper user-satellite association policy is designed through a tailored many-to-many stable marriage (i.e., Gale-Shapley) algorithm. Then, the optimal power control mechanism at the user terminal (UT) is designed. The proposed algorithm achieves an EMF exposure reduction of one order of magnitude compared to Space single-input single-output (SISO) scheme while maintaining a data rate of 20 [Mbps]. https://doi.org/10.1109/infocomwkshps65812.2025.11153015

3D Electric Field Simulation and Proper Shielding Consideration Under Overhead High Voltage Transmission Lines in the Presence of Human Body
Damatopoulou, T., Christodoulou, C., Gonos, I., Kladas, A. and Hristoforou, E. (2023). 2023 Olympiad in Engineering Science Conference-OES, null, GREECE.
Electric field simulations and measurements under overhead high voltage transmission lines, in the presence of human body, are undertaken in this paper, in an effort to assess improvements in the finite element analysis (FEA) precision achieved by using 3-dimensional representation with respect to 2-dimensional one, enabling appropriate shielding consideration. The current work illustrates a more realistic representation of the electric field inside and in the vicinity of human bodies, close to the measurement's sites, that is in qualitative agreement with previously proposed 2-D simulation techniques. However, field measurements and additional modeling clearly illustrate that such accumulation of electric fields is split among a plurality of conductive materials and human bodies when they are close to the vicinity of measurements and the power transmission lines. These field measurements enabled proper simulation and shielding design against electric field, permitting minimization of electric field under certain conditions, thus allowing for long time human activity or work, following certain precautions, in otherwise restricted areas in the vicinity of overhead transmission lines. This technology can be implemented in aluminum facades, doors, windows, and shaders, by means of using the metal as grounding means. https://doi.org/10.1007/978-3-031-49723-0_29

Human Proximity Detection and Power Control Based on Antenna Sensing for EMF Touch Compliance of Indoor Base Stations,
Fu, W. F., Colombi, D., He, S. L. and Zhekov, S. S., *Ieee Transactions on Antennas and Propagation*, Dec 2025, Vol. 73, no. 12, p. 9763-9772.

Small-cell indoor base stations (BSs) are intended to extend network coverage inside buildings and support reliable, high-performing cellular services and Internet of Things (IoT) applications. To gain full installation flexibility, it is desirable to minimize the electromagnetic field (EMF) compliance distance of indoor BSs. To this end, this study proposes a novel approach that enables indoor BSs to adjust their transmitted power dynamically based on human proximity, without requiring the use of specialized sensors. The proposed solution involves a dedicated patch antenna, designed for both robust proximity detection and wireless communication. Proximity detection is achieved by monitoring the variation in the reflection coefficient of the antenna that occurs when a human body is nearby. With this approach, the measured reflection coefficients for various distances between the antenna and a human phantom match well with simulations, showing a detectable distance up to 260 mm. The measured 10-g specific absorption rate (SAR) of the proposed antenna system remains below the regulatory limit at any distance from the BS, resulting in EMF touch compliance. The proposed human proximity detection and power control system can be used as a practical solution to simplify indoor BS installations without unnecessarily reducing the transmitted power under normal operating conditions. https://doi.org/10.1109/tap.2025.3603846

Comparing Explainable AI Models: SHAP, LIME, and Their Role in Electric Field Strength Prediction over Urban Areas,
Givisis, I., Kalatzis, D., Christakis, C. and Kiouvrekis, Y., *Electronics*, Dec 4 2025, Vol. 14, no. 23.

This study presents a comparative evaluation of state-of-the-art Machine Learning (ML) and Explainable Artificial Intelligence (XAI) methods, specifically SHAP and LIME, for predicting electromagnetic field (EMF) strength in urban environments. Using more than 19,000 in situ EMF measurements across Catalonia, Spain, combined with high-resolution geospatial features such as building height, built-up volume, and population density, six ML algorithms were trained and

assessed over 50 randomized train-test splits. The k-Nearest Neighbors (kNN) model achieved the highest predictive accuracy (RMSE = 0.623), followed by XGBoost (RMSE = 0.711) and LightGBM (RMSE = 0.717). Explainability analysis showed that SHAP consistently identified built-up volume, building height, degree of urbanization, and population density as the dominant global predictors of EMF strength, whereas LIME revealed that degree of urbanization, population density, and building height were the most influential at the local (micro-scale) level. The results demonstrate that integrating interpretable ML frameworks with enriched geospatial datasets improves both predictive performance and transparency in EMF exposure modeling, supporting data-driven urban planning and public health assessment. https://doi.org/10.3390/electronics14234766

Model Variability in Assessment of Human Exposure to Radiofrequency Fields,
Hirata, A., Laakso, I., Apollonio, F., Kodera, S., Kubota, Y., Lan, J. Q., Li, K., Liberti, M., Poljak, D., Sasaki, K., Zhadobov, M. and Diao, Y. L., *Ieee Journal of Microwaves*, 2025.

The recent advances in computational dosimetry for electromagnetics and thermodynamics are reviewed to assess human exposure to electromagnetic fields in the MHz-to-terahertz range. This review emphasizes model variability in computational dosimetry. Apart from computational electromagnetic methods and their usage, the developments in anatomical phantoms and tissue dielectric properties characterization are also surveyed. In addition, the rationale for dosimetric quantities prescribed in international exposure guidelines, such as the specific absorption rate (SAR) and absorbed power density, is revisited in relation to their correlation with local and core temperature rises in various tissues and populations. A heating factor, which is defined as a steady-state temperature rise per SAR, for the brain, eye lens, skin, and body core is evaluated to estimate heating resulting from exposure to electromagnetic fields. The transition of a physical quantity in the guidelines at 6 GHz, from SAR to the absorbed power density, is discussed along with the optimal spatial averaging volume and areas. Computational evaluations of product compliance, 5G devices, and wireless power transfer systems are also reviewed. This review aims to synthesize the current knowledge, identify key sources of computational model variability and uncertainty, and outline further research needs for setting exposure guidelines and compliance assessment. https://doi.org/10.1109/jmw.2025.3628902

Frequency-dependent electromagnetic energy absorption and thermal gradients in human skin layers,
Mirekhtiary, F., Abbasi, A. and Maden, S., *Journal of Microwave Power and Electromagnetic Energy*, Oct 2 2025, Vol. 59, no. 4, p. 378-394.

This study presents a frequency-specific model of electromagnetic wave penetration and energy absorption in layered human skin. Using Python-based simulations, we visualize specific absorption rate SAR depth profiles for selected frequencies and analyze the resulting thermal gradients. The model reveals that localized heating can exceed physiological thresholds, potentially leading to effects such as thermal sensation, nociceptor activation, or protein denaturation. These results underscore the significance of spatial SAR analysis in evaluating the biological effects of electromagnetic exposure. https://doi.org/10.1080/08327823.2025.2576646

Development and validation of an in vivo pain assessment method for 28-day exposure to intermediate frequency magnetic fields,
Ohtani, S., Ushiyama, A., Wada, K., Ikehata, M., Suzuki, Y. and Hattori, K., *Journal of Radiation Research*, 2025.

The objective of this study was to establish guidelines for evaluating the health effects of electromagnetic fields (EMFs). To achieve this, a comprehensive evaluation of EMF effects on living organisms from both engineering and biological perspectives is essential. As part of this study, we examined the impact of intermediate-frequency magnetic fields (IF-MF) exposure on peripheral nerves in mice and validated the reliability of five pain assessment methods. The engineering approach was based on our pilot study, while the biological approach involved exposing mice to IF-MF for a 28-day period and assessing neurotoxicity through the implementation of five pain tests. The von Frey test, conducted with a Dynamic Plantar Aesthesiometer, was performed at various time points during exposure. The results indicated that leg withdrawal time was shortened only in the positive control group. After conducting a series of assessments, we demonstrated that no statistically significant differences were observed among the IF-MF-exposed, sham-exposed and control groups. However, the positive control group exhibited significant variations in the four supplemental assessments. No significant differences were detected in the other three groups. These findings suggest that subacute (28-day) IF-MF exposure at 2.3 times the basic restriction for occupational exposure according to International Commission on Non-Ionizing Radiation Protection guideline does not result in peripheral neurotoxicity and that the utilized pain assessment methods used for IF-MF exposure are effective. https://doi.org/10.1093/jrr/rraf068

Research on Magnetic Field Detection Method for Live State of High Voltage Direct Current Transmission Lines
Wang, S. L., Wu, J., Du, Y., Shi, Y., Wang, S., Zhao, W., Chen, X. S. and Ieee Computer, S. O. C. (2025). 2nd International Conference on Artificial Intelligence and Digital Technology-ICAIDT, Guangzhou, PEOPLES R CHINA.
Electroscope plays an important role in judging the charged condition of transmission lines and the operating conditions of transmission lines. The commonly used contact electroscope has the disadvantages of cumbersome measurement steps and easy to cause safety hazards to workers. This paper proposes a new type of non-contact electroscope using magnetic field detection to detect power lines. In this paper, the basic principle of the high voltage DC magnetic field electroscope is sorted out, and then the hardware circuit module is built and the software program is compiled. In the finite element software, the distribution characteristics of the magnetic field around the HVDC transmission line under different working conditions and the attenuation characteristics of the magnetic field under different paths are simulated and analyzed. The electroscope alarm threshold is extracted under different analysis paths and different operating conditions. Finally, the developed high-voltage DC magnetic field electroscope was tested. In the experimental test, it was found that the high-voltage DC magnetic field electroscope has good performance, and there are no dead zone and false alarm problems, which can be effectively applied in practical engineering.
https://doi.org/10.1109/icaidt66272.2025.00090

Development of Human-Equivalent Phantom for Induced Electric Field Measurements in EV-WPT Exposure Assessment,
Yanaga, Y., Shimizu, Y., Arima, T. and Nagaoka, T., *Ieee Transactions on Electromagnetic Compatibility*, 2025.

Wireless power transfer (WPT) devices for electric vehicles operate in the 85 kHz band frequency, necessitating an assessment of human exposure to electromagnetic field (EMF). The International Commission on Non-Ionizing Radiation Protection guidelines state that the in-body induced electric field is the basic restriction for frequencies below 100 kHz. Numerical simulations for the induced electric field have been considered so far. However, an induced electric field measurement method using a human-equivalent phantom was rarely discussed. Moreover, phantom dimensions used for measurement have not been analyzed. In this study, we determine the appropriate phantom

dimensions by analyzing the induced electric field in computational human models and validation with physical phantoms. We utilized the magnetic field measurements around a WPT device to analyze the induced electric fields and determine optimal phantom size. Direct measurements revealed that adequate depth is essential for accurate assessment, presenting phantom dimensions of 100 mm x 200 mm x 180 mm. The measured values were 30% higher than the simulations, indicating that these dimensions are suitable for conservative EMF assessment under the tested conditions (200-250 mm separation, standing posture). The applicability of the phantom to various WPT systems and configurations must be investigated in future studies.
https://doi.org/10.1109/temc.2025.3640939

Toxicité sur les animaux

Male Reproductive and Cellular Damage After Prenatal 3.5 GHz Radiation Exposure: One-Year Postnatal Effects,
Dolanbay, E. G., Mert, T., Bender, G., Bektas, H., Uslu, U., Fernandez-Rodriguez, C. E. and Dasdag, S., *Annals of the New York Academy of Sciences*, Dec 2025, Vol. 1554, no. 1, p. 140-152.

This study investigates the long-term effects of prenatal exposure to 3.5 GHz radiofrequency radiation (RFR) on male reproductive health. Pregnant Wistar Hannover rats were divided into sham control, full-gestation exposure (3T RFR), and late-gestation exposure (2T RFR) groups (2 h/day). Male offspring were euthanized at 12 months for testicular analysis. In the 3T RFR group, seminiferous tubule diameter and epithelial height were significantly reduced compared to controls (adjusted p = 0.03 and 9.71 x 10-8), along with lower Johnsen scores (adjusted p = 0.022). Abnormal sperm morphology increased significantly (adjusted p = 0.036). gamma-H2AX immunostaining scores were elevated in the 2T and 3T groups (adjusted p = 0.012 and 6.36 x 10-9). Beclin-1 expression was significantly higher in the 3T group versus sham and 2T groups (adjusted p = 8.55 x 10-4 and 4.51 x 10-6). TUNEL-positive cell counts were significantly higher in both RFR groups than in sham (adjusted p = 8.77 x 10-18 for 3T, 6.42 x 10-17 for 2T), as was the apoptosis index (adjusted p = 8.77 x 10-18 for 3T, 5.66 x 10-17 for 2T). All p values were Holm-Bonferroni corrected. These findings indicate that prenatal exposure to 3.5 GHz RFR results in persistent testicular damage, impaired spermatogenesis, and increased DNA damage, autophagy, and apoptosis in adult male rats. https://doi.org/10.1111/nyas.70116

Prenatal Exposure to 3.5 GHz Radiofrequency Radiation and Long-Term Skin Histomorphometry: An 18-Month Experimental Rat Study,
Dolanbay, E. G., Mert, T., Kurtoglu, R. N., Uslu, U. and Dasdag, S., *Medeniyet Medical Journal*, Dec 2025, Vol. 40, no. 4, p. 209-216.

Objective: This study aimed to evaluate long-term skin histomorphometry at 18 months postpartum in rats exposed in utero to 3.5 G Hz radiofrequency radiation (RFR). Methods: Pregnant Wistar Hannover rats were exposed to Global System for Mobile Communications-modulated 3.5 GHz RFR for 2 h/day throughout gestation, while the sham group underwent mock exposure. Offspring (n=5 per group) were not exposed to any further RFR until 18 months after birth. Dorsal skin samples were stained with hematoxylin-eosin and Masson's trichrome, and dermal thickness, adipose tissue area, dermal area, adipose/dermis ratio, and fat percentage were quantified. Specific absorption rate (SAR) was calculated using CST Studio Suite. Data were analyzed using the Student's t-test or the Mann-Whitney U test. Statistical significance was defined as p<0.05. Results: The peak spatial SAR (psSAR) values were 0.06622 mW/g (for1 g) and 0.03825 mW/g (for 10 g). No statistically significant differences were observed between RFR-exposed and sham groups in dermal thickness (655.32 +/- 87.4 6 pm vs 544.42 +/- 135.01 pm); fat area percentage (0.73 +/- 0.2 9% vs 0.66 +/-

0.22%); dermal area (1.05 +/- 0.1 7 vs 0.88 +/- 0.22); adipose/dermis ratio (1.78 +/- 0.24vs 1.54 +/- 0.28); or fat percentage (40.04 +/- 11.78% vs 42.96 +/- 11.60%) (all p>0.05). Conclusions: Prenatal exposure to 3.5 GHz RFR did not cause significant skin histomorphometric alterations in the dermis of aged female rats. The skin's barrier properties, regenerative capacity, and repair mechanisms may mitigate long-term structural effects of such exposures.
https://doi.org/10.4274/MMJ.galenos.2025.48323

The effects of acute and chronic exposure of 2100 MHz radiofrequency radiation on rat mismatch negativity,
Er, H., Hidisoglu, E., Kantar, D., Acun, A. D., Akkoyunlu, G., Ozen, S. and Yargicoglu, P., *Journal of Radiation Research and Applied Sciences*, Mar 2026, Vol. 19, no. 1.

Cell phones operate by emitting radiofrequency radiation (RFR), a form of electromagnetic radiation (EMR). Consequently, ongoing researches target to determine whether it poses potential risks to human health. One of these risks is related with brain and auditory system. This study aims to examine the impact of acute and chronic exposure to 2100 MHz radiofrequency radiation on mismatch negativity (MMN) in rats. In this study, we established 1-week (RFR1) and 10-week (RFR10) RFR groups from rats, which were subjected to 2100 MHz RFR exposure. Cage control groups (CC1, CC10) and sham groups (S1, S10) that were not subjected to RFR for equivalent durations were also established. Following auditory event-related potential (AERP) recordings, MMN waves were computed and analyzed. Additionally, brain samples were collected and biochemical and histological analyses were performed. The RFR1 group exhibited a reduction in AMPAR GluR2 subunit protein levels relative to the CC1 and S1 groups, although GFAP protein levels increased. Conversely, the opposite was observed in the chronic groups. Edema of astrocytic endfeet, mitochondrial damage, and lysosomal vesicles were identified in the RFR1 group. The MMN amplitude was found to be reduced in the RFR1 group relative to the CC1 group. The RFR1 group exhibited a reduction in delta and theta power relative to the S1/CC1 groups. Alpha coherence diminished in the RFR1 group relative to the S1 group, however it augmented in the RFR10 group compared to the S10 group. The assessment of event-related potentials indicated that 2100 MHz RFR led to a decrease in MMN amplitude, power spectrum, and coherence values in the RFR1 group relative to the S1 and CC1 groups, but an increase was observed in the RFR10 group compared to the S10 group. Consequently, in the acute period, 2100 MHz RFR may have adverse effects on auditory sensory memory. https://doi.org/10.1016/j.jrras.2025.102126

One-year follow-up of thyroid status in rats exposed to 2.45 Ghz radiofrequency radiation during the prenatal period,
Özyilmaz, C., Dasdag, S., Oktay, M. F., Ulukaya, E., Genel, M. E., Emre, F. and Yegin, K., *Electromagnetic Biology and Medicine*, 2025.

The aim of this study is to investigate the thyroid status of offspring exposed to prenatal 2.45 GHz radiofrequency radiation (RFR). In this study, which is the second phase of our previous study, the thyroids of rats exposed to prenatal 2.45 GHz RFR were examined one year after birth. The mothers of the offspring in the experimental group (n = 8) were exposed to 2.45 GHz RFR (whole-body specific absorption rate (SAR): 12 mW/kg; maximum point SAR: 25 mW/kg) 24 hours per day throughout pregnancy. The mothers in the sham group (n = 8) were kept under the same experimental conditions except for RFR exposure. The offspring in this study were not exposed to RFR after birth and continued their daily lives for one year. When the offspring reached one year of age, they were sacrificed and their thyroids were removed and evaluated. Mann-Whitney U and t tests were used for statistical analysis. Increases in fibrosis (p = 0.038), atypical thyrocytes (p = 0.002) and degenerated follicles (p = 0.007) and colloid reduction (p = 0.002) were found to be

significant in the experimental group compared to the sham group. However, the increase in the percentage of apoptosis positive cells (p = 0.006) and H2A.X antibody levels (p = 0.007) showed a statistically significant difference in the experimental group compared to the sham group. This study provides evidence that prenatal exposure to 2.45 GHz RFR can induce persistent histological changes, increase apoptosis, and cause DNA double-strand breaks in thyroid tissue observed one year after birth. These results underscore the importance of further long-term studies to assess developmental risks associated with prenatal RFR exposure.
https://doi.org/10.1080/15368378.2025.2577318

Actualité, société et mesures de prévention

Exposition aux ondes : de nouvelles études précisent les connaissances sur le risque de cancer, *ANSES* (novembre 2025),
L'Anses publie une actualisation de son expertise sur les effets des ondes radiofréquences, centrée sur le risque de cancer. Depuis ses évaluations de 2013 et 2016, près d'un millier d'études scientifiques ont été menées, enrichissant considérablement les connaissances sur ce sujet. L'évaluation de ces nouvelles connaissances, associées aux précédentes données scientifiques, ne met pas en évidence de lien entre l'exposition aux ondes radiofréquences, principalement émises par la téléphonie mobile, et l'apparition de cancers. Face à des usages qui évoluent très vite et qui peuvent générer d'autres effets sanitaires, l'Agence maintient néanmoins ses recommandations de prudence, en particulier pour les enfants. https://www.anses.fr/system/files/AP2016-SA-0176-RA.pdf
https://www.anses.fr/fr/content/exposition-aux-ondes-de-nouvelles-etudes-precisent-les-connaissances-sur-le-risque-de

Le seuil des points atypiques sera fixé à 9 V/m à partir du 1er janvier 2026, *ANFR* (décembre 2025),
A l'issue de la consultation publique qui s'est tenue du 10 juillet au 19 septembre 2025, l'Agence nationale des fréquences (ANFR) révise le seuil des points atypiques. Ce seuil est fixé à 9 V/m à compter du 1er janvier 2026. Les valeurs limites réglementaires d'exposition fixées par le Gouvernement restent inchangées, à un niveau bien plus élevé (de 28 à 61 V/m selon les fréquences considérées). https://www.anfr.fr/liste-actualites/actualite/le-seuil-des-points-atypiques-sera-fixe-a-9-v-m-a-partir-du-1er-janvier-2026

Valeurs limites d'exposition aux postes de travail. 1903.F, *SUVA* (janvier 2026), 56 p.,
Cette brochure explique comment évaluer et respecter les valeurs limites d'exposition sur les lieux de travail en Suisse. Pour les substances chimiques, elle renvoie aux listes actualisées des valeurs limites moyennes d'exposition (VME) et des valeurs biologiques tolérables (VBT) disponibles sur le site de la Suva (www.suva.ch/valeurs-limites). Elle décrit les méthodes de mesure de l'exposition professionnelle, la surveillance médicale et biologique, ainsi que les principales mesures de prévention à mettre en œuvre. Elle définit les VME et leurs conditions d'utilisation (symboles, substances cancérogènes, mutagènes et reprotoxiques, effets sur le fœtus, poussières, aérosols, nanoparticules, mélanges, substances sans VME), puis présente les principes d'établissement et d'interprétation des VBT, notamment pour les cancérogènes C1A et C1B, ainsi que les exigences de qualité des analyses de surveillance biologique. Le chapitre 3 fournit les valeurs admissibles pour les principaux agents physiques : radiations ionisantes, radiations non ionisantes (lasers, rayonnements

ultraviolets, visible et infrarouge, champs électromagnétiques), bruit continu et impulsionnel, ultrasons, infrasons, vibrations main-bras et corps entier, milieu hyperbare, chaleur par rayonnement infrarouge. Le chapitre 4 présente les valeurs indicatives relatives aux contraintes corporelles et aux poids lors de manutentions de charges, ainsi que les paramètres qui conditionnent son application (type de tâche, posture, fréquence, etc.). https://www.suva.ch/1903.f

Wireless charging for electric vehicles: A review on environmental, health, technical, and policy landscape,
Chowdhury, P., Shovon, M. M. A., Yeassin, R. and Farrok, O., *Energy Conversion and Management-X*, Oct 2025, Vol. 28.

Although wireless electric vehicle charging (WEVC) has numerous advantages over conventional plug-in systems, its adoption raises concerns that extend beyond technical efficacy. Comprehensive studies that connect environmental, health, technical, and policy aspects remain unaddressed in existing articles. This paper addresses it by reviewing WEVCs from multiple perspectives. The findings show several environmental challenges compared to wired systems, and ecological risks associated with electromagnetic fields. Health and safety issues are also evident regarding electromagnetic exposure, thermal hazards, coil misalignment, and battery degradation under high-frequency charging conditions. On the technical side, key concerns include battery issues, coil design, efficiency losses, component reliability, and maintenance complexity. While current standards provide guidance, they remain fragmented and incomplete, especially for high-power and dynamic charging applications. Analysis of the policy-standards nexus shows limited specific policies for WEVCs. By combining these perspectives, the paper identifies major gaps, calls for global standards, and suggests a policy roadmap for effective and sustainable WEVC deployment.
https://doi.org/10.1016/j.ecmx.2025.101363

Fulfilment of the promises of 5G according to business and industry stakeholders in Europe and the United Kingdom,
Hulls, P. M., Castaño-Vinyals, G., Röösli, M., Joseph, W., Polanska, K., Politanski, P., Guxens, M. and De Vocht, F., *Scientific Reports*, Nov 27 2025, Vol. 15, no. 1.

For businesses there is now the opportunity to incorporate fifth generation cellular technology (5G) into working practices to, for example, deliver contextual information in real time by ultra short latency and connect large numbers of devices, alongside artificial intelligence applications. The aim of this study was to gain insights into the development, implementation and the use of 5G in Europe, and to obtain an overview of developments associated specifically for occupational settings. We interviewed 14 experts from business, industry and (inter)national stakeholder organisations from the UK, Belgium, Spain, Poland and Switzerland between March and September 2023 using a semi-structured topic guide. Interviews were then transcribed, coded and analysed. Participants had mixed opinions about 5G as "it will not be the solution to the problems that we thought", but "5G is still developing". The introduction of 5G in workplaces was viewed as "pretty small" and in several countries "hasn't been very well taken up". Occupational settings where 5G had been initially incorporated included farming, manufacturing, airports, and university campuses. Introduction was also influenced by government-funded schemes to pilot 5G within businesses. Participants felt 5G could lead to a "natural evolution in factories". However, this would require continuing investment in user equipment and resources, as "all equipment would need to be able to connect to the 5G network". Experiences varied, but participants acknowledged that COVID-19 had had an impact on public perception, with misinformation being a prominent factor. Employment of 5G in industrial settings in Europe has been behind expectations, and to date mostly limited to test sites. Although work began in 2015, 5G deployment is continuing across Europe. Further research is needed to

understand how businesses can effectively implement 5G. https://doi.org/10.1038/s41598-025-26376-4

Flora and fauna: how nonhuman species interact with natural and man-made EMF at ecosystem levels and public policy recommendations,
Levitt, B. B., Lai, H. C., Manville, A. M., Ii and Scarato, T., *Frontiers in Public Health*, Nov 19 2025, Vol. 13.

In the last 60 years, there has been a steady increase in ambient exposures from nonionizing electromagnetic fields (EMF) between 0 and 300 GHz, primarily in the radiofrequency (RF) ranges between 30 kHz and 3 GHz. Each technology has introduced a layer of exposures with different transmission characteristics into the environment, creating what is today a broad scope of complex chronic, low-intensity, ambient exposures known to be biologically active in human and nonhuman species alike. The next generation of broadband technology employs a wide span of simultaneous frequency exposures for pervasive civilian use with signaling characteristics heretofore never deployed. Fifth and sixth generation (5G, 6G) networks utilize significantly higher areas of the electromagnetic spectrum >3.5 GHz unlike previous wireless technologies. The scale at which this EMF deployment unfolded has now reached documented proportions that simply do not exist in nature, creating 24/7 exposures to a novel energetic form of air pollution. While there are extensive local variations in exposure intensities, e.g., rural versus urban environments with proximity to transmission sources being the controlling variable, the advent of significantly increased satellites in low earth orbits, disseminating radiofrequency EMF (RF-EMF) toward Earth in broad radiation patterns, has now all but erased such demographic distinctions. Nowhere on Earth today is completely RF-EMF free. Nonhuman species are highly sensitive to the Earth's geomagnetic fields which are used for orientation, migration, mating, food finding, territorial defense, and all of life's activities. Compared to human abilities, myriad species have evolved an exceptionally sensitive physical array of electro/magneto-receptors with which to perceive environmental EMF often at, or very near, natural geomagnetic fields. Today's exposures are capable, even at very low intensities, of disrupting critical fauna/flora functions. Any existing exposure standards are strictly for humans. Discussed are nonhuman unique physiologies and potential resonant matches at ambient levels today. Policy recommendations for wildlife protection includes discussion of "airspace as habitat," adherence to existing laws, and mitigation that could include frequency re-allocation, redesign of hardware and network engineering, and societies moving away from certain competitive economic models, as well as EMF-free zones during migration and breeding seasons where possible.
https://doi.org/10.3389/fpubh.2025.1693873

US policy on wireless technologies and public health protection: regulatory gaps and proposed reforms,
Scarato, T., *Frontiers in Public Health*, Dec 19 2025, Vol. 13.

The current U.S. regulatory framework governing non-ionizing radiofrequency radiation (RFR) used in all wireless technology is outdated and lacks adequate protection, oversight, and enforcement. The U.S. Federal Communications Commission (FCC) was given regulatory jurisdiction by the U.S. Congress in 1996 over RFR exposure standards setting even though FCC has no in-house expertise regarding health or environmental effects from RFR. FCC is a licensing/engineering entity that relies on other government agencies for guidance on ambient exposures and devices. However, all relevant civilian public health and environmental agencies have been defunded from non-ionizing radiation research activities and oversight. Thus, current regulations have remained unchanged since 1996. Human exposure limits are designed to protect against short-term high-intensity effects, not today's long-term chronic low-intensity exposures. Scientific evidence indicates that children's

thinner skulls, unique physiology, and more conductive tissues result in significantly higher RFR absorption rates deeper into critical brain regions, which are still in development and thus more sensitive to environmental insults. However, current policies offer no safeguards for children/pregnancy or vulnerable populations. Growing research also indicates risks to wildlife, especially pollinators. In 2021, a U.S. federal court mandated that the FCC show proper review of growing scientific evidence, after a cursory FCC re-approval of limits in 2019, but FCC has yet to respond. This paper explores regulatory infrastructure deficiencies, including the absence of monitoring/oversight, premarket safety testing, post-market surveillance, emissions compliance/enforcement, occupational safety, and wildlife protection. Compliance tests for cell phones do not reflect real-world consumer use and can therefore camouflage exposures that exceed even FCC's outdated limits. Other countries enforce stricter limits, robust monitoring, transparency measures, and compliance programs with additional policies to protect children. Also discussed is the chronic revolving door between FCC leadership and the wireless industry, resulting in a state of regulatory capture. Policy recommendations for common-sense reforms are made for reinvigorating independent research, developing science-based safety limits, ensuring pre- and post-market surveillance, and improving oversight/enforcement, as well as implementing risk mitigation to reduce exposures to children, vulnerable groups, and wildlife.
https://doi.org/10.3389/fpubh.2025.1677583

Towards a Planetary Health Impact Assessment Framework: Exploring Expert Knowledge and Artificial Intelligence for a RF-EMF Exposure Case-Study,
Stefanopoulou, M., Sonnenschein, T. S., De Gannes, F. P., Scheider, S., Vermeulen, R., Röösli, M. and Huss, A., *Bioelectromagnetics*, Dec 2025, Vol. 46, no. 8.

While recent WHO systematic reviews have comprehensively assessed the direct health effects of radiofrequency electromagnetic field (RF-EMF) exposure, its potential indirect impacts on human health via ecosystem disruption remain unstudied. Therefore, we propose a Planetary Health Impact Assessment (PHIA) approach, which incorporates both direct and ecologically mediated pathways. Developing the underlying framework requires a method for organizing and visualizing complex, interdisciplinary knowledge. This study explores an approach for constructing a PHIA framework in the form of knowledge graphs (KGs). Using RF-EMF exposure from mobile telecommunication technologies as a case study, we developed an expert-based KG in collaboration with 12 specialists. We further evaluated the potential of an artificial intelligence (AI)-based tool, incorporating Natural Language Processing (NLP) and Deep Learning, to extract relevant information from scientific literature and generate KGs to explore ways to enhance the expert-based approach. Experts developed and visualized jointly the hypothesized pathways linking RF-EMF exposure to direct health effects on organisms and indirect effects on human health through ecological consequences. The AI tool quickly processed large volumes of literature and visualized it into KGs with varied structures but required extensive expert validation due to limitations in precision and context sensitivity. The expert-based KG can serve as organizer of the available knowledge and as a first step in PHIA development. While AI tools offer potential for exploratory analysis, they currently require substantial human oversight and cannot replace expert judgment. The resulting KGs also identified possible gaps in the scientific literature. https://doi.org/10.1002/bem.70038

Experience of Polish Physicians on Electromagnetic Hypersensitivity
Undas, K., Kanclerz, G., Popielak, J., Taton, G. and Ieee (2025). 2025 Progress in Applied Electrical Engineering Conference-PAEE, Zakopane, POLAND.
The aim of this project was to assess the knowledge of Polish physicians about the impact of electromagnetic fields (EMF) on human health, their knowledge of electromagnetic hypersensitivity (EHS), and their experiences with patients who consider themselves hypersensitive to EMF. A

questionnaire survey was conducted among physicians in a traditional paper-based format, as well as using an online form. Responses were obtained from 355 doctors of various specialties and with different levels of experience, both clinical and scientific. A subjective and objective assessment of the respondents' knowledge about the impact of EMF on humans leads to the disturbing conclusion that their knowledge cannot be considered broad. For example, the subjective self-assessment of knowledge in 1/3 of the respondents is at a very low or low level. Physicians do not seem to be familiar with the WHO guidelines for dealing with people who perceive themselves as hypersensitive to EMF. Respondents are aware of the low level of their knowledge about EMF and most of them are ready to improve their qualifications in this field. They also see the need to spread reliable knowledge about the EMF and its impact on society. The low assessment of doctors' knowledge of EMF and EHS is even more concerning as EHS is a phenomenon many encounter in their daily professional practice. Almost 45% of physicians declared that they had to deal with patients who associated their symptoms with the impact of EMF, and some physicians claim that they deal with such patients even several times a month or more often. These findings may lead to significant for public health conclusions. EHS is not a marginal phenomenon, and physicians are striving to properly address this condition. At the same time, their knowledge about EHS and about EMF in general is limited. In such cases, they are unable to adequately help their patients and may become a source of unreliable or unverified information, which could lead to anxiety.
https://doi.org/10.1109/paee68231.2025.11155985