

Bulletin de veille
Champs électromagnétiques
N°16 – Juin/Juillet 2026

Objectif : surveillance de la littérature scientifique concernant les impacts sur la santé humaine de l'exposition aux champs électromagnétiques

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.

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Exposition professionnelle

Trajectory-specific motion-induced electromotive force assessment of pacemaker-carrying workers in MRI environments,
Hartwig, V., Acri, G., Calcagnini, G., Vivarelli, C., Falsaperla, R. and Mattei, E., *Medical Physics*, Jul 16 2026, Vol. 53, no. 7.
Purpose Motion of individuals carrying active implantable medical devices (AIMDs), such as pacemakers (PMs) and implantable cardioverter defibrillators (ICDs), within the spatially varying static magnetic field in and around magnetic resonance imaging (MRI) systems can induce electromotive forces (EMFs) in conductive leads. This mechanism is not explicitly addressed in standard MRI safety assessments. This study presents a measurement-based computational framework to estimate motion-induced EMF under representative exposure conditions relevant to clinical practice.Methods Measured maps of the static magnetic field components (Bx, Bz) in the

fringe region of 3 and 7 T MRI systems were interpolated on regular grids. Spatial gradients were derived and used to compute motion-induced EMF in an equivalent conductive loop representing a PM/ICD lead configuration. Three motion types were considered: linear motion along the scanner axis (z), linear motion transverse to the bore (x), and in-place rotation of the loop. EMF was calculated using Faraday's law, assuming a loop area of 0.0225 m2, a reference linear velocity of 1 m/s, and an angular velocity of 1 rad/s. Spatial EMF distributions and time-dependent waveforms were obtained for each motion scenario.Results Induced EMF varied significantly with motion direction and spatial location. For linear motion, the highest values were observed near the bore entrance, where strong spatial field variations occur. At 3 T, maximum EMF reached 160 mV (z-motion) and 114 mV (x-motion), while at 7 T the corresponding values were 81 and 104 mV for the analyzed trajectories. Rotational motion produced lower and more localized EMF values, with maxima of 30 mV (3 T) and 35 mV (7 T). Despite the higher nominal field strength, the 7 T system did not consistently yield higher EMF, reflecting differences in spatial field gradients.Conclusions Motion-induced EMF in MRI fringe fields depends on local spatial field gradients and motion characteristics rather than nominal field strength alone. The proposed measurement-based framework provides spatially resolved, scenario-specific estimates of EMF and can be applied to different MRI systems given appropriate field maps. This approach complements existing safety assessments by addressing motion-related exposure conditions not explicitly covered in standard evaluations. https://doi.org/10.1002/mp.70524

Application of HAZOP-HSE methodology to analyze health, safety and environmental hazards in the production of sintered magnets: Comparison between neodymium and ferrites permanent magnets,
Innocenzi, V., Amato, A., Bernardi, P., Montes, M. and Beolchini, F., *Safety Science*, Dec 2026, Vol. 204.
A permanent magnet (PM) is a material that can provide magnetic flux when magnetized with an applied magnetic field; PMs manufactured with hard ferromagnetic materials maintain their magnetic properties until they are demagnetized. This phenomenon occurs when a magnetic field is applied contrary to the beginning. Among the best-known magnets are the Nd-Fe-B, ferrites (ceramic), SmCo, and Alnico magnets. Neodymium magnets are currently the most widely used. Still, efforts are being made to replace these with other types of magnets, such as ferrites, given the supply risk of neodymium, a critical raw material. Permanent magnets are used in the mechanical industry, bioengineering, aeronautical and aerospace technology and are essential for renewable energy and the e-mobility sector. Magnet production involves many process units (mechanical, chemical, and thermal operations); thus, various health and safety matters are associated with it. This work focuses on assessing health and safety risks to workers in the magnet manufacturing industry using HAZOP-HSE methods, in order to identify the Safety Integrity Level, SIL. Two different production routes have been analyzed: neodymium and ferrite permanent magnets. The results show that around 22 % of the analyzed scenarios in NdFeB magnet production fall into SIL 3-4 categories, whereas in ferrite magnet production, no SIL 4 scenarios were identified. In this last case, more than 50 % of the investigated scenario has SIL 0, so no HSE engineering actions are required. https://doi.org/10.1016/j.ssci.2026.107354

Editorial: Non-ionizing radiation: impacts on human health from exposures in occupational settings,
Modenese, A., Nogueira, C. M. C. A. and Wittlich, M., *Frontiers in Public Health*, 2026-July-13 2026, Vol. Volume 14 - 2026.
https://doi.org/10.3389/fpubh.2026.1880564

Interference of high 50/60-Hz electric and magnetic fields with the normal functioning of active cardiac implants: implications for newly implanted workers returning to or entering work in the utility sector,
Ostiguy, G., Barbieri, M. B., Cabanes, P. A., Deschamps, F., Jackson, S., Korpinen, L., Magne, I., Nguyen, D. H., Plante, M., Souques, M., Stunder, D., Tripp, H. and Wall, C., *International Journal of Occupational Safety and Ergonomics*, 2026 May 2026.
The 50/60-Hz electric and magnetic fields in substations or under high-voltage lines may interfere with the operation of cardiac implantable electronic devices (CIEDs). This review of the literature over the last 20 years provides guidance to occupational physicians who give orientations when newly implanted workers return to or enter work. For magnetic fields, CIEDs are generally not affected up to 100 mu T. For electric fields, CIEDs set to nominal sensitivity and in bipolar mode are unaffected up to 5 kV/m. Clinically significant or symptomatic disturbances are unlikely up to 10 kV/m. Specific advice may be necessary for patients implanted in unipolar mode or with very low sensitivity thresholds. Some atrial configurations in the presence of high electric fields may require special attention. Two approaches are used when entering or returning to work: compliance with restrictions relative to exposure to electric and magnetic fields, or particular workstation tests under medical supervision. https://doi.org/10.1080/10803548.2026.2667648

Generic neural network model for estimating exposure levels in industrial environments,
Plets, D., Apostolidis, C., Wang, S., Valič, B., Martens, L., Samaras, T. and Gajšek, P., *Journal of Radiological Protection*, 2026/05/22 2026, Vol. 46, no. 2, p. 021518.
This study describes a neural network-based method for estimating exposure levels in industrial environments, without requiring detailed technical inputs, allowing usage of the model by layman people or by workers active in these areas. A pipeline based on Blender environments and MATLAB ray-tracing simulations is created and after defining a set of 11 candidate input parameters for the model, more than 20 000 different wireless configurations are simulated, varying the different environmental and wireless input parameters. A correlation analysis shows that main inputs influencing the exposure levels in the industrial area are the transmit power of the antennas, the density of clutter in the area, the density of transmitters in the area, and the height and location of the transmitters. A multi-layer fully connected neural network regression model is developed to predict median (E50) and 95th percentile (E95) exposure levels in industrial areas. Testing the obtained model on an unseen dataset of environments with E50 values between 0 and 3.25 V m−1 and E95 values between 0 and 7 V m−1, demonstrates the good prediction performance of the model: root-mean-square error values below 0.173 V m−1 and R2 values above 95% are obtained. Subsequently, the model is validated with measurement data collected in three distinct realistic industrial environments. The average absolute deviation of the model predictions with respect to the measurements is limited to 20.4%. This novel and broadly accessible approach demonstrates that it is possible to reliably estimate exposure levels in realistic environments without having to rely on external experts or on dedicated complex software. https://doi.org/10.1088/1361-6498/ae6c32

Workers' Exposure Due to Private 5G Networks,
Valic, B., Plets, D., Vermeeren, G., Apostolidis, C. and Gajsek, P., *Telecom*, Jun 2026, Vol. 7, no. 3.
Private 5G mobile networks are emerging as a platform for wireless connectivity in professional applications across smart industrial sectors such as automated warehousing, logistics, autonomous vehicle deployments in campus environments, mining, and material processing, among others. It is expected that most Machine-to-Machine (M2M) and Industrial Internet of Things (IIoT) communication links will increasingly rely on wireless solutions, as the flexibility they offer provides clear advantages over hard-wired network installations. To gain insight into workers' exposure to radiofrequency electromagnetic fields (RF EMF) emitted by 5G private mobile networks, an analysis was conducted based on measured and calculated RF EMF levels from various 5G private networks

in real-world scenarios across different smart industrial sectors and R&D platforms in three countries. Several exposure scenarios were evaluated, including production facilities, logistics operations, office environments, and research sites. The installations included different configurations: private standalone and non-standalone 5G networks operating at 3.5 GHz and 26 GHz, as well as public networks with private slicing. The results clearly demonstrated that exposure levels in all investigated scenarios were well below existing exposure limits. In a typical indoor industrial environment where pico 5G base stations are deployed, the measured exposure was found to be no greater than 0.006% of the Directive 2013/35/EU action value and 0.03% of the ICNIRP guideline limits for the general public. https://doi.org/10.3390/telecom7030063

Etudes épidémiologiques

An Exploratory Study Using an Artificial Neural Network to Predict Fatigue from Mobile Phone Use: A Population-Based Survey in Algeria,
Boumaiza, S., Bouharati, S. and Bouzidi, A., *International Journal of Medical Toxicology and Forensic Medicine*, 2026, Vol. 16.
Background: Mobile phones are widely used, raising questions about the possible health effects of the radiofrequency electromagnetic fields they emit. Fatigue is frequently reported in this context, but it is influenced by multiple, interacting factors that are difficult to model with classical statistical methods. Artificial neural networks (ANNs) may help explore these complex relationships. Methods: An ANN model was developed to estimate fatigue associated with cell phone use. Data were collected via a semi-structured questionnaire completed by 478 Algerian participants. The survey recorded sociodemographic data and patterns of mobile phone use. The network had a 5-101 architecture, and its performance was evaluated by mean squared error (MSE) and the coefficient of determination (R2). A simple MATLAB interface was created to allow user input and display model outputs with a colour-coded indicator. Results: The ANN achieved an MSE of 0.5993, indicating that it reproduced some general patterns in the data. However, the coefficient of determination was low (R2 = 0.0338), showing that only a small proportion of the variability in fatigue scores was explained and that individual predictions were imprecise. Conclusion: This exploratory study suggests that ANN-based models are feasible for analysing fatigue associated with mobile phone use, but the findings should be regarded as preliminary and are subject to some limitations. Larger, more diverse samples and richer, preferably objective, exposure and health measures will be required before such tools can be used for reliable risk assessment or public health guidance.
https://doi.org/10.22037/ijmtfm.v16.50757

Maternal mobile phone use during pregnancy versus early childhood in relation to behavioral problems in preschool-aged children: A prospective cohort study,
Joo, H., Choi, J., Lim, H., Choi, H. D., Lee, A. K., Moon, J. and Ha, M., no. 1096-0953 (Electronic).
Evidence on the effect of maternal mobile phone use on child behavioral development remains inconsistent, particularly regarding the relative importance of the prenatal and early childhood exposure periods. We aimed to examine associations between maternal mobile phone call duration during pregnancy and early childhood and behavioral problems in preschool-aged children. We analyzed data from the Mothers and Children's Environmental Health (MOCEH) prospective birth cohort. Maternal mobile phone use was measured by questionnaire during pregnancy and at ages 3-5 years, and child behavioral problems were assessed using the Korean Child Behavior Checklist (K-CBCL) at ages 4, 5, and 6 years. Maternal daily call duration (minutes/day), used as a proxy indicator of mobile phone use, was calculated from daily call frequency and average duration per call. Associations with behavioral problem scores were estimated using linear mixed-effects models in sub-cohorts with available exposure information for the whole period (n = 780), pregnancy (n = 763), and early childhood (n = 418). Mutually adjusted models accounted for maternal mobile

phone use during the other exposure period, with missing information treated as a separate category. Early childhood maternal mobile phone use was significantly associated with higher total (β = 1.37, 95% CI: 0.46-2.28) and externalizing (β = 1.44, 0.54-2.33) problem scores, whereas prenatal use was not. Sex-stratified analyses showed associations for total and externalizing problems in males and internalizing problems in females. These findings suggest that maternal mobile phone use during early childhood, rather than pregnancy, is associated with child behavioral problems, pointing to the caregiving pathways, such as interruptions in parent-child interaction caused by technology use, as a plausible explanation.
https://doi.org/10.1016/j.envres.2026.125314

No thermal skin effects at environmental 26 GHz field strengths relevant to 5G deployment, Michelant, L., Delanaud, S., Hugueville, L., Leveque, P., Bach, V., Tourneux, P. and Selmaoui, B., *Scientific Reports*, Apr 2026, Vol. 16, no. 1.
The deployment of 5G millimeter wave technology at 26 GHz raises questions about potential thermal effects on human tissues. Controlled human studies examining millimeter wave thermal responses remain limited. We investigated the effects of acute 26 GHz exposure on skin temperature in healthy volunteers under controlled laboratory conditions. Thirty-one healthy young adults participated in a triple-blind, randomized, crossover study. Participants underwent genuine 26 GHz exposure (2 V/m at head level, 1 V/m at torso level) and sham exposure, each lasting 26 minutes 30 seconds. Skin temperature was continuously monitored using infrared thermography at five anatomical regions (face, bilateral hand dorsum, bilateral infraclavicular areas) across three experimental phases. No statistically significant thermal effects were detected, with no main effect of exposure condition for any skin region (all $p > 0.34$). No significant exposure-phase interactions were detected for any measurement (all $p > 0.09$). Progressive decreases in distal skin temperatures (exceeding 1.5 degrees C, $p < 0.0001$) occurred independently of exposure condition, reflecting normal thermoregulatory adaptation to seated immobility. Distal-proximal gradient analysis showed no significant difference between conditions (right: $p = 0.332$; left: $p = 0.319$), and bilateral comparisons revealed no thermal asymmetry ($p = 0.269$). These findings provide reassuring evidence that acute 26 GHz exposure at environmental field strengths produces no detectable thermal effects in healthy young adults, at levels substantially below ICNIRP reference limits. However, these results should not be interpreted as a direct validation of those guideline threshold values. https://doi.org/10.1038/s41598-026-49616-7

Effects of 26 GHz radiofrequency exposure on electrodermal activity in healthy young adults, Michelant, L., Hugueville, L., Leveque, P. and Selmaoui, B., *International Journal of Radiation Biology*, 2026 Jun 2026.
PurposeThe deployment of 26 GHz millimeter wave technology represents the next phase of 5 G implementation, yet potential effects on autonomic nervous system function remain unexplored. This study investigated whether environmental-level 26 GHz exposure influences electrodermal activity (EDA), a sensitive marker of sympathetic nervous system activation.Materials and methodsTwenty-two healthy young adults participated in a randomized, counterbalanced, triple-blind study examining EDA responses to controlled 26 GHz exposure. Participants underwent two sessions (real and sham exposure) with electric field intensities of 2 V/m at head level and 1 V/m at torso level, representing upper environmental exposure ranges. EDA parameters were measured during pre-exposure, exposure (25.5 min), and post-exposure phases using established continuous decomposition analysis. Both tonic components (baseline sympathetic activation) and phasic responses (stimulus-evoked reactions) were assessed following standardized auditory stimulation protocols.ResultsNo statistically significant effects of 26 GHz exposure were observed across all measured EDA parameters. Tonic activity, phasic responses, response latency, amplitude measures, and global skin conductance remained unchanged during and following RF exposure compared to

sham conditions across all experimental phases.ConclusionsEnvironmental-level 26 GHz exposure does not produce detectable acute effects on sympathetic nervous system activity as measured through electrodermal responses. These findings contrast with reported effects at lower 5 G frequencies, suggesting frequency-specific biological interactions. The limited tissue penetration of millimeter waves likely prevents electromagnetic energy from reaching sympathetically innervated structures. Results support current guidelines yet emphasize the need for complementary study. https://doi.org/10.1080/09553002.2026.2678295

The Effects of Short-Term Post-Exposure to 3.6 GHz 5G Mobile Phone Electromagnetic Exposure on Static and Dynamic Postural Control in Healthy Adults: A Randomized Sham-Controlled Pilot Study,
Torkan, A., Zoghi, M., Foroughimehr, N. and Jaberzadeh, S., *Sensors*, Jun 2026, Vol. 26, no. 12.
The rapid global expansion of 5G technology has increased concerns regarding its potential health effects. Postural balance, a complex sensorimotor function reflecting central nervous system integrity, may be susceptible to electromagnetic field exposure. However, evidence on 5G effects on comprehensive balance outcomes remains limited. This randomized controlled pilot study investigated the effects of short-term exposure to 5G mobile phones on static and dynamic postural balance using computerized posturography. Nineteen healthy adults (mean age: 31 +/- 7 years) participated in a randomized crossover design involving three conditions: 5-min exposure, 20-min exposure, and sham. Static and dynamic balance were assessed using the NeuroCom Balance Master, including the Unilateral Stance, Rhythmic Weight Shift, and Limits of Stability tests, which were performed immediately before and after each condition. Two-way repeated-measures ANOVA showed no significant interaction between exposure condition and time (pre vs. post) across all outcomes. Bayesian analyses provided support against detectable exposure-related interaction effects, although evidence for some time-related effects was inconclusive or varied across outcomes. These findings suggest that short-term 5G exposure did not produce detectable alterations in postural control under the experimental conditions tested. https://doi.org/10.3390/s26123750

Evaluation de l'exposition

Exposition aux ondes : l'ANFR publie les résultats 2025 des contrôles de surveillance du marché des terminaux mobiles,
ANFR (juillet 2026),
En 2025, l'Agence nationale des fréquences (ANFR) a contrôlé 80 équipements mobiles de 33 marques différentes afin de vérifier leur conformité avec les limites réglementaires fixées au niveau européen. Elle a ainsi mesuré le débit d'absorption spécifique (DAS), indicateur de l'exposition aux ondes électromagnétiques pour les terminaux mobiles. L'ANFR publie aujourd'hui le bilan de ces vérifications et les mesures correctives engagées lorsque des non conformités ont été constatées. https://www.anfr.fr/liste-actualites/actualite/exposition-aux-ondes-lanfr-publie-les-resultats-2025-des-controles-de-surveillance-du-marche-des-terminaux-mobiles

Maximum Exposure of 5G Base Stations in the mmWave Band: The Impact of Multi-User MIMO and CSI-RS Ports,
Adda, S., De Donno, D., Franci, D., Moresi, F., Pasquino, N. and Pavoncello, S., *Ieee Transactions on Instrumentation and Measurement*, 2026, Vol. 75.

Multi-user (MU) multiple-input multiple-output (MIMO) operation at millimeter-wave (mmWave) frequencies enables 5G base stations (BSs) to simultaneously transmit to several users by forming multiple beams in parallel. This feature, while boosting capacity, modifies the exposure landscape compared to the conventional single-user (SU) mode, where resources are time-multiplexed. In this

work, we investigate how MU-MIMO operation affects maximum power extrapolation (MPE) procedures used to assess electromagnetic field (EMF) exposure in accordance with IEC 62232. Building on the experimental framework and measurement methodologies validated for SU-MIMO in a recently published work by the authors, we extend the analysis to signals configured with MU-MIMO transmission and variable numbers of channel state information reference signal (CSI-RS) antenna ports. Results show that concurrent user scheduling may reduce the received power per beam by several dB, leading to a systematic underestimation of maximum exposure when MPE procedures are applied without knowledge of the active mode. Furthermore, the number of CSI-RS ports influences the measured levels, resulting in reductions of up to 12 dB. These findings underscore the need to incorporate MU-MIMO and CSI-RS port configurations into updated exposure assessment standards. https://doi.org/10.1109/tim.2026.3690868

Toward Autonomous UGV-Based Radio-Frequency Measurement Campaigns: Tutorial and Application,
Callea, M., Masocco, R., Cretu, A., Manca, G., Tenaglia, A., Mattogno, S., Chiaraviglio, L., Franci, D., Pavoncello, S., Marsico, G. and Carnevale, D., *Ieee Access*, 2026, Vol. 14, p. 83139-83156.
In-situ RF measurements are essential for regulatory Electromagnetic Field (EMF) exposure assessment and radio coverage characterization. These tasks have historically relied on labor-intensive surveys based on discrete spot measurements, which provide limited spatial resolution and, therefore, often require support from simulation tools. These limitations call for a shift toward automated and scalable RF measurement campaigns. This paper formalizes a set of design guidelines for autonomous RF measurement campaigns using mobile robotic platforms and illustrates their implementation within a modular system architecture, showing how to integrate RF sensing and autonomous robotic navigation to enable consistent, geo-referenced data collection and adaptive acquisition strategies tailored to specific measurement objectives and driven by observed radio conditions. The proposed framework is validated through an outdoor measurement campaign on a private 5G Standalone network using a quadruped robot equipped with professional RF instrumentation. Experimental results show that the system supports the autonomous execution of measurement missions for both coverage characterization and EMF exposure assessment, demonstrating the potential of the proposed approach as a scalable and effective alternative to traditional RF measurement practices. https://doi.org/10.1109/access.2026.3699128

Electromagnetic Exposure to Child Passengers of Positioning Antennas for Autonomous Driving Electric Vehicles,
Dong, X. W., Ren, Y. F. and Lu, M., *Applied Computational Electromagnetics Society Journal*, Mar 2026, Vol. 41, no. 3, p. 244-257.
With the rapid development of electric vehicles (EVs) and autonomous driving (AD) technologies, the issue of electromagnetic exposure of passengers, especially children, to the electromagnetic radiation generated by the positioning antennas of AD has received increasing attention. In this study, COMSOL Multi-physics is used to construct the models of an EV, a positioning antenna and a child human body, and the levels of electromagnetic exposure of a child passenger to the positioning antenna in AD are calculated. Results indicate that the maximum value of induced electric field in a child's body is 23 V/m, and the maximum value of the SAR1g of the child's body is 0.19 W/kg. Additionally, the maximum temperature rise in the child body is 0.55 degrees C. The electromagnetic exposure levels of the child passenger calculated in this study are all lower than the safety limits defined by international authoritative institutions. Therefore, the electromagnetic radiation levels from the positioning antenna comply with international safety standards. Based on the analysis of this study, no significant health effects on child passengers have been observed. The results of this study can supplement studies on the electromagnetic environment of AD in EVs and

can provide guidance for ensuring the travel safety of child passengers.
https://doi.org/10.13052/2026.Aces.J.410306

NEMESI: 5G Non-Invasive EMF Multi-User Exposure Surveillance and Inspection,
Franci, D., Palamá, I., Mangione, S., Adda, S., Vaccarono, M. and Bianchi, G., *Ieee Transactions on Green Communications and Networking*, 2026, Vol. 10, p. 3246-3258.
Surveillance of electromagnetic field exposure in 5G networks is crucial for regulatory compliance but currently relies on intrusive and expensive active traffic injection. We propose a hardware-agnostic, automated, and non-invasive framework for exposure assessment in real-world deployments. By leveraging a blind Downlink Control Information (DCI) decoding mechanism, our method extracts scheduling information to isolate user-specific Physical Downlink Shared Channel (PDSCH) resources. Experimental validation in frequency range (FR)1 and FR2 demonstrates that this approach enables a procedural mapping of radiated power while obviating the need for full carrier bandwidth saturation. By abstracting the acquisition hardware as an IQ sample provider, the pipeline is designed to operate across heterogeneous receivers, including low-cost Software-Defined Radios (SDRs). While absolute metrological accuracy remains dependent on specific device calibration, this methodology supports a streamlined, user-specific Maximum-Power Extrapolation (MPE) analysis workflow at the signal-processing level that is independent of network traffic conditions. https://doi.org/10.1109/tgcn.2026.3695297

Determinants of radiofrequency electromagnetic fields emitted by smartphones in French cellular telephony networks,
Guida, F., Moissonnier, M., Beranger, R., Lagroye, I., Orlacchio, R., Laplanche, A., Dejardin, O., Conil, E., Huss, A., Mazloum, T., Wiart, J., Danjou, A., Schüz, J., Bories, S. and Deltour, I., *Environmental Research*, Sep 2026, Vol. 305.
Smartphones are a major source of radiofrequency electromagnetic field exposure, yet real-life determinants of uplink emissions remain poorly characterised. We conducted the first epidemiological study of smartphone cellular network uplink emissions in a general population sample, recruiting 167 volunteers across three French cities in 2022-2023. Emissions were measured quasi-continuously for a week during everyday activities using the novel DEVIN exposimeter, while the XMobiSensePlus application simultaneously recorded sensor values and smartphone activities in the background. Determinants of UL emission occurrence and level were analysed using logistic and linear regressions. Over 8001 h analysed, voice calls were recorded in 2.4% of time and data uploads in 81.3%. Voice calls were associated to emission occurrence (OR = 7.09, 95% CI: 5.96-8.43). In fully adjusted models, emission levels were associated to calls (+9.16 dBm, CI: 7.15; 11.16), and to Wi-Fi connection with substantially lower cellular emissions outside call periods (-15.37 dBm, CI: -17.28, -13.46). Cellular upload rates differentially increased emissions depending on Wi-Fi connection, while received signal quality differentially reduced emissions depending on call status. Legacy technologies (2G, 3G) were associated with higher emissions than 4G. Results varied across centers. Smartphone brand, operator, and Android version showed no independent association with emitted power after System-on-Chip adjustment. These findings demonstrate that real-life smartphone radiofrequency electromagnetic cellular emissions are shaped by a complex interplay of usage patterns, network conditions, and device characteristics.
https://doi.org/10.1016/j.envres.2026.125023

Personal radio frequency electromagnetic field exposure among Swiss adolescents in the 5G era,
Jalilian, H., Waibl, V. J., Wipf, I., Mootz, I., Abend, S., Diez, N. S., Veludo, A. F., Loizeau, N., Dongus, S., Guxens, M. and Röösli, M., *Environmental Research*, Aug 2026, Vol. 304.
Introduction: The rapid expansion of wireless technologies, including 5G, has introduced complex radiofrequency electromagnetic field (RF-EMF) exposure patterns, yet real-world data on personal

exposure in adolescents remain limited. This study, conducted within the HERMES3 (Health Effects Related to Mobile Phone Use in Adolescents) cohort, aims to characterize personal RF-EMF exposure among Swiss adolescents. Methods: A subsample of 143 adolescents participated in a personal measurement study between June 2023 and January 2025. Participants carried a personal exposimeter (ExpoM-RF4) for ca. 72-hours, to collect Geographic Positioning System coordinates and exposure data from 35 frequency bands. During this period, participants were asked to fill-out an electronic activity diary. Following data quality control, frequency bands were categorized by source and analyzed descriptively. Results: Mean and median daily total RF-EMF levels of 0.09 mW/m2 and 0.06 mW/m2, respectively, were measured. WiFi/Bluetooth contributed most to total exposure (35 %), followed by broadcast (31 %), uplink (19 %), downlink (10 %), time division duplex (4 %), and Digital Enhanced Cordless Telecommunications (0.7 %). Across environments, average RF-EMF exposure was highest in transport systems (0.47 mW/m2) and lowest at school (0.08 mW/m2) and home (0.07 mW/m2). Conclusion: Despite widespread 5G deployment, overall personal exposure among adolescents remains similar to pre-5G levels, with variations mainly reflecting user behavior and network density. However, this should not be interpreted as a direct causal estimate of the independent effect of 5G deployment. Personal measurements underestimate exposure contributions from sources emitting close to body. https://doi.org/10.1016/j.envres.2026.124775

Combined Experimental-Numerical Spatio-Temporal Mapping of RF-EMF Exposure in City Environments,
Leeman, M., Deprez, K., Van Der Straeten, J., Verlaek, M., Goethals, M., Van Campenhout, K., Vermeeren, G. and Joseph, W., *Ieee Open Journal of the Communications Society*, 2026, Vol. 7, p. 5840-5857.
The rollout of 5G has increased spatial and temporal variability in RF-EMF exposure due to higher frequency bands, beamforming, and denser deployments, challenging conventional maps that rely only on simulations or sparse measurements. We present a hybrid framework that fuses deterministic ray-tracing with heterogeneous data (static sensor node data gathered over a two-year period, a mobile spectrum analyzer (SA) campaign, and personal exposimeter measurements) to generate high-resolution spatio-temporal exposure maps for a dense urban area of 2.5 km2. At its core is the Mean-Matched Gradient-Preserving Optimization (MMGPO), which estimates a smooth multiplicative correction field over the simulated grid to remove bias while preserving logarithmic gradients. When validated against 28 independent SA measurements, MMGPO achieves an RMSE=5.47 dB and correlation r=0.70 for the total electric field exposure over all frequency bands. By incorporating temporally varying node data, this approach provides policymakers, researchers, and the public with reliable, high-resolution exposure assessments across multiple time windows, capturing spatial detail while reflecting temporal variations in modern wireless networks. https://doi.org/10.1109/ojcoms.2026.3695293

Realistic EMF Exposure Estimation from Low Density Sensor Network by Finite & Infinite Neural Networks
Mallik, M., Clavier, L., Gaillot, D. P. and Ieee (2025). 19th European Conference on Antennas and Propagation-EUCAP-Annual, Stockholm, SWEDEN.
Understanding the spatial and temporal patterns of environmental exposure to radio-frequency electromagnetic fields (RF-EMF) is essential for conducting risk assessments. These assessments aim to explore potential connections between RF-EMF exposure and its effects on human health, as well as on wildlife and plant life. Existing research has used different machine learning tools for EMF exposure estimation; however, a comparative analysis of these techniques is required to better understand their performance for real-world datasets. In this work, we present both finite and infinite-width convolutional network-based methods to estimate and assess EMF exposure levels from 70 real-world sensors in Lille, France. A comparative analysis has been conducted to analyze

the performance of the methods' execution time and estimation accuracy. To improve estimation accuracy for higher-resolution grids, we utilized a preconditioned gradient descent method for kernel estimation. Root Mean Square Error (RMSE) is used as the evaluation criterion for comparing the performance of these deep learning models. https://hal.science/hal-05150287

Computational dosimetry of electromagnetic and thermal exposure for pacemaker wearers in vehicle-to-vehicle environments,
Song, Y. X. and Lu, M., *Electromagnetic Biology and Medicine*, 2026.
This study conducts a quantitative safety assessment for pacemaker wearers by evaluating their electromagnetic and thermal exposure to vehicle-mounted antennas in a realistic Vehicle-to-Vehicle (V2V) communication scenario. An integrated exposure scenario comprising a vehicle with a V2V antenna, an implanted cardiac pacemaker, and an anatomical human model is constructed using COMSOL Multiphysics (R). Coupled simulations of radiofrequency electromagnetic fields (RF-EMF) and bioheat transfer are conducted to compute the specific absorption rate averaged over 10g of tissue (SAR10g) and the induced temperature rise. The results indicate that the peak SAR10g occurs in the superficial tissues at the skin of the left ear, which is the region closest to the antenna and the vehicle's side window. The peak SAR10g of skin tissue is 0.067 W/kg, which accounts for 3.35% of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) public exposure limit of 2 W/kg. Cardiac exposure SAR10g peaks at a significantly lower value of 0.19 mW/kg. The maximum temperature rise at the critical pacemaker lead-electrode interface is 0.061 degrees C, substantially below the International Organization for Standardization (ISO) 14708-2 safety threshold of 2 degrees C. The corresponding temperature increase within the heart tissue is merely 0.059 degrees C. All evaluated exposure values comply with ICNIRP guidelines for general public exposure. The findings indicate that the modeled V2V communications do not pose a health risk from RF-EMF exposure to pacemaker wearers in the investigated scenario, thereby providing key data to alleviate their travel safety concerns in current environments.
https://doi.org/10.1080/15368378.2026.2695362

Exposure to Electromagnetic Radiation from a 4G Smart Helmet,
Stankovic, V., Jovanovic, D., Jevtic, A., Raos, M. and Zivaljevic, D., *Tehnicki Vjesnik-Technical Gazette*, Jun 2026, Vol. 33, no. 4, p. 1486-1493.
This paper discusses the impact of electromagnetic radiation from a smart 4G (fourth-generation mobile network) helmet on human head tissues and organs. The research was conducted at a 4G mobile network frequency of 2,6 GHz. The software used for creating 3D numerical models of the head, helmet, and 4G antenna is based on the Finite Integration Technique. The head model comprises homogeneous, isotropic domains corresponding to tissues and organs, designated by electromagnetic properties specific to the assigned radiation frequency. The helmet model was created based on the dimensions of a real sample and the corresponding specifications of the material from which it was made. The simulation results show increased values of electric field intensity and SAR (Specific Absorption Rate) in tissues directly beneath the 4G antenna of the smart helmet. The obtained results serve as a basis for future research on the impact of electromagnetic field from 4G helmets on human health. https://doi.org/10.17559/tv-20250419002609

Urban radio-frequency electromagnetic field exposure in New York City,
Thielens, A., Davi, S., Hema, S. and Toledo-Crow, R., *Environmental Research*, Sep 15 2026, Vol. 306.
This study investigates Radio Frequency Electromagnetic Field (RF-EMF) exposure across New York City's five boroughs. The RF-EMF exposure was measured in 39 bands across the 88 MHz to 5.925 GHz frequency range using an exposimeter fixed in a backpack that was worn during walks along 38

predetermined paths in various representative urban environments of the city from September 2024 to May 2025. We calculated the summary statistics (minimum, p25, arithmetic mean, geometric mean, median, p25, p50, p75, p90, standard deviation) in units of electric field strength (V/m) and compared RF-EMF exposure quantitatively across urban environment type: commercial, residential, greenery, train underground, water ferry, indoor; across the five boroughs of the City: Manhattan, Brooklyn, Queens, Bronx, and Staten Island; and across six technology categories: radio and TV broadcast, cellular downlink, cellular uplink, WiFi (WLAN), Time Division Duplex (TDD), and Total Exposure. We also analyzed whether population density and foot traffic in each area correlate with RF-EMF exposure. A mean total RF-EMF exposure of 0.97 +/- 0.88 V/m was measured in NYC. We found that cellular downlink is the dominant contributor to mean environmental exposure, accounting for 45% to 55% of the total exposure in each borough. We found a moderate positive correlation (rho = 0.5, p-value <0.05) between exposure and foot traffic, and a weak or negligible, but statistically significant, positive correlation (rho = 0.1, p-value <0.05) between exposure and domiciled population density. The study provides a detailed assessment of the RF-EMF exposure levels in various urban environments offering a clearer understanding of the extent of exposure in a densely populated city like New York where wireless communication networks are continuously expanding. These results are important for policymakers when establishing RF exposure guidelines for the population of NYC and other urban areas in North America.
https://doi.org/10.1016/j.envres.2026.125040

Toxicité

Non-ionizing radiation and cancer: A review on current evidence, mechanistic insights, and public health implications,
Agrahari, M., Gupta, S., Thakur, G., Tanwar, S., Gautam, R. and Arora, T., *Biochemistry and Biophysics Reports*, Sep 2026, Vol. 47.
Non-ionizing radiation (NIR) generated from the high power transmission lines, broadcasting antennas and cellular phones represent one of the widespread environmental exposures which can induce carcinogenic outcome. Although NIR lacks sufficient energy to dislodge the electrons for ionization, an indirect mechanism has been proposed to be involved in adverse outcomes under certain exposure conditions. Consequently, radiofrequency electromagnetic field (RF-EMF) exposure remains a consistent scientific and public health concern regarding its possible role in cancer manifestation. This review aims to analyze the findings of RF-EMF exposure and carcinogenicity by integrating epidemiological studies and experimental findings to demonstrate its potential function in cancer manifestation.The available evidence is not sufficient to conclude that RF-EMF exposure is a direct-acting genotoxic carcinogen or cancer initiator. However, laboratory studies have indicated that long-term exposure to non-thermal RF-EMF can cause oxidative stress, genomic instability, epigenetic alterations, ion transport disruption and dysregulation of cell-signaling pathways. These biological effects may contribute to the promotion and progression stages of carcinogenesis, but are not directly responsible for tumor/ cancer initiation. The epidemiological evidence significantly varies between extremely low-frequency magnetic fields (ELF-MF) and radiofrequency electromagnetic fields (RF-EMF). Although ELF-MF exposure has demonstrated a more reliable association with childhood leukemia, the data connecting RF-EMF exposure to cancer is less consistent.Studies with the larger sample size and increased exposure duration are needed to strongly corroborate its involvement in cancer development.
https://doi.org/10.1016/j.bbrep.2026.102705

Biological Effects of High-Frequency Electromagnetic Fields on CNS Function and Neuroimmune Responses: A Systematic Review of In Vitro and In Vivo Experimental Studies,
Fang, S. H. and Chen, S. H., *Neurotoxicity Research*, Jul 8 2026, Vol. 44, no. 4.

Background the deployment of fifth-generation (5G) wireless telecommunications infrastructure, incorporating millimeter-wave (mmWave, 24-100 GHz) and sub-6 GHz frequencies, has renewed scientific and public health interest in the potential neurobiological effects of radiofrequency electromagnetic fields (RF-EMF). While extensive research has examined lower-frequency RF-EMF from 2G/3G/4G technologies, the specific effects of mmWave frequencies on CNS cellular biology-including microglial polarization and intracellular calcium signaling-remain less characterized. This systematic review evaluates experimental evidence from in vitro and in vivo studies on the effects of high-frequency EMF (300 MHz-300 GHz) on neuroimmune responses, microglial function, CNS calcium homeostasis, and related outcomes. Methods PubMed, EMBASE, Web of Science, and the EMF-Portal were searched from inception to January 2026 following PRISMA 2020 guidelines. Experimental (in vitro and animal) studies reporting CNS-relevant outcomes after high-frequency RF-EMF exposure were eligible. Exposure must have been within the 300 MHz to 300 GHz range. Quality assessment used adapted OHAT risk-of-bias criteria. A narrative synthesis was conducted; quantitative pooling was performed where three or more studies reported the same outcome. Results forty-one studies met inclusion criteria (see PRISMA Flow Diagram, Fig. 1): 7 in vitro (cell culture), 29 in vivo (rodent model), and 5 reviews/meta-analyses. The detailed characteristics of all included studies are summarized in Table 1. At specific absorption rate (SAR) levels at or below the International Commission on Non-Ionizing Radiation Protection (ICNIRP) general public exposure guidelines (2 W/kg averaged over 10 g), the majority of studies (27/41, 66%) found no statistically significant effects on neuroinflammatory markers, microglial morphology, or calcium signaling. Eleven studies (27%) reported transient, low-magnitude increases in intracellular Ca & sup2;(+) or pro-inflammatory cytokine expression at exposures near or exceeding guideline limits; these effects were not consistently reproducible across independent laboratories. Three studies (7%) reported effects below guideline thresholds that may warrant further investigation. No study identified neuropathological changes (neuronal death, axonal injury) attributable to RF-EMF at guideline-compliant exposures. Conclusions current experimental evidence does not establish that high-frequency RF-EMF at guideline-compliant exposure levels produces significant adverse effects on microglial polarization, CNS calcium homeostasis, or neuroinflammatory responses. Methodological heterogeneity, inadequate dosimetry, and limited independent replication constrain confidence in both positive and negative findings. Standardized, rigorously controlled experimental studies are needed, particularly for mmWave frequencies (> 6 GHz) where data are sparse. Our findings support the current scientific consensus that high-frequency RF-EMF below regulatory limits does not pose a clearly established neurobiological hazard. https://doi.org/10.1007/s12640-026-00810-5

Interpretation of Epidemiological Studies on the Relationship Between Mobile Phone Use and Cancer,
Kundi, M. and Hutter, H. P., *Epidemiologia*, Jun 2026, Vol. 7, no. 3.
Background: In May 2011 the IARC (International Agency for Research on Cancer) classified radiofrequency electromagnetic fields as a possible human carcinogen mainly based on epidemiological studies about the association between mobile phone (MP) use and brain tumors. Considering that brain tumors have long latencies of around 30 years, it is unlikely that this association is due to an 'initiating' activity of MPs since virtually all studied brain tumor cases must have had already a covertly growing tumor when they started MP use. But there could be other adverse effects exerted by a MP when acting on later stages of malignant development. We propose that MP use acts adversely by increasing tumor growth rate and model it by an impact on the latency distribution shifting the age-incidence function to younger age. Methods: We calculate (1) relative risks (RRs) for MP use in comparison to the meta-analytic RR estimate for glioma in adults; (2) RRs for neuroepithelial childhood brain tumors in comparison to the findings of the MOBIkids study; and (3) hazard ratios in comparison to the results of the Million Women Study (MWS). Results: The meta-analytical odds ratio for glioma and long-term MP use in adults of 1.22

(95% confidence-interval: 1.02-1.46) could be explained by a shift in the age-incidence function by 32% of MP usage duration. Applying a 20% shift for childhood neuroepithelial brain tumors reproduced the ORs that were predominantly less than 1 in the MOBIkids study. For glioma risk in perimenopausal women in relation to long-term MP use in the MWS we found hazard-ratios close to 1 applying a 32% shift in the age-incidence function. Conclusions: The standard interpretation of relative risk estimates must be revised if exposure to the agent commenced after the malignant development has already started. All reported RR estimates of MP use can be reproduced by positing MP use increased tumor growth rate. However, since these results are obtained applying a modeling approach, further tests using epidemiological methods, which will be difficult or hardly feasible, or utilizing more promising laboratory methods are needed.
https://doi.org/10.3390/epidemiologia7030086

Impact of low-frequency electromagnetic fields on DNA instability caused by environmentally and occupationally relevant chemicals in lymphocytes of donors with different demographic characteristics,
Misík, M., Kundi, M., Ferk, F., Hutter, H. P., Nersesyan, A., Grusch, M. and Knasmueller, S., *Archives of Toxicology*, 2026.
Aim of this study was to find out if demographic factors (age and body weight) have an impact on the sensitivity of peripheral lymphocytes towards DNA damage caused by extremely low frequency electromagnetic fields (ELF-EMF), to which humans are exposed worldwide. Cells from three different groups (young normal-weight, young obese, and old normal-weight individuals) were treated with different intensities of ELF-EMF (50 Hz, 50, 200 and 1000 µT) in combination with genotoxic agents, which cause damage to the genetic material via different molecular mechanisms. BPDE (benzo[a]pyrene diol epoxide) is a metabolite of the polycyclic aromatic hydrocarbon benzo(a)pyrene (B(a)P); 4-nitroquinoline oxide (4NQO) is a UV-mimetic agent; the metal compounds NiCl2 and CrO3 induce cross-links and oxidative damage. The cells were treated with radiation in combination with the different chemicals (simultaneous and sequential exposure), subsequently, DNA damage was monitored using single-cell gel electrophoresis (SCGE) experiments. We found no evidence for induction of genetic damage by the radiation in cells from the different groups. However, a decrease of damage was observed in combined experiments with NiCl2, and an increase of DNA migration was detected in some experiments with BPDE. These findings indicate that ELF-EMF does not cause DNA damage in lymphocytes regardless of the age and body weight of the donors. Furthermore, our results show that the radiation has an impact on the extent of DNA damage caused by specific environmentally and occupationally relevant exposures and may increase the genotoxic effects of polycyclic aromatic hydrocarbons.
https://doi.org/10.1007/s00204-026-04509-6

Electromagnetic and Thermal Characterization of a 3 GHz TEM Cell for Observing Microwave-Induced Thermoelastic Expansion of Tissue,
Roper, C. J., Hagness, S. C. and Ma, C., *Ieee Journal of Electromagnetics Rf and Microwaves in Medicine and Biology*, 2026 2026.
In this study we present the design, multi-physics simulation, and experimental validation of a custom 3 GHz transverse electromagnetic (TEM) cell developed for real-time monitoring of pulsed-microwave-induced thermoelastic expansion in biological tissue. The TEM cell configuration enables high-resolution thermal and mechanical deformation data collection during pulsed microwave exposure through its open design that allows contact-free infrared imaging and the inclusion of a glass-covered aperture for viewing the tissue response via an inverted microscope. A key innovation of this work is a compact and thermally isolated waveguide design, demonstrated through both simulation and experiments, that provides uniform power absorption in the tissue across the microscope's field of view and ensures that the only source of heating is microwave pulse

absorption. This TEM cell forms the foundation for future investigations with an experimental dosimetry system capable of capturing and elucidating the thermoelastic response of tissue during pulsed microwave exposure. https://doi.org/10.1109/jerm.2026.3693468

Experimental and clinical evidence on radiofrequency electromagnetic field effects on the blood-brain barrier: a scoping review,
Simsek, E. T., Sumser, K., Mansourinezhad, P., Kayhan, H., Paulides, M. M. and Buyukatalay, E. O., *Physics in Medicine and Biology*, May 2026, Vol. 71, no. 10.
Objective. This scoping review evaluates evidence on whether radiofrequency electromagnetic field (RF-EMF) exposure influences blood-brain barrier (BBB) permeability. Given inconsistent findings across decades of research and expanding wireless technology use, we summarize results from in vivo, in vitro, and human studies with emphasis on exposure characterization and thermal control. Methods. Literature covering RF-EMF exposures from similar to 900 MHz to frequencies relevant for emerging wireless systems was surveyed. Due to substantial heterogeneity in exposure conditions, i.e. specific absorption rates from 0.01 to >10 W kg(-1), diverse modulation schemes, and varied biological endpoints, we performed a qualitative synthesis supported by a methodological audit focusing on dosimetric rigor, temperature monitoring, and sham-control implementation. Results. Findings remain mixed: seventeen studies reported increased BBB permeability or molecular alterations, while eighteen observed no effects. Null-result studies generally applied stricter dosimetry and thermal safeguards, though incomplete temperature documentation was common. Some in vitro studies suggest effects on tight-junction proteins or cellular stress pathways, but these outcomes show limited reproducibility in animal models. Human data are sparse and do not clearly differentiate thermal from non-thermal influences. Conclusion. Current evidence does still not establish a causal link between RF-EMF exposure and BBB disruption. Persistent methodological variability limits interpretability. Future work should employ rigorous exposure characterization, validated BBB biomarkers, and robust thermal and sham controls, and address gaps at higher frequencies and in vulnerable populations (prenatal, elderly). https://doi.org/10.1088/1361-6560/ae6e17

Evaluation of the Effect of Electromagnetic Fields Emitted by Electric Vehicles on Cardiac Pacemakers,
Soucek, T., Urbancík, A. and Krcmár, L., *Pace-Pacing and Clinical Electrophysiology*, 2026.
Pacemakers can be affected by external electromagnetic fields in some cases. For this reason, it is necessary to know the potentially risky sources of interfering fields and the effect they may have on the patient's health. The aim of this paper is to evaluate the risks of using electric vehicles by patients with pacemakers. Measurements of electric and magnetic field strengths were performed in selected models of electric vehicles. Using a custom-built human body phantom and three explanted Biotronik pacemakers, we assessed whether the emitted fields could affect pacemaker function and whether any observed effects were clinically relevant. Both experiments were conducted under the maximum load in model situations: in the driver and passenger seats, in the back seat and near the charging cable during charging. The electric and magnetic fields detected were not assessed as significant in terms of risk to the pacing system. This study presents preliminary results obtained using pacemakers from a single manufacturer. Based on the monitored electrograms and pacing parameters, no impact on pacemaker function was identified in the three tested Biotronik devices. https://doi.org/10.1111/pace.70359

A Narrative Review on the Influence of Electromagnetic Fields Below 100 kHz on the Endocrine System,
Tojza, P. M., Redlarski, G., Litzbarski, L. S. and Czaplinski, M., *Applied Sciences-Basel*, May 2026, Vol. 16, no. 10.

Featured Application While our article is a review, it brings many important ideas for further consideration. Due to the ubiquity of low-frequency electromagnetic fields in everyday human environments, exposure to them is largely unavoidable. Their biological effects are still not fully understood. This work analyzes the relationship between low-frequency electromagnetic fields and the human endocrine system. As the endocrine system is responsible for regulating and maintaining the human body, its potential dysregulation may result in significant adverse health effects. This manuscript summarizes the existing studies addressing this topic and highlights several promising directions for future research.Abstract Background: Extremely low-frequency electromagnetic fields (ELF-EMFs), generated mainly by power infrastructure and household devices, have raised scientific interest due to their potential impact on the endocrine system. Animal research consistently shows effects on melatonin secretion, stress hormone levels, thyroid activity, and reproductive function-largely mediated by oxidative stress and calcium ion imbalance. In contrast, human studies remain inconsistent, often hindered by methodological limitations and insufficient exposure characterization. Objective: This review synthesizes experimental and epidemiological studies examining low-frequency electromagnetic field exposure (<= 100 kHz) and its influence on hormonal regulation. Methods: A bibliometric analysis highlights focused interest on specific endocrine targets, particularly the pineal gland. Importantly, many experimental studies use field strengths above those found near high-voltage power lines, limiting direct applicability. Conclusions: While a definitive causal link has not been established, the widespread exposure to low-frequency electromagnetic fields justifies precautionary considerations. Several important research gaps remain, many of which are identified in this review. The topic of low-frequency electromagnetic field effects on the endocrine system requires more rigorous, long-term human studies with accurate exposure assessment. https://doi.org/10.3390/app16104910

Transient biological response of human mesenchymal stem cells to a single wideband high-power electromagnetic pulse exposure: a preliminary study,
Trebinska-Stryjewska, A., Dobrzynska, M., Lewandowski, R. B., Kasprzycka, W., Stepinska, M., Osuchowska, P. N., Osuchowski, L. P., Starzynski, J., Mierczyk, Z. and Trafny, E. A., *Frontiers in Cell and Developmental Biology*, Jul 2 2026, Vol. 14.
This preliminary study examines the effects of a single wideband high-power electromagnetic (HPEM) pulse on human bone marrow-derived mesenchymal stem cells (hBM-MSCs). The exposure was designed to emulate a realistic electromagnetic exposure scenario involving a magnetocumulative generator, a non-repetitive but extremely high-energy source. The pulse, characterized by a peak field of 1 MV/m, 120 ns pulse width, and 50 MHz center frequency, was applied to hBM-MSCs primary cell lines. We assessed cellular morphology, viability, proliferation, mitochondrial function, oxidative stress, DNA damage, and gene expression at various time points post-exposure. Our findings indicate no observable changes in cell morphology, viability, or proliferation compared to control and sham-treated cells. Mitochondrial membrane potential was unaffected by exposure; however, a consistent increase in mitochondrial superoxide production was observed, with a main effect of treatment across both cell lines. DNA damage assessments revealed no detectable induction of single- or double-strand breaks. Gene set enrichment analysis identified transient upregulation in gene sets related to cell cycle progression and oxidative phosphorylation immediately post-exposure, though these effects were not sustained. Overall, a single HPEM pulse did not cause lasting detrimental effects on hBM-MSCs. However, subtle and transient biological responses were observed, highlighting the need for further investigation into the effects of electromagnetic pulses on human cells. https://doi.org/10.3389/fcell.2026.1873951

Gender Differentiation Based Mobile Terminal Electromagnetic Exposure Safety Analysis and Corresponding Antenna Miniaturized-Based Protective Measures,

Zhou, W. Y., Luo, M. F., Wang, P. P., Li, Y. X. and Lu, M., *Bioelectromagnetics*, May 2026, Vol. 47, no. 4.
The rapid development of 5 G technology raises concerns about near-field electromagnetic exposure from mobile terminals, especially its potential risks to reproductive and vital organs. However, gender-based differences in tissue dielectric properties and their impact on exposure are often overlooked. This study has two main objectives: to analyze the influence of gender differences on near-field electromagnetic exposure, with a particular focus on key tissues, by calculating gender-specific dielectric properties of different organ tissues; and to propose antenna miniaturization as an active electromagnetic protective measure for reducing specific absorption rate (SAR). This study employs finite element modeling to construct male and female human models, incorporating reproductive systems and key organs, to evaluate SAR before and after the miniaturization of a MIMO mobile terminal antenna at 2.6 GHz and 3.5 GHz. The results show that SAR values in male tissues, particularly in reproductive organs, are significantly higher than in female counterparts. Antenna miniaturization effectively reduces peak SAR by over 30% in multiple tissues, demonstrating its role as an active electromagnetic protective measure. This work highlights gender differences in electromagnetic exposure and confirms the feasibility of antenna miniaturization for improving mobile terminal safety design. https://doi.org/10.1002/bem.70055

Méthodes

Field Reconstruction for High-Frequency Electromagnetic Exposure Assessment Based on Deep Learning,
Cao, M., Liu, Z. C., Matkerim, B., Wu, T. N., Li, C. Y., Zong, Y. L. and Qi, B., *Ieee Transactions on Antennas and Propagation*, Jul 2026, Vol. 74, no. 7, p. 6954-6966.
Fifth-generation (5G) communication systems, operating in higher frequency bands from 3 to 300 GHz, provide unprecedented bandwidth to enable ultrahigh data rates and low-latency services. However, the use of millimeter-wave frequencies raises public health concerns regarding prolonged electromagnetic radiation (EMR) exposure. Above 6 GHz, the incident power density (IPD) is used instead of the specific absorption rate (SAR) for exposure assessment, owing to the shallow penetration depth of millimeter waves. This article proposes a hybrid field reconstruction framework that integrates classical electromagnetic algorithms with deep learning to evaluate the IPD of wireless communication devices operating at 30 GHz, thereby determining compliance with established RF exposure limits. An initial estimate of the electric field on the evaluation plane is obtained using a classical reconstruction algorithm, followed by refinement through a neural network model that learns the mapping between the initial and accurate values. A multiantenna dataset, generated via full-wave simulation, is used for training and testing. The impacts of training strategy, initial-value algorithm, reconstruction distance, and measurement sampling density on model performance are analyzed. Results show that the proposed method significantly improves reconstruction accuracy, achieving an average relative error (RE) of 4.57% for electric field reconstruction and 0.12 dB for peak spatial-average IPD estimation on the test dataset. Additionally, the effects of practical uncertainty factors, including probe misalignment, interprobe coupling, and measurement noise, are quantitatively assessed.
https://doi.org/10.1109/tap.2026.3681071

EMFusion: Uncertainty-Aware Conditional Diffusion Model for Multivariate Narrow-Band Exposure Forecasting,
Yan, Z. J., Huang, Y. X., Pei, J. H., Tabassum, H. and Chiaraviglio, L., *Ieee Transactions on Network Science and Engineering*, 2026 2026, Vol. 13, p. 10289-10307.
The rapid growth in wireless infrastructure has increased the need to accurately estimate and forecast electromagnetic field (EMF) levels to ensure ongoing compliance, assess potential health

impacts, and support efficient network planning. While existing studies rely on univariate forecasting of wideband aggregate EMF data, multivariate narrow-band EMF forecasting is needed to capture the inter-operator and inter-frequency variations essential for proactive network planning. To this end, this paper introduces EMFusion, a conditional diffusion-based EMF forecasting framework that integrates diverse contextual factors (e.g., time of day, season, and holidays) while providing uncertainty-aware probabilistic forecasts. The proposed architecture features a residual U-Net backbone enhanced by a cross-attention mechanism that dynamically integrates external conditions to guide the generation process. Furthermore, EMFusion integrates an imputation-based sampling strategy that treats forecasting as a structural inpainting task, ensuring temporal coherence even with irregular measurements. Unlike standard point forecasters, EMFusion generates empirical probabilistic prediction intervals from the learned conditional distribution, providing uncertainty-aware probabilistic forecasting rather than simple point estimation. Numerical experiments conducted on the multivariate narrow-band EMF datasets demonstrate that EMFusion with the contextual information of working hours outperforms the baseline models with or without conditions. The proposed EMFusion outperforms the best baseline by 23.85% in continuous ranked probability score (CRPS) and 13.93% in normalized root mean square error. https://doi.org/10.1109/tnse.2026.3707403

Toxicité sur les animaux

Impact of 2.45 GHz Wi-Fi Radiation on Primordial Follicles in Female Rats: Protective Role of Folic Acid and Vitamin D,
Karabas, S. A., Yoldas, A., Dag, S. S., Yaylali, A., Çelik, I. S. and Sögüt, Ö., *International Journal of Morphology*, Apr 2026, Vol. 44, no. 2, p. 645-653.
This study investigates the impact of 2.45 GHz Wi-Fi radiation on ovarian primordial follicles in female rats and explores the potential protective roles of folic acid and vitamin D. A total of 42 female offspring rats, derived from six experimental groups, were analyzed for histopathological, immunohistochemical, and biochemical changes following prenatal exposure to Wi-Fi radiation. Pregnant rats were exposed to Wi-Fi for 60 minutes daily throughout gestation, with folic acid and vitamin D administered to treatment groups at a dose of 5 mg/kg/day via oral gavage. Histopathological evaluation revealed a significant increase in atretic follicle count and a decrease in total follicle number in the Wi-Fi-exposed group compared to controls. Caspase immunostaining indicated increased apoptotic activity in the Wi-Fi group, whereas no significant difference was found between treatment and Wi-Fi-only groups. Biochemical analysis showed a significant reduction in Total Antioxidant Status (TAS) and an increase in Total Oxidant Status (TOS) in the Wi-Fi group, suggesting oxidative stress. However, folic acid and vitamin D did not significantly reverse these changes. No statistically significant alterations were observed in estrogen, Anti-Mullerian Hormone (AMH), or TGF-b1 levels across groups. In conclusion, prenatal Wi-Fi exposure may impair ovarian follicle development and induce oxidative stress in female rats. Neither folic acid nor vitamin D provided significant histological or biochemical protection under the tested conditions. Further studies are recommended to explore alternative antioxidants and varying exposure parameters.
https://doi.org/10.4067/s0717-95022026000200645

Corrigendum to "Effects of radiofrequency electromagnetic field exposure on cancer in laboratory animal studies, a systematic review" [Environ. Int. 199 (2025) 109482],
Mevissen, M., Ducray, A., Ward, J. M., Kopp-Schneider, A., Mcnamee, J. P., Wood, A. W., Rivero, T. M. and Straif, K., no. 1873-6750 (Electronic).
BACKGROUND: More than ten years ago, the World Health Organization's (WHO) International Agency for Research on Cancer (IARC) published a monograph concluding there was limited evidence in experimental animals for carcinogenicity of Radio Frequency Electromagnetic Field (RF

EMF). OBJECTIVE: The objective of this review was to systematically evaluate the effects of RF EMF exposure on cancer in experimental animals. METHODS: Eligibility criteria: Based on pre-established Populations, Exposures, Comparators, Outcomes, and Study Type (PECOS) criteria, studies in experimental animals of the following study types were included: chronic cancer bioassays, initiation-(co-)promotion studies, and studies with tumor-prone animals. DISCUSSION: Meta-analysis was considered inappropriate due to the heterogeneity in study methods. The GRADE/OHAT CoE framework has not been frequently applied to animal studies and experience to date suggests refinements are needed. We deferred to standard methods in environmental health where CoE is framed in the context of strength of the evidence providing positive support for carcinogenicity. High CoE can be interpreted as the true effect is highly likely to be reflected in the apparent relationship. Moderate CoE indicates the true effect may be reflected in the apparent relationship. Cancer bioassays conducted in experimental animals are commonly used to identify potential human carcinogens. We note that the two tumor types with high CoE in animals in this systematic review are the same as those identified with limited evidence in humans by the IARC Working Group. However, even in cases where the animal evidence demonstrates high CoE, the extrapolation of risk from cancer bioassays to humans is particularly complex for RF EMF. Without a better understanding of the mechanism of the carcinogenicity of RF-EMF, the choice of exposure metric for risk extrapolation (whole body versus localized), intensity or cumulative exposure whether or not a monotonic dose response holds for carcinogenic effects, and whether SAR is the appropriate dose metric for adverse effects induced by RF-EMF may be critical. OTHER: This review was partially funded by the WHO radioprotection programme. The protocol for this review was registered in Prospero reg. no. CRD42021265563 and published in Environment International 2022 (Mevissen et al., 2022). https://doi.org/10.1016/j.envint.2026.110368

Influence of radiofrequency electromagnetic radiation on spermatogenesis and sperm function in rodent models: A systematic review,
Naderi, N., Tavalaee, M., Far, P. H., Mokhtari, A. and Nasr-Esfahani, M. H., *Reproductive Toxicology*, Sep 2026, Vol. 144.
Infertility is increasing worldwide and has been associated with several lifestyle and environmental exposures, including radiofrequency electromagnetic radiation (RF-EMR). Because digital devices are often carried close to the body, possible effects on male reproduction remain a public health concern. This systematic review addressed the PECO question: how does RF-EMR exposure affect male fertility in rodent models? Studies published up to December 2025 were searched in PubMed, Google Scholar, SpringerLink, ScienceDirect, and Scopus (PROS-PERO: CRD42023417536). From 4220 records, screening and updated searches yielded 88 eligible studies. Methodological quality and risk of bias were assessed using SYRCLE's Risk of Bias tool. Included studies used multiple rat and mouse strains exposed to 800-24,000 MHz RF-EMR, with reported specific absorption rates of 0.014-34 W/kg. Exposure durations varied and were mainly subchronic. Evaluated outcomes included sperm parameters, oxidative stress biomarkers, lipid peroxidation, DNA damage, apoptosis, testicular histopathology, and hormonal indices. Oxidative and reproductive alterations were reported in subsets of studies; however, findings were heterogeneous and limited by uncertainties in allocation, housing, blinding, dosimetry, and outcome assessment. Current evidence suggests biologically plausible signals but does not support a uniform causal interpretation. Standardized, well-controlled studies are needed with comprehensive, clearly defined reproductive and fertility endpoints.
https://doi.org/10.1016/j.reprotox.2026.109300

Impact of 3G, 4G and 5G mobile phone radiation on brain and reproductive system of Wistar rat
Singh, K. V., Gautam, R., Jha, N., Nirala, J. P., Rajamani, P. and Ieee (2025). 2025 Microwaves Antennas and Propagation Conference-MAPCON-Annual, Kochi, INDIA.

Proliferation of cell phones has raised concerns regarding radio frequency radiation (RFR) exposure and its potential health effects on environment and human health. Young adolescents use it for longer durations, which exposes them to radiofrequency electromagnetic radiation (RF-EMR). This exposure may lead to neuropsychiatric changes. The underlying cellular mechanism behind these changes requires detailed investigation. Hence the present study, we investigated the effect of RF-EMR emitted from mobile phones on Wistar rat. Wistar rats (young adolescent and old male and female) were exposed to 3G, 4G and 5G mobile phone radiation (specific absorption rate (SAR) of 1.51 W/kg) for different durations. Various biochemical assays such as catalase, glutathione peroxidase, super oxide dismutase, level of inflammatory cytokines, corticosterone and hippocampus dependent memory, DNA strand breaks and morphological alteration etc. were performed in rat exposed to different frequencies of microwave radiation. Results show that a significant changes in the level of pro-inflammatory cytokines, hypothalamic pituitary adrenal axis (HPA) activity and oxidative stress in hippocampus of exposed rats. Exposed group showed changes in reproductive parameters in male rat and female rat.
https://doi.org/10.1109/mapcon65020.2025.11425030

The GR of CA1 is involved in anxiety-like behavior induced by 0.8/2.65 GHz dual-frequency electromagnetic radiation,
Sun, B., Xue, T., Liu, Y. N., He, S., Zhao, M. Y., Zhou, H. M., Gao, A. N., Wang, X. Y., Ma, Y., Li, Z. H., Dong, G. F. and Wang, C. Z., *Frontiers in Molecular Neuroscience*, Jun 22 2026, Vol. 19.
Introduction The proliferation of wireless communication has increased environmental exposure to complex radiofrequency electromagnetic radiation (EMR), sparking concerns about its impact on brain function and emotional regulation. Most studies use single-frequency paradigms that do not reflect real-world multifrequency exposure.Methods We developed a dual-frequency EMR mouse model (0.8/2.65 GHz, 4 W/kg, 4 h/day for 21 days) to evaluate behavioral, endocrine, neurophysiological, and molecular outcomes.Results Dual-frequency EMR induced anxiety-like behaviors without depression-like phenotypes, accompanied by hyperactivation of the hypothalamic-pituitary-adrenal (HPA) axis. Molecular analysis showed selective downregulation of glucocorticoid receptors (GRs) in the hippocampal CA1 region, while mineralocorticoid receptors (MR) and FKBP51 remained unchanged. GR overexpression in CA1 alleviated anxiety-like behavior, whereas GR knockdown exacerbated it and increased corticosterone levels. Effects were consistent in male and female mice, but functional validations were limited to males.Discussion Our findings indicate that CA1 GR signaling may mediate the link between dual-frequency EMR exposure, HPA axis dysregulation, and anxiety-like behavior, suggesting GR restoration as a potential therapeutic target for EMR-induced emotional disturbances. https://doi.org/10.3389/fnmol.2026.1779797

Evaluation of the Effects of 50 Hz Magnetic Field Exposure on the Human Hematopoietic System in Humanized Mice,
Takahashi, M., Nishimura, I. and Toda, T., *Bioelectromagnetics*, May 2026, Vol. 47, no. 4.
Accumulating evidence from experimental animal studies is essential for clarifying the causal relationship between exposure to power-frequency magnetic fields (MFs) and childhood leukemia. In this study, we developed a 50 Hz MF exposure system for experimental animals. To ensure uniform whole-body exposure of multiple animals placed at the center of the coil, we fabricated a Merritt-type coil. The maximum MF output inside the coil was 5 mT(rms), and spatial variation remained within +/- 2.5% of the target intensity. The system enabled stable exposure of experimental animals to uniform 50 Hz MFs while eliminating equipment-related artifacts. We then conducted exposure experiments using humanized mice, in which a human-like hematopoietic system was established by transplanting human hematopoietic stem and progenitor cells (HSPCs), to a 50 Hz, 5 mT(rms) MF for 2 months. After exposure, the chimerism rates of human leukocytes in hematopoietic organs of the MF-exposed group were comparable to those in the control group.

Furthermore, exposure to the 50 Hz MF did not affect early differentiation of human B cells in the bone marrow of humanized mice. These findings support our previous in vitro results and validate the use of humanized mice for evaluating the effects of power-frequency MFs on human hematopoiesis. This system is expected to evaluate the effects of 50 Hz MFs not only on normal human hematopoiesis in humanized mice but also under abnormal conditions such as preleukemic state induced by transplanting genetically modified HSPCs. https://doi.org/10.1002/bem.70054

Actualité, société et mesures de prévention

Exposition aux ondes radiofréquences : de nouvelles études précisent les connaissances sur le risque de cancer,
Références en Santé au Travail, mars 2026, no. 185.
L'Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail (Anses) vient de publier une actualisation de son expertise sur les effets des ondes radiofréquences, centrée sur le risque de cancer.
https://www.inrs.fr/media.html?refINRS=AC%20201

Les risques d'exposition aux rayonnements dans le BTP (Mise à jour du dossier sur le site Prévention BTP),
OPPBTP (juin 2026),
Les risques d'exposition aux champs électromagnétiques touchent tous les métiers du bâtiment et des travaux publics. Ces champs électromagnétiques génèrent des rayonnements non ionisants comme les appareils électriques ou la lumière, et des rayonnements ionisants comme les rayons X. Leurs effets peuvent aller du simple 'coup de soleil' (rayons UV) aux vertiges, nausées ou brûlures par rayonnements radioactifs. Bien sûr, les conséquences ne sont pas les mêmes. Petits ou grands risques, la protection est essentielle. https://www.preventionbtp.fr/ressources/risques/rayons-ultraviolets-uv-appareils-lasers-champs-electromagnetiques-les-risques-d-exposition-aux-rayonnements-sur-les-chantiers_MAeQKvG7QmGXQ3LJYNLyw5

Human health and electromagnetic radiation: The role of knitted yarns, fabrics, and garments - a critical review,
Ahmed, U., Fayyaz, H. B., Ullah, N., Hussain, T., Ahmad, S. and Khan, M. S., *Journal of Engineered Fibers and Fabrics*, May 2026, Vol. 21.
The usage of electronic devices connected with Wi-Fi has raised several concerns regarding electromagnetic pollution. Prolonged exposure to electromagnetic radiation has been associated with adverse effects on human health. Reported health issues include increased risk of anxiety, depression, sleep disturbances, and infertility. Protection against these harmful effects is essential, and textiles offer a promising solution. Since textile fabrics are in direct contact with the human body for extended periods, they must be soft, flexible, and non-toxic to ensure comfort and safety. The use of advanced conductive fibers can effectively attenuate harmful electromagnetic radiation. The aim of this review is to examine the impact of low-frequency electromagnetic radiation on human health and to explore the potential role of advance fibers and knitted fabrics in attenuating such radiation. This study also investigates the health issues associated with long-term exposure to low frequency range electromagnetic radiation. Various end use applications of knitted electromagnetic shielded fabrics, along with the materials used in their structures, were studied. Key parameters, as well as the machinery used in their production, were analyzed. The literature indicates that knitted fabrics hold significant potential for electromagnetic shielding applications due to their breathability, flexibility, elasticity, and the ability to control loop.
https://doi.org/10.1177/15589250261433247

Editorial: The 4th international expert forum on the public health and environmental impacts of cellular and wireless radiation exposure 2024,
Ben Ishai, P., Butler, T., Davis, D., Leszczynski, D. and Taylor, H., *Frontiers in Public Health*, 2026-June-10 2026, Vol. Volume 14 - 2026.
https://doi.org/10.3389/fpubh.2026.1856852

Investigation d'une suspicion d'agrégat de tumeurs cérébrales parmi les salariés d'une entreprise du numérique en Île-de-France. Période 2014-2019,
Conte, M., Marchand, J.-L. and Tarantola, A., *Santé Publique France* (juin 2026): 49 p.,
Le 11 avril 2019, le médecin du travail d'une entreprise spécialisée dans la fourniture de services numériques a signalé à l'Agence régionale de santé (ARS) d'Île-de-France, la survenue, depuis 2015, de plusieurs cas de gliomes parmi les salariés d'un des sites de l'entreprise localisé dans les Yvelines (78). Il indique suspecter l'exposition aux champs électromagnétiques comme pouvant avoir un rôle dans la survenue de ces cas. Suite à ce signalement, le 8 juillet 2019, Santé publique France a été destinataire d'une saisine conjointe de l'ARS et de la direction régionale des entreprises, de la concurrence, de la consommation, du travail et de l'emploi (Direccte) Île-de-France pour mener une investigation épidémiologique. L'agence a ainsi mené une investigation afin de recenser et documenter les cas, objectiver l'excès de cas et déterminer la présence ou non d'expositions susceptibles d'être reliées à cet excès, le cas échéant. https://www.santepubliquefrance.fr/regions-et-territoires/ile-de-france/enquetesetudes/investigation-dune-suspicion-dagregat-de-tumeurs-cerebrales-parmi-les-salaries-dune-entreprise-du

Health risks of radiofrequency electromagnetic fields, and the World Health Organization's programme,
Elwood, M. and Karipidis, K., The New Zealand medical journal 139(1638):91-99
Radiofrequencies (electromagnetic fields from 100kHz to 300GHz) are used for communications, such as mobile phones, radio and television broadcasting, and some other applications such as diathermy. Possible health effects have been studied extensively, especially whether the use of mobile phones increases the risk of brain cancer. The World Health Organization (WHO) has sponsored 13 extensive reviews of the scientific studies on health effects. For human epidemiological and some experimental studies on volunteers, the studies found no increased risk for most effects, with up to moderate confidence (the highest category for observational studies). Some results showed effects on cognitive performance and reduced sperm vitality, but with very low confidence. For animal studies, increases in glioma and heart schwannoma in male rats were reported with high confidence. Increases in some other cancers, and reductions in foetal weight, pregnancy rate and sperm count, were found with moderate or low confidence. The relevance of the animal studies to humans is a key issue. These reviews will be used by the WHO in risk assessment and setting guidelines for exposure and good practice.
https://www.researchgate.net/publication/410259272_Health_risks_of_radiofrequency_electromagnetic_fields_and_the_World_Health_Organization's_programme

Spotlight on EMF research: a literature review service by the German federal office for radiation protection.
Leymann, H. a.-O., Astanin, A., Baaken, D. a.-O., Belenki, D. a.-O., Deser, A. a.-O., Gernand, L., Geschwentner, D., Meyer, F. a.-O., Pophof, B. a.-O., Schmidt, J. a.-O., Weiser, E. a.-O., Wilsdorf-Koehler, H., Zang, M. a.-O. and Kuhne, J. a.-O., no. 1361-6498 (Electronic).
In the area of research on electromagnetic fields (EMFs) and health, decision makers and practitioners face an increasingly complex information landscape, characterised by high publication volumes, heterogeneous methods and the occasional spread of oversimplified claims. 'Spotlight on EMF Research', offered by the German Federal Office for Radiation Protection (BfS), wants to

support the EMF-interested community by providing regular, structured assessments of selected scientific publications. Spotlight on EMF Researchoffers concise summaries and critical commentaries, brief Literature Suggestions, comprehensive literature lists, and a quarterly newsletter aimed at regulators, advisory bodies, scientists, and other expert users. This article describes the underlying rationale and workflow, including regular database searches, AI-assisted categorisation, and an interdisciplinary editorial and review process. It also presents descriptive data on the screened and featured literature and summarises early user feedback. We discuss the systematic limitations and potential selection biases of the format, its implications for risk communication in a changing media landscape, and howSpotlight on EMF Researchcomplements existing scientific EMF literature information services. https://doi.org/10.1088/1361-6498/ae8aff

Risk perception of electromagnetic fields among school teachers and nursery school teachers: a mixed-methods study,
Lüthy, K., Riesmeyer, C., Kühn, J., Forster, F., Radon, K. and Weinmann, T., *Bmc Public Health*, Jun 23 2026, Vol. 26, no. 1.
Background Although there is no evidence for adverse health effects from non-ionising electromagnetic fields (EMFs) exposure below legal limits, this concern is widespread among the general population. School teachers and nursery school teachers are considered multipliers of health-related information as they impart knowledge to parents and children. However, there is a lack of knowledge about the risk perception regarding EMFs among these professional groups. The extent to which school teachers and nursery school teachers are in contact with questions concerning EMFs and health in their work has not been investigated. Nor is there any knowledge about the information level of school teachers and nursery school teachers regarding EMFs. Data on teachers' perception regarding EMFs is important though to meet information needs.Methods A cross-sectional study among school teachers and nursery school teachers in Germany was carried out in 2024, combining an online survey (N = 1400) with focus groups (N = 29). We calculated prevalence estimates for participants' risk perception, subjective information level, and EMFs relevance in everyday work with correction for non-response. Furthermore, we conducted a latent class analysis to identify types of EMFs risk perception.Results A third of all participating school teachers (32%) and nursery school teachers (33%) indicated that, in their view, EMF exposure below legal limits may cause adverse health effects. Five types of risk perception concerning EMFs were identified using latent class analysis, with the high risk perception class comprising 11% of the participants. Many school teachers (56%) and nursery school teachers (77%) perceived themselves as poorly informed about EMFs. The group discussions provided deeper insights and supported these findings. The interviews revealed that both professional groups had concerns about the health effects of EMFs. Knowledge of scientific evidence concerning EMFs and health was low. Moreover, the discussions revealed a desire for more information on EMFs and health.Conclusions A notable proportion of school teachers and nursery school teachers indicated considerable risk perception towards EMFs. Most participants indicated low subjective information levels, expressing a need for information on EMF health effects. Communication formats tailored to this target group should be developed and evaluated. https://doi.org/10.1186/s12889-026-27964-3

Conflicting views in experimental carcinogenesis: a commentary on design and methodological deficiencies in the follow-up validation studies on radiofrequency radiation,
Melnick, R. L., Moskowitz, J. M., Héroux, P. and International Commission on the Biological Effects of Electromagnetic, F., *Environmental Health*, 2026/07/29 2026, Vol. 25, no. 1, p. 66.
Conflicting views in experimental carcinogenesis often arise due to differences in study design among reported studies. For carcinogenicity assessments, regulatory agencies, such as the US Food and Drug Administration (FDA), and intergovernmental advisory organizations, such as the Organization for Economic Co-operation and Development (OECD), specify the use of at least three

dose levels plus control group for trend analyses, with the highest dose inducing a measurable toxic response. In addition, there needs to be a sufficient number of animals per group to have adequate power to detect a true carcinogenic effect. Departure from such recommendations can weaken the interpretations of study results. We examine here two recent carcinogenicity studies from Japan and Korea that were conducted following the positive carcinogenicity study of radiofrequency radiation (RFR) in experimental animals by the National Toxicology Program (NTP). The Japan and Korea follow-up studies used fewer animals per group, a single RFR exposure group, and a lower exposure level than the NTP study. Not surprisingly, while the NTP study revealed the carcinogenicity of RFR, the Japanese and Korean studies, which had reduced statistical power compared to the NTP study, issued conclusions conflicting with those of the more substantial NTP study on the health effects of RFR. In general, carcinogenicity studies with weaker doses, fewer exposure groups, and reduced statistical power should not be used to test the validity of more robust studies.
https://doi.org/10.1186/s12940-026-01324-5

Evolution of Human Exposure Research in Response to Changes in Radiofrequency Service
Moon, J. I. and Ieee (2025). 2025 Asia-Pacific Microwave Conference-APMC-Annual, Jeju, SOUTH KOREA.
With the rapid evolution of mobile communication technologies such as 5G and 6G, and the growing use of high-frequency bands and digital infrastructure, public concern about electromagnetic fields (EMFs) continues to rise. Due to uncertainties regarding potential health effects, particularly from high-frequency EMFs, there is an urgent need for objective and independent studies. This paper presents interdisciplinary research conducted by ETRI and partner institutions, focusing on the evolution of methods and findings related to the biological effects of EMFs.
https://doi.org/10.1109/apmc65046.2025.11378034

Electromagnetic interference safety margins of cardiac implantable electronic devices from electric vehicle charging stations,
Vivarelli, C., Ricci, F., Burriesci, G., D'agostino, S., Falsaperla, R., Calcagnini, G. and Mattei, E., *Europace*, May 2026, Vol. 28, no. 5.
Electric vehicle (EV) charging stations represent an increasingly common source of electromagnetic fields (EMFs) in public and domestic environments, raising questions about possible electromagnetic interference (EMI) with cardiac implantable electronic devices (CIEDs). Although recent clinical studies have not identified malfunctions during EV charging,1–6 the actual safety margin between real-world EMF exposure and the minimum interference thresholds defined by international standards remains unknown. This study reports a quantitative assessment of EMF-to-CIED coupling during AC and DC charging under worst case but realistic conditions, using on-site measurements and a sensorized physical twin of a pacemaker/defibrillator. The aim was to determine the induced voltage at the CIED input stage and to quantify the electromagnetic safety margin relative to ISO 141177 requirements.
https://doi.org/10.1093/europace/euag078

Design and Fabrication of Porous Polymer Gels Composites with Enhanced Electromagnetic Interference Shielding Performance,
Yu, Z. Y., Jiang, C. W., Zi, C. F., Li, G. G., Tao, M. W., Chen, Y. H., Hao, C. X., Li, S. J., Xing, P. Z. and Tian, Y. Q., *Acs Applied Engineering Materials*, Jun 2026, Vol. 4, no. 6, p. 3206-3217.
With growing concern over the potential health risks of electromagnetic radiation, the development of efficient and eco-friendly electromagnetic interference (EMI) shielding materials has become increasingly important. In absorption-dominated shielding systems, performance enhancement primarily arises from the synergistic dielectric and magnetic losses, while three-dimensional porous architectures effectively facilitate the internal attenuation of electromagnetic waves. In this study,

nickel was deposited onto graphene nanoplatelets through a dopamine-assisted electroless plating process, followed by the incorporation of carbon fibers (CF) and nickel-coated graphene nanoplatelets (GNP@PDA@Ni) into a poly(vinyl alcohol) (PVA) matrix to form a flexible PVA/CF/GNP@PDA@Ni(PCGN) polymer gels system. Experimental results demonstrate that the PCGN-15 gel achieves an EMI shielding effectiveness (SE) of 45 dB in the X-band with an absorption-dominated mechanism (A/R > 1). Furthermore, the PCGN-25 composite exhibits a superior SE of 75 dB, effectively blocking 99.99% of microwave radiation, which meets the stringent requirements for radio frequency devices and electronic communications. Notably, the PCGN polymer gels also display robust mechanical properties, the elongation at break reaches 264%, and the tensile strength reaches 273 kPa and excellent flexibility at low temperatures (-20 degrees C), indicating their suitability for diverse environmental conditions. These attributes collectively highlight the material's potential for future deployment in advanced electromagnetic protection systems and emerging flexible electronic technologies. https://doi.org/10.1021/acsaenm.6c00340