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Exposition professionnelle

Enhanced Radiation Exposure of Airline Crew and Passengers During the May 2024 Geomagnetic Storm,

Aryan, H., Bortnik, J., Tobiska, W. K., Mehta, P., Hogan, B., Siddalingappa, R. and Challa, H., *Journal of Geophysical Research-Space Physics*, Jan 21 2026, Vol. 131, no. 1.

Enhanced radiation at aviation altitudes is a concern for flight crew and passengers. During space weather events, solar flares and coronal mass ejection (CME) driven shocks are sources of energetic particles that can reach Earth's near-space environment and interact with its magnetic field and atmosphere. Although Earth's magnetic field and atmosphere offer some protection, at high aviation altitudes and particularly near the poles, this shielding effect is weaker leading to increasing radiation exposure and related health risks. In this study, we use data from the Automated Radiation Measurements for Aerospace Safety (ARMAS) instrument onboard a commercial United Airlines flight from San Francisco to Paris that deviated its flight path to mitigate the risk of increased radiation doses during the extreme geomagnetic storm in May 2024. This allows investigation of how the crew and passengers may have experienced enhanced radiation onboard the aircraft. For comparison, we estimate radiation exposure for an alternative flight from

San Francisco to Paris around the same time that did not deviate from its planned path. The results show that during the 10 May 2024 geomagnetic storm, ARMAS measured sporadic high absorbed dose rates onboard the deviated flight. However, exposure could have been significantly higher (up to three times higher) if the airline had not deviated to lower latitudes, highlighting the need for precautionary measures during space weather events. Additionally, it is shown that precipitating electrons from the Van Allen radiation belts may significantly contribute to radiation levels at flight altitudes during enhanced geomagnetic activity. <https://doi.org/10.1029/2025ja034217>

Quality of life and physical activity levels of musculoskeletal disorders in workers exposed to high and low frequency magnetic fields: A comparative study,

Çankaya, M. and Cingöz, H. T., *Work-a Journal of Prevention Assessment & Rehabilitation*, 2026.

Background The increased use of electronic devices and technological advances has led to greater exposure to electromagnetic fields (EMF) in various occupational environments. *Objectives* The study's objective was to assess the effect of work-related musculoskeletal disorders (WMSD) on the quality of life and physical activity levels of individuals exposed to high-frequency magnetic fields. *Methods* The mean age of one hundred and twenty EMF exposed workers was 37.44 +/- 9.16 years. The following were assessed: musculoskeletal symptoms in the last 12 months (using the Extended Nordic Musculoskeletal Questionnaire Version (ENMQ) and the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ), working posture (Ovako Working Posture Analysis System (OWAS), physical activity level (International Physical Activity Questionnaire Short Form (IPAQ-Sf), and quality of life (World Health Organization Quality of Life Scale (WHOQOL-Bref). *Results* The highest prevalence rate of ENMQ in the last 12 months was 77.5% (n = 31) in the low back region and 50% (n = 20) in the shoulder region in those exposed to high-grade magnetic fields. The mean scores of WHOQOL-Bref were given for those exposed to high and low magnetic fields and those not exposed to magnetic fields (M +/- SD: 63.51 +/- 8.35; 73.27 +/- 9.37; 76.43 +/- 8.43, respectively). *Conclusion* The prevalence of WMSD in workers was found to be highest in the low back, shoulder, and hand region in HF-MF workers. LF-MF group, the highest concentration was found to be highest in the neck region. Prevalence rates have been reported for different body sites, with the highest prevalence rates observed in the group exposed to HF-MF. Quality of life was found to be lower in the group exposed to HF-MF. <https://doi.org/10.1177/10519815251414411>

Intersubject variability in a comprehensive numerical assessment of operator electromagnetic exposure to TMS,

D'agostino, S., Colella, M., Falsaperla, R., Liberti, M. and Apollonio, F., *Frontiers in Public Health*, Feb 2 2026, Vol. 13.

Introduction Transcranial magnetic stimulation (TMS) is increasingly used in clinical and research settings, often requiring the operator to remain in close proximity to the stimulation coil. While regulatory guidelines exist for patient safety, the workplace exposure assessment, particularly its dependence on operator anatomy, remains limited. This study aimed to comprehensively evaluate the electric field (E-field) induced in TMS operators under realistic working conditions, with a focus on how inter-subject anatomical variability affects compliance with international safety guidelines. *Methods* Numerical simulations were performed using four anatomically detailed virtual human models exposed to a circular TMS coil in clinically relevant positions. Two coil heights (chest and abdomen) and three coil-to-operator distances (12 cm, 22 cm, 40 cm) were analyzed. The induced E-field was computed using magneto-quasi-static solvers, and the results were compared with the ICNIRP basic restriction for occupational exposure (1.13 V/m) and with the experimental

threshold for peripheral neurostimulation (4 V/m). Whole-body percentiles, localized distributions, and anatomical cross-sections were evaluated to characterize inter-subject variability. Results At 40 cm, all models and exposure scenarios were compliant with ICNIRP limits. At 22 cm, most configurations remained compliant, though some models slightly exceeded the reference level, particularly in the abdominal region. At 12 cm, the induced E-field systematically exceeded the occupational limit across all models, while remaining below the neurostimulation threshold. Anatomical features, such as subcutaneous adipose tissue thickness and tissue discontinuities, were found to strongly influence field localization and intensity, especially at closer distances. Conclusion Operator exposure to TMS is influenced by both coil positioning and individual anatomical characteristics. While increasing distance ensures compliance and reduces variability, closer configurations may require tailored assessments or mitigation strategies. These findings highlight the importance of considering inter-subject variability in the evaluation of operator exposure and suggest that anatomical models may underestimate variability in real clinical contexts. A limitation of this study is the assumption of a static operator not manually holding the coil, a common condition in clinical practice that warrants further investigation.

<https://doi.org/10.3389/fpubh.2025.1705893>

The Influence of MRI, X-ray, and Nano-Scale Effects on Hospital Workers' Health,

Khilf, H. M., Hussein, M. U. and Oueslati, A., *Journal of Nanostructures*, Win 2026, Vol. 16, no. 1, p. 27-35.

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

Enhancing Occupational Safety in Welding: Identifying Hazards and Improving Personal Protective Equipment Utilization Through Hierarchical Task Analysis,

Khorshidikia, S., Popov, M. R. G., Popov, G. and Habibi, E., *Health Scope*, Feb 2026, Vol. 15, no. 1.

Background: Welding processes expose workers to a range of occupational hazards, including chemical pollutants, noise, and non-ionizing radiation, which can compromise health. Effective

selection and consistent use of personal protective equipment (PPE), along with engineering and management controls, are essential for mitigating these risks. Objectives: The present study aimed to identify occupational hazards in welding operations and propose strategies to enhance worker safety and health through optimized PPE use and workplace risk management. Methods: Hierarchical task analysis (HTA) was applied to systematically decompose the tasks of argon arc welding (TIG) and submerged arc welding (SAW). Other roles and activities within the workshop were examined to assess potential cross-exposures. Workplace hazards were evaluated using a combined qualitative and quantitative approach, including field observations, interviews with workers and technical experts, and analysis of technical and safety documentation. Environmental measurements included noise, airborne pollutants, and radiation levels. Results: The HTA identified multiple stages in welding processes where workers are exposed to hazards such as metal fumes, hazardous chemicals, noise, non-ionizing radiation, and molten metal spatter. Noise levels frequently exceeded recommended limits, while elevated concentrations of manganese and crystalline silica fumes were detected. Shared workspaces led to secondary exposure to hazards from adjacent tasks. Proper use of PPE, including hearing protection, respiratory masks, flameresistant clothing, and welding helmets, was shown to effectively mitigate these risks. Conclusions: Welding hazards are cumulative and influenced by both task-specific and environmental factors. Continuous and correct use of PPE, combined with engineering controls and management measures such as task rotation, is critical to protect workers' health. Ongoing training, supervision, and workplace monitoring are recommended to ensure compliance and reduce occupational risks in welding environments. <https://doi.org/10.5812/healthscope-164956>

Electromagnetic Exposure from RF Antennas on Subway Station Attendant: A Thermal Analysis, Li, J., Zhang, Q. Q. and Lu, M., *Sensors*, Jan 21 2026, Vol. 26, no. 2.

With the rapid development of wireless communication systems, the electromagnetic environment in subway stations has become increasingly complex, raising concerns about the long-term safety of station attendants who are chronically exposed to radiofrequency (RF) fields. At present, multiphysics analyses specifically addressing RF antenna exposure scenarios for subway attendants remain limited. To assess occupational electromagnetic exposure risks, this paper establishes a comprehensive electromagnetic-thermal coupling simulation model incorporating RF antennas, station-platform structures, and a realistic human model with organs including the brain, heart, and liver. Using the finite-element software COMSOL Multiphysics (v.6.3), numerical simulations are performed to calculate the specific absorption rate (SAR) in the trunk and major organs of the subway station attendant at RF antennas frequencies of 900 MHz, 2600 MHz, and 3500 MHz, as well as the temperature rise distribution of the human trunk and important tissues and organs under different initial temperatures of the environment. The results show that among the three frequencies, the maximum SAR of 5.55×10^{-4} W/kg occurs in the trunk at 3500 MHz. Tissue temperatures reach thermal steady state after 30 min of exposure, with the maximum temperature rises occurring in the brain at an ambient temperature of 18 degrees C and an operating frequency of 900 MHz, reaching 0.2123 degrees C. Across all simulated scenarios, both SAR values and temperature rises remain significantly below the occupational exposure limits established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). These findings indicate that RF radiation generated by antennas in the subway station environment poses low health risks to female station attendants of similar physical characteristics to the Ella model. This study provides a scientific reference for the occupational RF protection of subway personnel and contributes data for the development of electromagnetic exposure standards in rail transit systems.

<https://doi.org/10.3390/s26020709>

Occupational Exposure to Extremely Low-Frequency Magnetic Fields and Postmenopausal Breast Cancer Risk,

Moayedi-Nia, S., Almadin, C., Labrèche, F., Goldberg, M. S., Richardson, L., Cardis, E. and Ho, V., *Journal of Occupational and Environmental Medicine*, Feb 2026, Vol. 68, no. 2, p. e163-e171.

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

Ambient RF-EMF exposure in surgical operating rooms from telecommunication antennas and Wi-Fi sources,

Peyró-Sánchez, R., Gonzalez-Rubio, J., Gerónimo-Pardo, M. and Nájera, A., *Frontiers in Public Health*, Jan 6 2026, Vol. 13.

In recent years, many studies have characterized ambient exposure to radiofrequency electromagnetic fields (RF-EMF) in various environments. In hospitals, operating rooms accommodate many professionals for extended periods, often with waiting times during which mobile devices connected to wireless networks are used. These conditions could increase workers' exposure during surgical procedures. This study aimed to characterize ambient RF-EMF exposure during surgical operations in 15 operating rooms at the General University Hospital and the Perpetuo Socorro Hospital in Albacete (Spain). Measurements were conducted using a Satimo EME Spy 140 exposimeter between 10 January and 3 March 2020. The device was configured to record data every 5 s from 08:30 to 15:00, selecting only periods corresponding to ongoing surgical operations. The exposimeter was mounted on a plastic tripod in a preferably central and unobstructed location, keeping a reasonable distance from walls and electronic equipment. In total, 67 surgical procedures were monitored, representing 120 h and 45 min of measurement. The highest recorded mean value was 58.82 μ W/m² on the 2.4 GHz Wi-Fi band. The exposure levels observed were comparable to those reported in other European studies conducted in indoor microenvironments. In all operating rooms analyzed, ambient exposure remained below 0.4% of the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 2020) reference level, even under the least favorable conditions regarding the number of people or devices present. <https://doi.org/10.3389/fpubh.2025.1721454>

Evaluating Adherence to Safety Standards for Physical Space Design, Equipment, and Patient and Staff Protection in Magnetic Resonance Imaging Centers: A Descriptive Cross-sectional Study, Sadeghinasab, A., Fatahiasl, J., Mohammadi-Sadr, M., Kahkesh, M. H. and Tahmasbi, M., *Health Physics*, Jan 2026, Vol. 130, no. 1, p. 1-12.

Magnetic resonance imaging (MRI) has revolutionized disease diagnosis and treatment. However, the technology poses safety risks, such as exposure to magnetic fields, RF pulses, and cryogenics, necessitating strict adherence to safety protocols to protect patients and healthcare workers. This cross-sectional descriptive study assessed compliance with MRI safety standards in Khuzestan province, Iran) imaging centers, focusing on electromagnetic fields and other key safety domains. A 61-item researcher-developed checklist, based on international safety guidelines, was used to evaluate safety protocols in 11 MRI centers across seven domains, including facility design, equipment labeling, static magnetic and gradient fields, RF waves, cryogenics, patient and staff protection, and infection control. MRI staff responded with yes/no answers. Responses to three additional questions also were collected. Data analysis was conducted using SPSS 26. A p -value < 0.05 was considered statistically significant. Overall, facility design scores ranged from 54.5% to 100%, but static magnetic field safety ratings were significantly lower (25% to 100%). Although safety equipment availability reached 100% in some centers, gaps were noted in labeling ferromagnetic devices. Infection control adherence was high, but only seven centers featured seamless flooring in the magnet room. Cryogen safety showed partial compliance with some centers lacking exhaust fans. Employee and patient safety measures were inconsistent, with one center scoring as low as 18%. While MRI centers demonstrated strengths in infection control and facility design, critical deficiencies in static magnetic field safety and emergency protocols highlight the need for targeted training, regular audits, and updated policies. Addressing these gaps is essential to enhancing MRI safety practices and aligning with international standards.
<https://doi.org/10.1097/hp.0000000000001991>

Study of Leakage Electromagnetic Field Monitoring with a Wide Frequency Range on Safety Management in a Magnetic Fusion Facility,

Tanaka, M., Wang, J. Q. and Uda, T., *Journal of Fusion Energy*, Feb 7 2026, Vol. 45, no. 1.

With respect to considerations of nuclear fusion systems, since the electromagnetic field in the wide frequency range from the static magnetic field to extremely high frequency was utilized for the plasma confinement, heating at the magnetic confinement fusion facilities, not only ionizing radiation but also non-ionizing radiation should be investigated and discussed in terms of occupational protection as one of the issues in fusion facilities. To clarify the behavior of non-ionizing radiation, leakage from electric and magnetic fields has been observed at the Large Helical Device (LHD), because a strong magnetic field generated by large superconducting magnet coils for plasma confinement, in addition to high-frequency and high-power oscillators for ion cyclotron range of frequencies (ICRF) and electron cyclotron resonance heating (ECRH) for plasma heating, are used. In the LHD experiments, magnetic field leakage has been observed at extremely low frequencies (ELFs) around a power supply system for superconducting magnet coils. The magnetic field outside the experimental hall and the intensity of electric field leakage from the oscillators for ICRF and ECRH are significantly below the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines and radio frequency exposure protection standards in Japan (RCR-STD38). The ICNIRP and RCR-STD38 provide guidelines for limiting exposure to electric and magnetic fields to protect against established adverse health effects. The guidelines for safety management to protect the working people in fusion facilities should be made clearer with respect to occupational protection from non-ionizing radiation. <https://doi.org/10.1007/s10894-026-00553-3>

The combined effect of cadmium and 50 Hz magnetic fields exposure at occupational levels on DNA damage in human fetal lung fibroblasts,

Wei, X. X., Zhao, H., Zhang, J. and Sun, C., *Ecotoxicology and Environmental Safety*, Feb 2026, Vol. 311.

In occupational environments with a high risk of cadmium (Cd) exposure, such as electroplating plants, workers are concurrently exposed to power frequency magnetic fields (MFs). However, health implications of combined exposure to these agents remain poorly understood. In this study, we examined both short-term (24 h) and longterm (4 weeks) exposure to Cd at an occupational exposure relative concentration (100 nM) and 0.4 mT, 50 Hz MFs on DNA damage, apoptosis, and cell viability in human fetal lung fibroblasts (WI-38). We found that coexposure to Cd and 50 Hz MFs have no significant impact on these endpoints. Additionally, we evaluated short-term exposure to high-dose Cd (10 µM) combined with 50 Hz MFs, as well as long-term exposure to 50 Hz MFs in cells pre-treated with 10 µM Cd for 24 h. Consistently, no significant effects of combined exposure were observed. In conclusion, at occupational relevant exposure levels, co-exposure to Cd and 50 Hz MFs does not appear to induce synergistic adverse effect on DNA integrity, apoptotic activity, or cell viability in WI-38 cells. <https://doi.org/10.1016/j.ecoenv.2026.119861>

Etudes épidémiologiques

Environmental and microbiome determinants of sperm quality: a narrative review on male health,

Qi, Y. R., Shi, J. T., Zhang, Q. Y., Xuan, Y., Zhang, H. and Duan, Y., *Translational Andrology and Urology*, Feb 28 2026, Vol. 15, no. 2.

Background and Objective: With the rapid development of modern production and daily life, human fertility has shown a declining trend, with male factors accounting for approximately half of the cases. Declining sperm quality is the primary issue in male infertility, and environmental factors play a significant role in its development. This paper aims to thoroughly explore the impact of environmental factors on male sperm quality and provide insights for the etiology and prevention of male infertility. Methods: A comprehensive literature search was conducted in PubMed from its inception to June 25, 2025, for articles on the effects of traditional environmental factors on male sperm quality. 84.9% of the references were published between 2020 and 2025, with most studies being recent and related to human male fertility. The search included all articles containing the following keywords: "sperm quality", "environmental factors", "temperature", "heavy metals", "pesticide", "phthalate", "viruses", "bacteria", "Radiofrequency Electromagnetic Radiation (RF-EMR)", "per-and polyfluoroalkyl substances (PFAS)", "air pollution", "Benzo[a]pyrene (BaP)", and "microbiome". The retrieved articles were reviewed to summarize the effects of environmental factors on male sperm quality. Key Content and Findings: A total of 250 articles were identified with these keywords and later screened for inclusion. We finally included 82 publications that were relevant to our topic. Based on recent studies within China and international research, this paper not only examines the effects of traditional pollutants at the molecular mechanism level but also focuses on emerging environmental factors such as the synergistic toxicity of new environmental pollutants-PFAS, and heavy metals-as well as 5G radiofrequency radiation. These environmental factors significantly reduce sperm concentration, motility, morphological integrity, and DNA stability through multiple mechanisms and systemic effects-including reactive oxygen species (ROS), endocrine disruption, DNA damage, and inflammatory responses-thereby impairing male fertility. Conclusions: Traditional and emerging environmental factors synergistically impair male sperm quality through multiple mechanisms, including oxidative stress, endocrine disruption, epigenetic alterations, and systemic inflammation. Future experimental research should shift from single-

pollutant studies to real-world mixture exposure investigations, utilizing multi-omics technologies to deeply analyze epigenetic mechanisms and transgenerational effects. Clinically, environmental risk factors should be incorporated into routine screening and counseling for male infertility, with enhanced antioxidant intervention measures. At the policy level, there is an urgent need to improve chemical regulation to prevent potentially stronger reproductive toxicity from novel substitutes and to enhance air pollution control. Curbing the global decline in fertility at its source holds significant importance for advancing population reproductive health. <https://doi.org/10.21037/tau-2025-aw-833>

Emotional Well-Being and Environmental Sensitivity: The Case of ELF-MF Exposure,

Raz-Steinkrycer, L. S., Gelberg, S. and Portnov, B. A., *Sustainability*, Jan 7 2026, Vol. 18, no. 2.

Extremely low-frequency magnetic fields (ELF-MFs) generated by high-voltage power lines raise concerns about their potential impact on health and well-being. Previous research suggests that chronic exposure to ELF-MFs can contribute to sleep disturbances, headaches, and mood disorders, possibly through physiological stress responses and melatonin disruption. This study examines whether self-reported happiness mediates the relationship between exposure to ELF-MFs and health symptoms among people living near a 161 kV transmission line in the city of Or Akiva in Israel. A total of 427 participants completed questionnaires on physical symptoms and life satisfaction, while fixed-site ELF-MF measurements were conducted at and around homes. The structural equation modelling (SEM) was then applied to assess the direct and indirect effects of exposure to ELF-MFs, complemented by logistic regressions for confounder analysis. The results indicate that higher exposure to ELF-MFs was associated with lower happiness and increased symptoms, including poor sleep and reduced mobility ($p < 0.05$). On the contrary, greater happiness was correlated with fewer headaches, better sleep quality, improved mobility, and reduced perceived need for medical care ($p < 0.01$). Mediation analysis also revealed that happiness partially buffers the adverse effects of ELF-MFs on headaches, mood, and sleep problems ($p < 0.05$). <https://doi.org/10.3390/su18020620>

Long-term residential magnetic field exposure and neurodegenerative disease mortality: An 18-year nationwide cohort study in Switzerland,

Sandoval-Diez, N., Loizeau, N., Huss, A., Rösli, M. and Vienneau, D., *Environment International*, Feb 2026, Vol. 208.

Background: Epidemiological evidence on the association between extremely low-frequency magnetic fields (ELFMF) exposure and neurodegenerative diseases (NDD) remains inconsistent. Few population-based studies using exposure from high-voltage power lines (HVPL) have found mixed findings, and none have yet considered exposure from railway lines. Methods: We followed 3,555,064 adults from the Swiss National Cohort (2001-2018), contributing 55.4 million person-years. Long-term ELF-MF exposure from HVPL (50 Hz) and railway lines (16.7 Hz) was modelled using validated proximity models and updated over four intervals (2001-2005, 2006-2010, 2011-2015, 2016-2018). Long-term ELF-MF exposure was calculated as a time-weighted average exposure over 10-year windows preceding each interval. Cox proportional hazards models estimated hazard ratios (HRs) for mortality from Alzheimer's disease (AD), other types of dementia (OTD), amyotrophic lateral sclerosis (ALS), Parkinson's disease (PD), and multiple sclerosis (MS), adjusting for sociodemographic and environmental co-exposures. Results: During follow-up, 146,655 NDD deaths occurred. Less than 1% of the population was exposed to longterm ELF-MF ≥ 0.3 & micro;T from HVPL and 2.4% from railway lines. HVPL exposure was positively associated with mortality from AD (HR per 1 & micro;T increase in exposure = 1.54; 95% CI: 1.23-1.92) and OTD (HR = 1.31; 95% CI: 1.13-1.52). Associations for railway exposure were weaker and attenuated after adjusting

for environmental co-exposures. No associations were observed for ALS, PD, or MS. Conclusions: Long-term ELF-MF exposure was associated with higher dementia mortality risk in the general population, but not with ALS, PD, or MS. Causal inference remains limited by the absence of established biological mechanisms. <https://doi.org/10.1016/j.envint.2026.110145>

Impact of electromagnetic fields on circadian rhythms: molecular and physiological insights, Tbahriti, H. F., Benbernou, M., Satani, A., Rebezov, M., Arcot, R., Thiruvengadam, M. and Shariati, M. A., *Sleep and Biological Rhythms*, 2026.

Purpose Electromagnetic fields (EMFs) are ubiquitous in modern environments, raising concerns about their potential influence on circadian rhythms and human health. This systematic review examines the biological mechanisms underlying EMF-circadian interactions to inform evidence-based public health policies. *Methods* Following PRISMA 2020 guidelines, we systematically searched PubMed/MEDLINE, Web of Science, Scopus, and EMBASE for peer-reviewed studies published between 2010 and 2024. From 892 initial records, 55 studies met inclusion criteria after rigorous screening, comprising 22 in vitro studies, 21 animal studies, and 12 human studies. *Results* EMF exposure can affect circadian regulation through multiple pathways including clock gene expression alterations, melatonin disruption, and cellular signaling modulation. The most robust evidence involves melatonin suppression (88% of high-quality animal studies) and sleep architecture changes. However, evidence quality varied considerably, with only 27% of studies meeting high methodological standards. Critical limitations include inadequate sham controls in 48% of animal studies, incomplete EMF exposure characterization in 33% of investigations, and minimal high-quality human research. The magnitude of melatonin suppression (20-50%) is substantially lower than light-induced effects (> 90%), raising questions about clinical significance. Translation from cellular effects to systemic circadian disruption remains incompletely established. *Conclusion* While EMFs can influence molecular and cellular circadian components, whether typical environmental exposures produce clinically meaningful circadian disruption in humans remains uncertain. The findings highlight critical evidence gaps and underscore the need for well-controlled studies with standardized protocols, rigorous designs, and comprehensive circadian assessment to clarify public health implications of chronic EMF exposure. <https://doi.org/10.1007/s41105-026-00643-x>

Evaluation de l'exposition

Non-ionising Electromagnetic Fields: Measurement of Exposure of City Dwellers in Urban Environments in Central Spain,

Alonso, A. A., Steinz, R. D., Felipe, M. A., Pérez, J. M. A. and Juárez, M. a. P., *Applied Sciences-Basel*, Jan 30 2026, Vol. 16, no. 3.

Despite existing protection limits established by different health agencies and regulatory bodies, chronic exposure to non-ionising electromagnetic field radiation (NIR) has raised concerns about its potential biological effects and its impact on human health. Exposure to NIR in urban environments is almost inevitable due to the density of devices and communication systems that emit these waves. Correctly measuring exposure levels among city residents is key to determining whether there is a relationship between these levels and potential health problems associated with NIR. Several factors, including the ubiquity of electromagnetic fields (EMFs) and people's unawareness of their exposure, make the NIR assessment challenging. This paper proposes a standardised procedure for NIR testing and measurement for frequencies from 100 kHz to 3 GHz, designed explicitly for outdoor urban environments. The measurement procedure is intended for populated

urban areas, a complex environment for signal propagation. The complete procedure, techniques, and equipment used for wideband and narrowband measurements are detailed, along with their corresponding overall uncertainty budgets. The data collected by this procedure are suitable and valuable for comparative epidemiological studies due to a systematic measurement protocol and rigorous control of measurement uncertainty. The proposed measurement procedure has been tested in two cities in central Spain, with a total population of 262,000. A total of 534 measurement points have been performed. The results can be used to verify compliance with exposure limits and to demonstrate levels below the applicable regulatory limits. Furthermore, it has been possible to test the validity of the hypothesis that urban environments can be characterised by NIR exposure, which was postulated in this work based on an ITU-R-inspired simplification that classifies urban outdoor areas into representative exposure categories. <https://doi.org/10.3390/app16031418>

Human Exposure to RF-EMF From Active RIS in Outdoor Environments: A Vehicular Communication Case Study,

Benini, M., Gallucci, S., Fiocchi, S., Parazzini, M., Ravazzani, P. and Tognola, G., *IEEE Open Journal of Antennas and Propagation*, Feb 2026, Vol. 7, no. 1, p. 6-17.

This study assesses the impact of reconfigurable intelligent surface (RIS) on the radio frequency electromagnetic field dose absorbed by a pedestrian in a vehicle-to-vehicle (V2V) communication scenario in urban settings. The exposure scenario consists of a two-lane road surrounded by buildings, with a transmitting vehicle (Tx - V2V antenna) and a target receiver (Rx) in non-line-of-sight condition due to the presence of a blocking vehicle. An active RIS is placed in the opposite lane to aid direct communication between the Tx and Rx. The absorbed dose induced by the environmental electric field - generated by the Tx and reradiated by the RIS - is assessed in pedestrians of different ages (adult and child human models) by computing the whole-body specific absorption rate (SAR_{wb} [W/kg]). The analysis considers (i) different pedestrian positions, (ii) two V2V frequencies (5.9 GHz and 28 GHz), (iii) two RIS set-ups (vehicle-mounted, infrastructure-mounted), (iv) three V2V antenna positions, and (v) three RIS locations relative to the V2V antenna. At 28 GHz we also analyzed the absorbed power density (S_{ab} [W/m²]). The presence of the RIS induced a maximum SAR_{wb} of 0.13 mW/kg and S_{ab} of 5.8 mW/m² in the child at 28 GHz and a maximum relative increase of dose absorbed -compared to the case without the RIS - that is + 1.60 times greater. Results highlight how V2V antenna position significantly impact (p < 0.05) the increase of the dose absorbed. Nevertheless, all the exposure levels found are well below the limits recommended by the ICNIRP guidelines. <https://doi.org/10.1109/ojap.2025.3625767>

Electromagnetic Exposure Assessment of 5G Mobile Phones: SAR and Thermal Distribution in a Multi-Layer Human Head Model,

Chen, D. P. and Zhang, B. T., *Sensors*, Feb 26 2026, Vol. 26, no. 5.

The rapid deployment of 5G technology has raised public concern regarding the potential health effects of electromagnetic radiation from mobile devices. This study systematically evaluates the specific absorption rate (SAR) and temperature distribution in a multi-layer spherical head model exposed to near-field radiation from a 5G mobile phone antenna. A planar inverted-F antenna (PIFA) covering the 3.5 GHz band was integrated into a smartphone model, and simulations were performed in COMSOL Multiphysics 6.3 under input powers of 21 dBm and 24 dBm at varying antenna-head distances. The results show that the peak SAR in the brain layer remained at 0.034 W/kg and 0.065 W/kg for the two power levels, both well below the International Commission on Non-Ionizing Radiation Protection (ICNIRP) safety limit of 2 W/kg. The highest SAR occurred in the

scalp layer, decreasing gradually through the skull and brain tissues. After 30 min of exposure, the maximum brain temperature reached only 37.223 degrees C, far lower than the thermal damage threshold. Increasing the antenna-head distance from 5 mm to 30 mm reduced SAR by up to 50.2%, while temperature variations remained negligible ($\leq 0.18\%$). These findings demonstrate that under typical usage conditions, 5G mobile phone radiation complies with international safety standards and poses no significant thermal risk, thereby contributing to a deeper understanding of bio-electromagnetic interactions and supporting ongoing wireless-communication safety assessments. <https://doi.org/10.3390/s26051468>

RF-EMF bystander exposure in the 5G era measured across various microenvironments in Greece, Delidimitriou, S., Babas, D., Manassas, A., Wiart, J. and Samaras, T., *Annals of Telecommunications*, 2026.

The rapid growth of mobile communication technologies and the introduction of new cellular networks have led to increased public exposure to radiofrequency electromagnetic fields (RF-EMFs), raising concerns regarding potential health effects. This study investigates RF-EMF exposure of individuals not using a wireless device themselves, referred to as "bystander exposure," across a wide range of indoor and outdoor locations in Greece. Measurements were conducted between September 2023 and September 2025 using the EME Spy Evolution personal exposimeter and covering all cellular uplink and downlink frequency bands, the 5G NR band at 3.6 GHz, and Wi-Fi bands of 2.4 GHz and 5 GHz. A total of 16,900 measurement points were collected across 76 microenvironments in urban, suburban, and rural locations, under both high- and low-traffic conditions. Results show that downlink exposure dominates in urban areas, while uplink exposure is higher in rural environments due to lower base station density. Indoor environments exhibit a greater uplink contribution to the total bystander exposure than outdoor environments, while outdoor locations are primarily dominated by downlink exposure. The 5G 3.6 GHz band contributes minimally to the average exposure but can produce occasional peaks reaching up to 82% of the total received power in certain cases. In indoor environments, the Wi-Fi band of 5 GHz contributes more to the total bystander exposure than the band of 2.4 GHz, whereas the 2.4 GHz Wi-Fi band contributes almost equally to both indoor and outdoor locations. <https://doi.org/10.1007/s12243-026-01143-2>

Experimental Validation of Thermoregulatory Modeling for Human Back Exposure at 28 GHz, Kato, S., Hirata, A., Masuda, H., Matsumoto, A. and Kodera, S., *Ieee Journal of Microwaves*, Mar 2026, Vol. 6, no. 2, p. 519-530.

This study investigates skin temperature rise during dorsal exposure to 28 GHz quasi-millimeter waves using an electromagnetic-thermal computational modeling framework considering thermoregulation. Human exposure experiments were numerically reproduced using anatomically detailed models of Japanese adults augmented with age- and sex-related thermoregulatory functions. An exposure system with dielectric lens antennas provided controlled irradiation to the back, and the measured skin temperatures were compared with the computational predictions. The computational framework reproduced the experimental temperature rises well for both the 64-region of interest (ROI) and 1-ROI. Furthermore, the model reproduced the tendency that female participants exhibited higher temperature rises than males, which was mainly attributed to anatomical variations in muscle and fat composition. Age-related effects were modest, likely because the older adult group was approximately 65 years old. The predicted temperature rise was 2.48 degrees C, which is within the permissible limit of 2.5 degrees C (derived from the operational

threshold of 5 degrees C with a reduction factor of 2) when evaluated at an absorbed power density of 100 W/m² for occupational exposure, as specified in international exposure guidelines. These findings demonstrate the applicability of the thermoregulatory model to superficial absorption for exposure to quasi- and millimeter waves and support its use for assessment across different populations, such as those differing in age, sex, and thermoregulatory capacity.

<https://doi.org/10.1109/jmw.2026.3662329>

Characterization of EMF exposure induced by French cellular networks,

Liu, J., Wang, S. S., Haider, Z., Sun, Q. F., Zhang, Y. R., Bories, S., Ourak, L. and Wiart, J., *Annals of Telecommunications*, 2026.

This study presents a comprehensive evaluation of electromagnetic exposure in operational French fourth generation (4 G)/long term evolution (LTE) networks, combining field measurements with computational modeling to assess both uplink (UL) and downlink (DL) contributions. We introduce the novel Radiated Energy per Bit Transmitted (REBT) metric to quantify network radiated energy efficiency, while characterizing TX power patterns across different services, revealing higher mean-to-maximum power ratios for data services compared to voice calls. Through analysis of a representative 2600 MHz user, we demonstrate field-strength-dependent exposure dynamics: with DL field strength of 1 V/m, UL contributes 30% (head) and 12.8% (whole body) of total exposure, while at 0.38 V/m, UL becomes predominant (75% head, 50.4% whole body). Notably, the relative contribution of UL exposure to the total head exposure is consistently higher than that of DL exposure across all scenarios. All measured exposure levels remain well below ICNIRP safety limits, validating safety compliance of LTE. The study establishes an important methodological framework, combining the global exposure index with detailed transfer function analysis, providing critical insights for both current 4 G and emerging fifth generation (5 G) exposure assessments.

<https://doi.org/10.1007/s12243-026-01156-x>

Mémoire de master. Etude d'optimisation des intensités des champs magnétique à proximité des lignes électriques HT,

Rouibah, T., Guemou, S. and Mahboub, M., *UNIVERSITÉ KASDI MERBAH – OUARGLA.*

Département de Génie électrique (2025),

Les lignes de transport d'énergie électrique à haute et très haute tension génèrent des champs électromagnétiques susceptibles d'affecter la santé humaine. Il devient donc essentiel, lors de la conception des réseaux électriques, de connaître l'intensité de ces champs magnétiques afin de limiter leurs effets néfastes sur l'environnement. L'objectif de notre travail est de proposer une méthode analytique simple, basée sur la théorie des images, pour déterminer le champ magnétique généré par les lignes à haute tension (HT) et très haute tension (THT), en plus d'étudier les caractéristiques spécifiques à ces lignes. Le champ magnétique B est directement lié à l'intensité du courant, mais aussi à d'autres paramètres tels que la hauteur des lignes, la distance entre les phases et leur positionnement, qui influencent tous la valeur du champ. Un programme de simulation a été développé sous MATLAB pour modéliser l'intensité des champs magnétiques à proximité des lignes de transport, en réalisant plusieurs études afin d'obtenir les résultats optimaux pour ce système.

<https://dspace.univ-ouargla.dz/jspui/handle/123456789/40398>

Pilot study on electromagnetic fields generated by battery electric vehicles,

Shalamanova, T., Petkova, H., Israel, M., Simionov, R., Ivanova, M., Ivanova, P. and Zaryabova, V., *European Physical Journal-Special Topics*, 2026.

In recent years, there has been a rise in the use of fully electric and hybrid vehicles. The Electric Vehicles Industrial Cluster in Bulgaria released statistics (<http://www.emic-bg.org/news/item/1605>) showing that the number of registered electric and hybrid vehicles increased by more than 100% in the previous year. However, users of this type of vehicle are concerned about potential negative effects related to exposure to electromagnetic fields (EMF). It is well-known that the low-frequency magnetic field was classified by the International Agency for Research on Cancer (IARC) (Non-ionizing radiation, Part 1: Static and extremely low-frequency (ELF) electric and magnetic fields. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. IARC Press, Lyon, 2002) as a possible carcinogen class 2B. Despite this, there is no national legislation in our country to protect the general public from exposure to low-frequency magnetic fields. The International Commission on Non-ionizing Radiation Protection (ICNIRP) has recommended limits for protecting humans exposed to electromagnetic fields (International Commission on Non-Ionizing Radiation Protection (ICNIRP) in Health Phys 74:494-522, 1998). The focus of the study was to perform pilot measurements of the static magnetic field, the low-frequency magnetic fields generated by battery electric vehicles (BEVs) and to explore the complex exposure conditions for the driver and passengers. For the purpose of the study we examine some of the commonly purchased models of BEVs for personal use in Bulgaria. The study aims to develop a methodology that would provide data for further evaluation of EMF exposure in light of international safety standards. A primary measurement protocol was developed based on the studied specificity of the EMF distribution in the confined space of BEVs and the obtained measurement results. The results from primary measurements and pilot exposure assessment comply with ICNIRP guidelines (International Commission on Non-Ionizing Radiation Protection (ICNIRP) 1998). However, there is a need for further investigation and more measurement data of EMF generated by BEVs considering the long-term exposure of the users and the complex EMF fields that occur in the limited space of BEVs. <https://doi.org/10.1140/epjs/s11734-026-02162-9>

Advancing EMF Compliance for 5G Massive MIMO Antennas: From 2-D Time-Averaged Models to Realistic 3-D SpatialTemporal Representations,

Valbonesi, S., Suman, R., D'elia, S., Garzia, A. and Grazioso, P., *Ieee Open Journal of Antennas and Propagation*, Feb 2026, Vol. 7, no. 1, p. 235-246.

The deployment of 5G networks, leveraging technologies like massive MIMO and beamforming, has transformed signal propagation by introducing dynamic and directional transmission patterns. While these advances improve spectral efficiency, the complexity of evaluating exposure to Radio Frequency Electromagnetic Field (RF-EMF) increased, rendering traditional compliance methods overly conservative. To address this, recent international standards on RF-EMF calculations and measurements have introduced statistical approaches that better reflect real-world operating conditions by accounting for temporal variability in traffic load and beam patterns. This paper presents a novel extension to the effective maximum approach defined by IEC (International Electrotechnical Committee) by incorporating spatial dynamics derived from real-time base station measurements. These measurements are stored in counters that capture the three-dimensional (3D) power distribution of transmitted signals, enabling a more accurate representation of actual operating conditions. Two innovative methodologies are proposed (semi-vectorial and vectorial), both resulting in a more realistic estimation of RF-EMF exposure with respect to currently used methodologies. Each method uses different power reduction factors to reflect how signals change over time and space. Unlike existing models, the two new approaches capture the full spatio-temporal complexity of 5G emissions, offering a first-of-its-kind framework for realistic RF-EMF exposure assessment. A real-world case study demonstrates that this methodology significantly

reduces conservatism in compliance boundaries, without compromising safety. These insights are particularly valuable for regulators and policymakers, enabling more accurate and proportionate exposure assessment methodologies that support the safe and efficient deployment of 5G and future wireless technologies. <https://doi.org/10.1109/ojap.2025.3642188>

Toxicité

Commentary on the systematic review of radiofrequency field exposure and animal cancer by Mevissen et al. (2025)-Revisiting the evidence and a quantitative perspective,

Belenki, D., Baaken, D., Meyer, F. and Kuhne, J., *Environment International*, Mar 2026, Vol. 209.

The systematic review by Mevissen et al. (2025, Environment International) evaluated the evidence on the carcinogenicity of radiofrequency electromagnetic fields (RF-EMF) in laboratory animals and concluded with a high certainty of evidence (CoE) that exposure to RF-EMF increases the risk of malignant glioma and malignant schwannoma in the brain and heart, respectively. Deviating from their pre-published systematic review protocol, the authors did not perform meta-analyses. Instead, they based their assessment on whether or not statistically significant increases in tumour rates were observed in the included studies. One positive finding was deemed sufficient to conclude an adverse effect of RF-EMF exposure in a specific organ, thereby setting the target of the CoE rating for that organ. Here, we question this approach because it does not consider all the available evidence, and highlight further methodologically inconsistent decisions, while laying out a quantitative alternative based on the protocol and common guidelines for systematic reviews. Re-assessing the eligible long-term carcinogenicity experiments, we consider important studies to be sufficiently similar to be combined in a meta-analysis (MA). We calculate odds ratios as the effect measure and perform MA as well as dose-response MA. Rating the results using GRADE and OHAT guidance, we downgrade the CoE for imprecision due to the very wide confidence intervals of the pooled odds ratios, and upgrade the CoE for malignant heart schwannomas because of a positive exposure-response association, concluding moderate and low CoE for carcinogenicity of RF-EMF exposures in the heart and brain, respectively. In summary, our quantitative assessment of the evidence results in lower CoE conclusions than those of Mevissen et al.

<https://doi.org/10.1016/j.envint.2026.110154>

Parametric analysis of electromagnetic wave interactions with layered biological tissues for varying frequency, polarization, and fat thickness,

Gasmelseed, A., *Scientific Reports*, Dec 26 2025, Vol. 16, no. 1.

Electromagnetic wave interaction with biological tissue is frequency-, angle-, and polarization-dependent, influencing both dosimetric parameters and resultant thermal effects. This work presents a comprehensive analysis across the major ISM bands (433, 915, 2450, and 5800 MHz) for transverse electric (TE) and transverse magnetic (TM) polarizations incident on a three-layer tissue model (skin-fat-muscle). A custom MATLAB code was developed to integrate the multilayer transmission line formalism, polarization-specific wave impedance modeling, Cole-Cole dielectric parameterization, and a finite difference method (FDM) solution of the Pennes bioheat equation. Simulations were performed for incident power density 50 W/m² and fat thicknesses from 0.005 m to 0.03 m, over incidence angles 0 degrees C- 80 degrees C. Throughout the manuscript, reflection is reported strictly as a power quantity

\usepackage{wasysym} \usepackage{amsmath} \usepackage{amssymb} \usepackage{amsbsy} \usepackage{mathrsfs} \usepackage{upgreek} \setlength{\oddsidemargin}{-69pt} \begin{document} \mathbb{R} = |\Gamma| <^> 2 \end{document} rather than a field-amplitude coefficient. The thermal pipeline solves the steady-state Pennes equation in its direct \documentclass[12pt]{minimal} \usepackage{amsmath} \usepackage{wasysym} \usepackage{amsmath} \usepackage{amssymb} \usepackage{amsbsy} \usepackage{mathrsfs} \usepackage{upgreek} \setlength{\oddsidemargin}{-69pt} \begin{document} \Delta T \end{document} form with consistent surface (Robin) and deep (Dirichlet) boundary conditions, and simulations are audited by an energy-conservation budget. Results indicate that while temperature increases remain below 0.4 degrees C at lower frequencies (433-915 MHz), significant superficial heating (up to 3.5 degrees C) occurs at 5.8 GHz due to reduced penetration depth, even at moderate exposure levels. The results demonstrate that subcutaneous fat acts as a low-loss impedance transformer whose thickness strongly modulates the balance between reflection and internal absorption, while polarization and angle primarily tune the detailed shape of angular reflection curves (including TM Brewster-like minima) at a given incident power. The analytical framework therefore complements voxel-based full-wave numerical models by providing fast, physically transparent trends across ISM bands that are directly relevant for preliminary assessment of wearable devices, implanted sensors, and compliance with radiofrequency safety limits. <https://doi.org/10.1038/s41598-025-33460-2>

5G RF-EMFs Mitigate UV-Induced Genotoxic Stress Through Redox Balance and p38 Pathway Regulation in Skin Cells,

Kim, J. H., Jin, H., Jang, K. M., Lee, J. E., Na, S., Jeon, S., Choi, H. D., Moon, J. I., Kim, N., Lim, K. M., Kim, H. R. and Lee, Y. S., *Antioxidants*, Jan 19 2026, Vol. 15, no. 1.

The biological effects of radiofrequency electromagnetic fields (RF-EMFs) remain an unresolved scientific issue with important societal relevance, particularly in the context of the global deployment of fifth-generation (5G) wireless technologies. The skin is continuously exposed to both RF-EMFs and ultraviolet (UV) radiation, a well-established inducer of oxidative stress and DNA damage, making it a relevant model for assessing combined environmental exposures. In this study, we investigated whether post-exposure to 5G RF-EMFs (3.5 and 28 GHz) modulates ultraviolet A (UVA)-induced genotoxic stress in human keratinocytes (HaCaT) and murine melanoma (B16) cells. Post-UV RF-EMF exposure significantly reduced DNA damage markers, including phosphorylated histone H2AX (gamma H2AX) foci formation (by approximately 30-50%) and comet tail moments (by 60-80%), and suppressed intracellular reactive oxygen species (ROS) accumulation (by 56-93%). These effects were accompanied by selective attenuation of p38 mitogen-activated protein kinase (MAPK) phosphorylation (reduced by 55-85%). The magnitude of molecular protection was comparable to that observed with N-acetylcysteine treatment or pharmacological inhibition of p38 MAPK. In contrast, RF-EMF exposure did not reverse UV-induced reductions in cell viability or alterations in cell cycle distribution, indicating that its protective effects are confined to early molecular stress-response pathways rather than downstream survival outcomes. Together, these findings demonstrate that 5G RF-EMFs can facilitate recovery from UVA-induced molecular damage via redox-sensitive and p38-dependent mechanisms, providing mechanistic insight into the interaction between modern telecommunication frequencies and UV-induced skin stress. <https://doi.org/10.3390/antiox15010127>

Is it time to reconsider chronic electromagnetic field exposure as a possible risk factor in oral cancer?

Krishnasamy, N. and Shree, K. H., *Journal of Stomatology Oral and Maxillofacial Surgery*, Jun 2026, Vol. 127, no. 3.

Introduction: Oral squamous cell carcinoma (OSCC) is a major global health burden, traditionally associated with tobacco, alcohol, and betel quid. In recent years, however, cases have emerged among individuals without these classic risk factors. Chronic exposure to electromagnetic fields (EMFs) from mobile phones and wireless devices has been classified as possibly carcinogenic, yet its potential role in oral carcinogenesis has not been systematically studied. Technical Note: This article highlights the biological plausibility that prolonged, localized EMF exposure may contribute to DNA damage, oxidative stress, and epigenetic modifications in oral epithelial tissues. Evidence from pilot cytogenetic studies, in vitro models, and limited epidemiological data observed increased micronucleus frequency and altered cellular stress responses in buccal mucosal cells of long-term mobile phone users. While direct causal data in OSCC remain absent, these findings suggest that EMFs could act alone or in synergy with established carcinogens. Discussion: The technical note underscores the urgent need for in vitro, in vivo, and epidemiological studies to evaluate whether chronic EMF exposure contributes to oral carcinogenesis. Recognizing this hypothesis is not alarmist but rather a call for rigorous and unbiased investigation. If validated, such evidence could inform preventive guidelines and public health policy for emerging exposures.

<https://doi.org/10.1016/j.jormas.2025.102703>

Effects of Extremely Low Frequency Magnetic Field Exposure (50 Hz, 200 μ T) on Cell Viability, DNA Damage and Micronucleus Formation of Human Skin Cells,

Meyer, V., Drees, K., Gronau, I. A. and Lerchl, A., *Bioelectromagnetics*, Feb 2026, Vol. 47, no. 2.

Both everyday electrical devices and high voltage transmission lines produce electric and magnetic fields with a frequency of 50 Hz in Europe and most other countries. Although several studies have already been investigating the effects of extremely low frequency magnetic field (ELF-MF) exposure on biological material, this topic is still debated. High-quality research is still needed to keep the available data up to date and to decrease the low-quality study design bias. We investigated the effects of 50 Hz magnetic fields with an intensity of 200 μ T (rms) on HaCaT cells, an immortal keratinocyte cell line derived from adult human skin cells. The exposure system allowed standard in vitro cultivation and blinded experimental design with simultaneous exposure and sham-exposure for 2 or 24 h. The biological endpoints were measured using the WST-1 assay (cell viability), the alkaline comet assay (DNA integrity), and the micronucleus test (chromosomal distribution). The results show no significant effects of the parameters mentioned. Our data support the assessment that 50 Hz ELF-MF up to 200 μ T do not cause health effects. This study contributes valuable knowledge to the existing pool of evidence for the effects of ELF-MF on human cells.

<https://doi.org/10.1002/bem.70046>

Electromagnetic exposure changes human Schwann cell motility and transcriptomic profile of hearing-loss-related genes,

Mohamed, T., Colciago, A., Faroni, A., Reid, A. J., Ferrero, G. and Magnaghi, V., *Iscience*, Mar 20 2026, Vol. 29, no. 3.

Schwann cells (SCs) are glial cells of the peripheral nervous system with functional plasticity in physio-pathological conditions, such as injury and oncotransformation. Interestingly, human SCs seem to develop, mature, and respond differently to other species to environmental challenges. Recently, concerns have been raised about the expansion of environmental electromagnetic fields

(EMFs) and the increasing incidence of vestibular schwannoma (VS). We previously demonstrated that SCs respond to EMF by acquiring a state prone to oncotransformation. However, the biodependence of such transformation on the species (rodents versus humans) deserves clarification. Here, we obtained and characterized human SCs, showing that EMF affects proliferation, migration, and transcriptomic profile. The expression of motility proteins increased, while that of cell-to-cell adhesion proteins decreased. The functional clustering of genes differentially expressed matched those involved in hearing loss. In summary, we provide insights into the effects of chronic EMF on human SCs, highlighting its potential role in VS onset.
<https://doi.org/10.1016/j.isci.2026.115130>

Numerical analysis of low-frequency electromagnetic field effects from three-phase transformer on coronary stents and cardiac tissues,

Tian, R., Luo, J. Y., Lu, M. and Cui, J. J., *Plos One*, Jan 30 2026, Vol. 21, no. 1.

The widespread clinical adoption of novel magnesium alloy coronary stents, combined with increasing densification of urban power transmission infrastructure, highlighted a significant research gap regarding the effects of power-frequency electromagnetic fields (EMFs) on these implants. This study employed field-circuit coupling numerical methods to simulate electromagnetic field exposure in simulated patients with implanted coronary stent positioned at various locations near a 200kVA three-phase transformer. The analysis focused on the distribution patterns of induced electromagnetic fields within both cardiac tissues and the stent, as well as the resultant Ampere forces acting on the stent. The results showed that the simulated patient directly beneath the three-phase transformer was exposed to the maximum electromagnetic radiation, but the magnetic flux density (B_{max}) and the induced electric field intensity (E_{max}) of the cardiac tissue were lower than the public exposure limits of the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The B_{max} and E_{max} of the stent at the same position were 1.245 μ T and 5.086×10^{-4} mV/m, respectively. The maximum Ampere force density of the stent in the Y-axis (perpendicular to the coronal plane) was 3.714×10^{-6} N/m³. The above findings indicate that, under the conditions of this simulation, a 200 kVA power transformer exerts minimal interference on the magnesium alloy stent and cardiac tissues. The magnetic flux density and induced electric field in the heart tissues, as well as the Ampere force acting on the magnesium alloy stent, all remain within established safety limits. <https://doi.org/10.1371/journal.pone.0340031>

Low-dose X-Ray induced genetic damage in human peripheral blood lymphocytes,

Villalba-Rondón, L. C., Vélez-Lemus, L., Jaramillo-Garzón, W., Pulido-Medellín, M., Rangel, N. and Rondón-Lagos, M., *Frontiers in Genetics*, Feb 25 2026, Vol. 17.

X-rays (XR) are electromagnetic waves capable of inducing significant biological effects in living organisms. Although widely used in medicine and industry, the impact of low-dose XR exposure on human health remains insufficiently characterized. XR can generate direct and indirect DNA damage such as single- and double-strand breaks, base modifications, and DNA-protein crosslinks, leading to chromosomal alterations that disrupt cellular homeostasis and may contribute to disease development. Although previous studies have reported general increases in cytogenetic damage at low exposures, they seldom provide detailed descriptions of which chromosomes are most affected, which structural or numerical alterations predominate, or how frequently each alteration occurs. This study aimed to characterize the type and frequency of chromosomal alterations and the spectrum of genetic damage, including both clonal and non-clonal alterations, in human lymphocytes exposed in vitro to a low X-ray dose (94.33 mGy), using non-exposed samples as

controls. Peripheral blood was collected from 12 healthy donors, and genetic damage was assessed using GTG-banding cytogenetics and the cytokinesis-block micronucleus assay. Irradiated samples exhibited a significantly higher frequency of chromosomal alterations and fragile sites compared with their respective controls ($p \leq 0.0093$). Among numerical alterations, monosomies were the most frequent, with chromosomes 8 and 21 being the most commonly affected, detected in 50% of irradiated samples. Structural chromosomal alterations predominantly involved chromosomes 11, 16, and 17, while recurrent deletions included $del(15)(q22)$ and $del(16)(q12)$. Among heterochromatic variants, $chtb(9)(q12)$ was the most frequent, and $fra(9)(q12)$ represented the most prevalent fragile site. MN frequency increased significantly after irradiation ($p = 0.0214$), and women exhibited higher MN frequencies than men regardless of treatment ($p = 0.0224$). Overall, these findings indicate that low-dose XR exposure is associated with detectable chromosomal damage and underscore the relevance of biosafety practices and cytogenetic monitoring approaches in contexts involving XR exposure, even at doses traditionally considered safe.
<https://doi.org/10.3389/fgene.2026.1768485>

Interaction of pulsed low frequency electromagnetic field (PEMF) with mitochondria,

Zavadskis, S., Gasser, A. S., Karas, M., Kostrebic, S., Flatscher, J., Vaglio-Garro, A., Dungal, P., Redl, H., Grillari, J., Weidinger, A., Slezak, P. and Kozlov, A. V., *Scientific Reports*, Jan 30 2026, Vol. 16, no. 1.

Pulsed electromagnetic field (PEMF) therapy is a non-invasive treatment that delivers electric and magnetic fields to tissues via inductive coils inducing salutary effects. Previously PEMF was reported to accelerate gas transport in the liquid phase. Drawing analogies from electrical elements, we hypothesized that PEMF can modulate transmembrane potential of biological membranes. Given that mitochondria interact with gaseous molecules such as oxygen and nitric oxide (NO) and contain voltage-sensitive channels, this study focused on the effects of a single PEMF device with a low input-energy and a 1ms, 30 kHz sine wave duty cycle per pulse on mitochondrial function. Experiments were conducted using cell cultures, tissue homogenates, and isolated mitochondria. We assessed mitochondrial membrane potential, NO levels, and mitochondrial respiration. We found no evidence that PEMF restores mitochondrial respiration inhibited by NO, but it can be restored by exposure of mitochondria to blue light. Our findings show that PEMF selectively stimulates respiration linked to ATP-synthesis affecting less uncoupled respiration. This suggests that changes in ATP-synthesis underlies the primary beneficial effects observed here. The underlying mechanisms may include interaction of PEMF with mitochondrial transport systems or activity of mitochondrial complexes. The exact mechanisms still should be investigated.

<https://doi.org/10.1038/s41598-026-37527-6>

Méthodes

The influences of electromagnetic energy caused by the cellular device in a human head based on the dual-delay model,

Abbas, I., Youssef, H. M., El-Bary, A. A. and Almuneef, A., *Open Physics*, Jan 23 2026, Vol. 24, no. 1.

This study involved the development of a mathematical model to simulate the structure of a head human, encompassing three layers: skin, bone, and brain. The model was designed to apply to individuals of different age groups, including both children and adults. The study utilized the concept of delay times to assess the internal thermal response occurring in the human head due to chemical processes. The governing equations were formulated within the framework of a dual phase-lag

model (DPL). By applying Laplace transforms and employing a numerical approximation approach, the inverse solutions were obtained. The study focused on the effect of electromagnetic waves emitted by cellular device on the human head. The variations of temperature within the head were calculated and analysed considering different parameters such as energy density, power transmission frequency, and different heat conduction models. Notably, the power waves density and power transmission frequency due to the electromagnetic wave have significant impacts on the temperature increments and the thermal damages quantity passing through the three studied layers of both adult's and child's heads. Moreover, the differences between the three studied heat conduction are major. The comparative evaluation among Pennes, SPL, and DPL models is presented. <https://doi.org/10.1515/phys-2025-0257>

Development of a 600-GHz Optical System for Electromagnetic Field Exposure Assessment Using a Gyrotron,

Fukunari, M., Mizuno, M., Tatematsu, Y., Yamaguchi, Y., Yamazaki, S. and Nagaoka, T., *Ieee Transactions on Terahertz Science and Technology*, Jan 2026, Vol. 16, no. 1, p. 27-34.

In this article, we report the development of an optical system for a 600-GHz gyrotron, which was developed as a light source for electromagnetic field exposure experiments to conduct exposure assessment and investigate the biological effects of the terahertz wave. In this study, we employed triaxial elliptical mirrors to shape the elliptical beam emitted from the gyrotron. The radiation from the optical system was measured and compared with the design value. Furthermore, stable irradiation power control was demonstrated without any change in the gyrotron operating conditions by integrating an irradiation power control module consisting of three wire grids into the beamline. <https://doi.org/10.1109/tthz.2025.3608314>

Electric field reduction in overhead transmission lines right-of-way using sine cosine optimization algorithm,

Guerrero, L. F. I., Barrera, M. a. R., Giral-Ramírez, D. A. and Olaya, H. F. I., *Results in Engineering*, Mar 2026, Vol. 29.

Population growth and the expansion of electrical infrastructure have intensified concerns regarding exposure to low-frequency electric fields, due to their potential effects on human health, including cardiac disorders and childhood leukemia-as well as on the environment. Considering the existing scientific uncertainty, this paper proposes a strategy to reduce the electric field generated by overhead transmission lines using the Sine-Cosine Algorithm (SCA). The methodology comprises five stages: (i) system configuration, (ii) geometric definition, (iii) SCA adaptation, (iv) validation strategies, and (v) mathematical formulation of the electric field. Two case studies are analyzed: single-and double-circuit configurations in right-of-way areas. The performance of the SCA is benchmarked against the Particle Swarm Optimization (PSO) and Ant Lion Optimizer (ALO) algorithms, as well as the phase-sequence permutation technique. The results demonstrate that SCA-based optimization achieves a significant reduction in electric field intensity relative to the original configurations, exhibiting competitive and consistent performance compared with the other evaluated techniques. This proposal therefore constitutes a technically viable tool for mitigating impacts in right-of-way areas, in accordance with the precautionary principle. <https://doi.org/10.1016/j.rineng.2026.109588>

Electrical bioimpedance analysis of structural modifications in biological tissues caused by a static magnetic field,

Kashina, S., Galindo, A. D. R., Luna, F. M. V., Ordaz, J. M. B. and Cordova, T., *Physiological Measurement*, Feb 27 2026, Vol. 47, no. 2.

Objective. To evaluate the effects of static magnetic field (SMF) on avian brain and muscle tissues using electrical bioimpedance (EBI) as a non-invasive monitoring method, assessing changes in tissue impedance and phase angle to understand cellular responses under a 200 mT SMF. *Approach.* A custom experimental setup with needle electrodes was used to acquire EBI data from avian brain and muscle tissues exposed to 200 mT SMF for 60 min. Impedance and phase angle measurements were analyzed to assess tissue-specific responses. Frequency analysis and Lissajous curves were employed to identify signal amplitude changes. *Main results.* Brain tissue exhibited a faster exponential impedance decay ($\tau = 13.3$ min) compared to muscle tissue ($\tau = 29.5$ min). Phase angle measurements indicated capacitive membrane dynamics. Frequency analysis revealed low-frequency metabolic disruptions and stable 51 Hz oscillations. Lissajous curves showed SMF-induced reductions in low-frequency signal amplitudes, more pronounced in brain tissue. *Significance.* EBI proved effective for real-time, non-invasive monitoring of SMF-induced changes in tissue electric properties, highlighting tissue-specific responses. These findings suggest EBI's potential as a diagnostic tool for studying SMF effects, with future research needed to explore varied tissues and SMF intensities to enhance clinical applications. <https://doi.org/10.1088/1361-6579/ae45ea>

Toxicité sur les animaux

Effect of dual RF-EMF and pulsed magnetic field exposure on eNOS expression and histological integrity in male rat reproductive tissues,

Asci, H., Comlekci, S., Taner, R., Tepebasi, M. Y., Imeci, O. B., Selçuk, E., Aslankoc, R., Gultekin, S., Comlekci, C. and Ozmen, O., *Journal of Molecular Histology*, Jan 28 2026, Vol. 57, no. 1.

This study investigated the molecular and histological responses of male rat reproductive tissues to combined radiofrequency electromagnetic field (RF-EMF) and pulsed magnetic field (PMF) exposure. Sixty adult male Wistar rats were assigned to ten groups and exposed once, twice, or three times daily for 1 day, 1 week, and 1 month. Penile, testicular, prostatic, and renal tissues were analyzed using real-time quantitative polymerase chain reaction (RT-qPCR), histopathology, and immunohistochemistry. Dual-mode electromagnetic exposure produced a marked increase in endothelial nitric oxide synthase (eNOS) mRNA expression, particularly in long-term and higher-frequency groups, whereas vascular endothelial growth factor (VEGF) levels displayed only minimal changes. Tumor necrosis factor-alpha (TNF-alpha) expression decreased in penile tissue following short-term exposure but showed a mild elevation in the long-term, high-frequency testicular group, indicating localized sensitivity. Histopathological examination revealed preserved tissue architecture in the penis, prostate, and kidneys, with hyperemia being the primary finding in penile sections. Caspase-3 (Cas-3) immunoreactivity remained low across all groups, demonstrating an absence of apoptotic activation. Testicular tissues maintained overall tubular integrity, although a moderate reduction in intratubular spermatozoa was noted in the one-month high-frequency group without accompanying necrosis or apoptosis. These findings indicate that RF-EMF and PMF exposure enhances endothelial activation mainly through eNOS upregulation while maintaining general tissue integrity in male reproductive organs. The mild testicular inflammatory response observed under prolonged exposure underscores the importance of dose-dependent application. Overall, the results support the biological safety and physiological relevance of dual electromagnetic stimulation under controlled experimental conditions. <https://doi.org/10.1007/s10735-026-10720-7>

The International Collaborative Animal Study of mobile phone radiofrequency radiation carcinogenicity and genotoxicity: the Japanese study,

Imaida, K., Kawabe, M., Wang, J. Q., Yokohira, M., Imai, N., Han, K. H., Kim, Y. B., Jeon, S. B., Kim, H. S. and Ahn, Y. H., *Toxicological Sciences*, 2026.

The potential carcinogenic and genotoxic effects of radiofrequency electromagnetic fields, particularly those emitted by mobile communication systems, have raised public health concerns. A previous study by the U.S. National Toxicology Program suggested increased incidences of gliomas and cardiac schwannomas in rats exposed to high levels of RF radiation. To evaluate these findings, an international collaborative study was initiated between Japan and Korea. Male Hsd:Sprague Dawley SD rats were exposed to 900 MHz CDMA-modulated RF-EMFs at a whole-body specific absorption rate of 4 W/kg for 18 h and 20 min daily over 2 yr. The study included a 28-d preliminary toxicity study, genotoxicity assays (alkaline comet and micronucleus tests), and a 2-yr carcinogenicity assessment. All procedures followed OECD guidelines and Good Laboratory Practice. No statistically significant increases in the incidences of neoplastic or non-neoplastic lesions were found in any major organ, including the brain, heart, and adrenal glands. Genotoxicity assays revealed no evidence of DNA damage or chromosomal aberrations in RF-exposed rats. A higher survival rate in the RF-exposed group, likely due to lower body weight and food consumption, was observed. This study, performed in Japan, jointly planned and executed by Japan and Korea, provides strong evidence that long-term exposure to 900 MHz RF-EMFs did not produce reproducible carcinogenic or genotoxic effects in male rats. Combined with data from the Korean counterpart study, these results are expected to contribute to future international assessments of the carcinogenic potential of electromagnetic radiation. <https://doi.org/10.1093/toxsci/kfag002>

Biological responses to 30 mT static magnetic field in young and 36-month-old rats,

Jovanovic, M., Ille, M., Vukovic, A., Milovanovich, I. D., Mitic, D. and De Luka, S. R., *Electromagnetic Biology and Medicine*, 2026.

This study aimed to investigate the effects of subchronic exposure to a 30 mT static magnetic field (SMF) on hematological parameters, spleen and tibia cellularity in 36-month-old and young rats. A total of 27 rats were divided into four groups (Young, Young SMF, Old, Old SMF) and two groups were exposed to SMF for 10 weeks. After exposure period, blood counts, neutrophil-to-lymphocyte ratio (NLR, an index of systemic inflammation), platelet-to-lymphocyte ratio (PLR, a platelet-based inflammatory marker) and cellularity of immune-related organs were analyzed. SMF exposure reduced lymphocyte counts and increased NLR in both age groups, while PLR increased only in young rats. In 36-month-old rats, SMF significantly reduced platelet counts, whereas this effect was not observed in young animals. SMF exposure also enhanced tibial and splenic cellularity in both groups but exerted opposite effects on the proportions of lymphocytes and erythrocytes depending on age. These findings suggest age-dependent immune modulation by SMF. In young animals, SMF likely promoted a proinflammatory shift, reflected by elevated NLR and PLR. In contrast, in 36-month-old rats, SMF may act as a nonspecific physiological stressor, potentially triggering the General Adaptation Syndrome (three-stage stress response), leading to corticosterone-mediated immunosuppression and cell redistribution. To our knowledge, this is the first study demonstrating age-dependent differential modulation of NLR and PLR by subchronic SMF exposure, linking proinflammatory shifts in youth with stress-related immunosuppression in aging. Overall, age appears to be a critical factor in determining the biological responses to SMF, underscoring the need for age-specific evaluation of SMF exposure. <https://doi.org/10.1080/15368378.2026.2617536>

Dose-dependent impact of extremely low-frequency electromagnetic field (ELF-EMF) on the neuroplasticity in the hippocampus of adult rats,

Klimiuk, M., Kletkiewicz, H., Wyszowska, J., Dokladny, K. and Rogalska, J., *Neuroscience Letters*, Mar 15 2026, Vol. 874.

Extremely low-frequency electromagnetic field (ELF-EMF) therapy is gaining attention for its potential benefits in treating neurodegenerative conditions. However, the underlying molecular mechanisms responsible for the possible protective effects of ELF-EMF remain unclear. Our previous research revealed that ELF-EMF exposure can establish a new "set-point" for stress responses, with outcomes dependent on field intensity. Stress hormones have been shown to modulate hippocampal function and plasticity. Therefore, our study aimed to assess how ELF-EMF exposure affects the expression of transcripts related to hippocampal plasticity, including genes related to neurogenesis (BDNF, TrkB, GAP43), synaptic activity (PSD95, SYN1), and cell survival (Bcl-2, Bcl-xL, Bak1). Adult rats were exposed to ELF-EMF (50 Hz) at 1 mT and 7 mT intensities for three 7-day periods, 1 h/day, with 3-week break between each cycle. A subset of animals was sacrificed after each exposure to collect hippocampi. The relative expression of neural/synaptic genes and anti-/pro-survival factors was measured by real-time quantitative polymerase chain reaction. Our findings indicate that ELF-EMF exposure modulates mRNA expression of neural/synaptic genes and anti-/pro-survival factors. The direction and dynamics of changes depend on ELF-EMF intensity and the number of exposures. "Low-intensity" ELF-EMF (1 mT) increased proneuroplastic factors expression, while "high-intensity" ELF-EMF (7 mT) decreased them. In summary, "low-intensity" ELF-EMF enhances adaptive processes like neuroplasticity by eliciting a mild stress response, while "high-intensity" exposure disrupts homeostasis and brain function by inducing severe stress. Our findings indicate that the overall effects of ELF-EMF depend on the intricate interplay between stress reactions and long-term brain plasticity. <https://doi.org/10.1016/j.neulet.2026.138520>

Actualité, société et mesures de prévention

Health risk assessment of 5G technologies: the ANSES approach,

Attia, D. and Merckel, O., *Annals of Telecommunications*, 2026.

The deployment of 5G technology presents new challenges for health risk assessment due to its technical specificities and accelerated deployment timeline. This article presents the methodological approach developed by the French Agency for Food, Environmental and Occupational Health & Safety (ANSES) to evaluate health risks associated with 5G electromagnetic field exposure across three frequency bands: 700-2100 MHz, 3.5 GHz, and 26 GHz. The assessment combined adapted methodologies for each frequency range, working group assessment, and public consultation. For the 700-2100 MHz band, existing knowledge from previous mobile technologies was considered relevant. For the 3.5 GHz band, despite limited specific data, extrapolation from lower frequencies suggested no new health risk. For the 26 GHz band, while effects are mainly localized to superficial tissues, current data remain insufficient for definitive conclusions. The study highlights the need for enhanced exposure characterization and targeted experimental research, particularly for higher frequency bands where wave penetration is limited to skin and eye surfaces.

<https://doi.org/10.1007/s12243-026-01158-9>

Electromagnetic shielding performance and mechanical properties of vermiculite-based lightweight geopolymers mortars,

Çelik, A. I., Tunç, U., Durmus, A., Karaköse, E., Alkurt, F. and Karaaslan, M., *Scientific Reports*, Feb 9 2026, Vol. 16, no. 1.

In recent years, the widespread use of electronic devices has led to an increase in electromagnetic pollution, which causes electromagnetic interference and reduces the performance of systems. Furthermore, increasing electromagnetic pollution can pose serious risks to human health. This study investigates the development of vermiculite-reinforced lightweight geopolymer composites for protection against electromagnetic pollution. The composites were produced using F-class fly ash and vermiculite in varying proportions between 0 and 100%, along with 10-13 M NaOH solutions. The electromagnetic performance of the 160 & times; 140 & times; 40 mm tablet samples is evaluated by measuring S11, S21, and shielding effectiveness (SE) for 3-40 GHz frequency bands, 16 GHz and 32 GHz used as representative points for cross-property plots. While electromagnetic SE was characterized across the broad 3-40 GHz band, the frequencies of 16 GHz and 32 GHz are selected as representative points for detailed cross-property analysis and surface plotting to illustrate the interaction between mechanical and electromagnetic performance. All mixtures showed good impedance matching with reflection values below - 10 dB. SE results show that V25-M12, V50-M12, and V100-M12 mixtures, especially in the Ka band, provided high electromagnetic attenuation by exhibiting resonance peaks above 50 dB. The increase in vermiculite content reduced the bulk density by 8-17% due to its porous structure. Higher molarities (especially 13 M) created a looser microstructure. The highest mechanical flexural strength (8.9 MPa) is obtained with 25% vermiculite and 11 M solution, while the highest compressive strength (30-32 MPa) is obtained with the vermiculite-free control sample. Taguchi analysis showed that the combination of 25% vermiculite and 11-13 M NaOH provided the most balanced mechanical and electromagnetic performance. <https://doi.org/10.1038/s41598-026-38722-1>

Research on Composite Shielding of Sector-Shaped Coil for Resonant Wireless Power Supply Cardiac Pacemaker,

Chen, W. H., Huang, Z. S., Yan, X. H., Huang, W. Y. and Zhu, F. Y., *International Journal of Circuit Theory and Applications*, 2026.

In response to the issues of severe magnetic leakage in the wireless power transfer (WPT) system for cardiac pacemaker, which poses a threat to human safety, this paper proposes a composite shielding method for a resonant wireless power supply cardiac pacemaker sector-shaped coil operating at a frequency of 180 kHz. Firstly, the working principle of the sector-shaped shielding coil is analyzed, and a WPT system based on the LCC-S compensation circuit is constructed. The structural parameters of the system are determined by optimizing the coupling coefficient between the transmission coils. Secondly, in order to investigate the influence of the central angle on the shielding performance of the circumferential sector-shaped shielding coil, five different shielding schemes are designed and their magnetic field leakage confinement capabilities as well as system performance are studied. Considering the potential risks of leakage magnetic fields to human health, a human model is established in COMSOL for safety assessment. Finally, an experimental platform is designed and constructed. The experimental results show that, after incorporating the 120 degrees circumferential sector-shaped shielding coil and composite shielding material, the leakage magnetic field at a distance of 36 mm from the center decreases by 34.7%, and the transmission efficiency is 72.3%. Under a 30-min charging test, the maximum tissue temperature rise is only 1.2 degrees C, which complies with human safety standards. <https://doi.org/10.1002/cta.70378>

Energy-efficient active shield for substation magnetic field mitigation,

Grinchenko, V., Tazowski, P., Perehuda, O. and Blachowski, B., *Electric Power Systems Research*, Jul 2026, Vol. 256.

As environmental pollution continues to rise, it is of great importance to ensure proper living conditions for humans. Along with rising electricity consumption, pollution from the magnetic field generated by electrical equipment and transmission lines is also increasing. The potential health effects of exposure to power frequency magnetic fields are referenced at levels of 0.2 & micro;T to 3 & micro;T in many countries. This study focuses on the magnetic field generated by indoor medium-voltage/low-voltage transformer substations. As the magnetic field in apartments above indoor substations exceeds the reference level, certain measures are to be taken. The so-called active shields are made of a closed current-carrying loop, a control system, and magnetic field sensors. They mitigate the magnetic field to the reference level. However, these shields continuously consume electric power. Therefore, the aim of this work is to develop a technique for designing energy-efficient active shields. The properties of these active shields are determined by solving an optimization problem that minimizes active power. Triangular, quadrangular, pentagonal, and hexagonal shapes of current-carrying loops are under study. Results show that using geometrically complex designs of active shields, particularly hexagonal ones, may be beneficial for energy-efficient and high-performance mitigation of the transformer substation magnetic field. Thus, the power consumption of the active shield is reduced from 50 W to 2.3 W when mitigating the magnetic field of the substation under study. <https://doi.org/10.1016/j.epr.2026.112828>

Nanoflower ZnO@NiCo/C@Polypyrrole Nanocomposites for Broadband Electromagnetic Wave Absorption,

Jia, R. F., Cheng, S. J., Yin, B. L., Liu, S. B. and Shang, W. P., *Journal of Applied Polymer Science*, Apr 5 2026, Vol. 143, no. 13.

In recent years, electromagnetic radiation poses a significant risk to the precision of equipment and human health. The fabrication of wave-absorbing composites with good morphology design by combining with different materials is expected to solve this problem. In here, ZnO@NiCo/C@PPy (ZNCP) nanocomposites with flower-like structure were synthesized through a combination of chemical, solvothermal, and in situ polymerization techniques. The outer layer of flower-like ZnO was successfully wrapped with NiCo alloy, and both Ni and Co are magnetic lossy materials. This not only curtails the occurrence of agglomeration phenomenon and facilitates the resonance loss, but also maintains the original flower-like structure of the material, and the conductive network skeleton of carbon obtained from high-temperature pyrolysis can multi-scatter the electromagnetic wave (EMW), which can further effectively deplete the EMW. As expected, the ZNCP nanocomposites exhibit optimal performance, at the frequency of 5.8 GHz reflection loss (RL_{min}) reaches -81.64 dB with a matching thickness of 5.5 mm, and at 10.64 GHz effective absorption bandwidth (EAB) reaches 4.5 GHz with a matching thickness of 3.13 mm. The findings show that the ZnO@NiCo/C@PPy nanocomposites have excellent EMW absorption performance, which can serve as a reference for designing wave-absorbing materials with superior structure and performance. <https://doi.org/10.1002/app.70347>

A durable wearable fabric with personal thermal management, infrared steal and electromagnetic shielding,

Lan, N., Zhao, Y. G., Li, Q., Wei, G. H., Cao, S. H., Zhang, X. Y., Fu, Y. J., He, D. Y. and Liu, Q. M., *Nano Research*, Feb 2026, Vol. 19, no. 2.

In today's era of climate variability, severe electromagnetic pollution, and advanced infrared detection technology, multifunctional fabrics integrating personal thermal management (PTM), infrared stealth, and electromagnetic shielding capabilities have become crucial for human health and safety. In this work, we combine the inherently low infrared emissivity of poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) with the high electrical conductivity and strong solar light absorption properties of carbon nanotubes (CNTs) to achieve a multifunctional wearable fabric. This fabric has a low mid-infrared (MIR) emissivity of 0.33 in the 8-13 μm band, thereby demonstrating remarkable infrared stealth properties and a passive radiative heating (PRH) performance of 3.1 degrees C, achieving an ideal covert thermal management effect. Its high electrical conductivity ($4204 \text{ S}\cdot\text{m}^{-1}$) and solar light absorptivity (95.45%) have endowed it with satisfactory photo/electric-heating performance and an electromagnetic interference shielding efficiency (EMI SE) of 55 dB. Furthermore, this fabric also exhibits excellent self-cleaning properties, along with wearable characteristics that ordinary functional fabrics should possess, such as flexibility, washing resistance, and abrasion resistance. This work not only obtains a functional fabric with broad application prospects in various scenarios such as daily life and military steal, but also fully demonstrated that the conductive polymer PEDOT:PSS is expected to become a highly promising functional material in the fields of thermal regulation and camouflage. <https://doi.org/10.26599/nr.2025.94908296>

Enhancing Permanent Magnet Sliding Bearings Through Multi-Layer Yoke for Minimized Magnetic Leakage,

Liu, Y., Zhao, H. T., Li, J. X., Wu, L. and Xia, Y., *Materials*, Feb 6 2026, Vol. 19, no. 3.

To mitigate the potential adverse effects of magnetic flux leakage from permanent-magnet sliding bearings on human health and the environment, this study proposes a leakage-suppressed design based on a multi-layer yoke configuration. The magnetic performance of the bearing was systematically investigated using finite element method (FEM) simulations. The results demonstrate a pronounced reduction in magnetic leakage when replacing a conventional single-layer yoke with an optimized multi-layer yoke structure. Targeted design refinements, including optimization of both the number and angular span of magnetic rings, as well as tuning of the yoke thickness, further enhance the effectiveness of the leakage-suppression strategy. The proposed multi-layer yoke configuration preserves both the magnetic force and the load-carrying capacity of the magnetic bearing, while concurrently providing a viable theoretical and engineering basis for the design and structural optimization of leakage-controlled permanent-magnet bearings. <https://doi.org/10.3390/ma19030642>

Biochar-Coated Drywall Panels for Electromagnetic Shielding Applications in the K-Band,

Ruscica, G., Savi, P., Perotti, M. and Sora, I. N., *Electronics*, Mar 4 2026, Vol. 15, no. 5.

With the rise of telecommunication systems in recent decades, the implications for human health have prompted a search for ways to reduce the impact of electromagnetic waves in buildings when necessary. A viable and promising solution to realize electromagnetic shielding could be the use of drywall panels coated with a biochar paste, as proposed in this study. Biochar (bio-charcoal), a low-

cost and carbon-based material, can be obtained by the thermochemical conversion of different biomass sources. A commercial wood-based biochar thermally treated at 750 degrees C is considered in this work. Transmission coefficients of several gypsum board elements with a biochar coating are measured in the frequency K-band (18-27 GHz). In addition, the SE of a double panel configuration, obtained by joining two coated boards to form a multilayer structure, is evaluated. The results show that the biochar coating significantly enhances the SE compared to uncoated drywall. At the highest biochar loading investigated (0.20 g/cm²), the shielding effectiveness consistently exceeds 27 dB for single panels and 46 dB for double panels across the entire frequency band. These findings indicate that biochar-coated drywall systems offer a practical and sustainable solution for integrating electromagnetic shielding into building envelopes, paving the way for innovative applications in indoor exposure control. <https://doi.org/10.3390/electronics15051073>

Managing smartphone-related health concerns: a case-study analysis using SAP-LAP hills framework,

Sharma, M., *Journal of Advances in Management Research*, 2026.

*Purpose*In the present scenario, a smartphone is a necessity in our daily lives. Over the last few years, smartphone usage has shown extraordinary progress. The Indian telecom market is one of the major revenue contributors to the Indian gross domestic product. Due to the increased use of smartphones, concerns are rising about the impact of electromagnetic radiation from towers and mobile phones. The purpose of the study is to understand the risk perception and attitudes towards the Electro-Magnetic Fields (EMF) associated with the smartphone.
*Design/methodology/approach*The variables for the study were taken from the present literature assessment and finalised with the support of professionals from industry and academia. Around these variables, a semi-structured interview was conducted, and responses were collected from a different segment of telecom experts and consumers. The study provides essential implications for practitioners and academicians.
*Findings*The research used a case study method to understand the scientific evidence and ground reality of the smartphone and tower radiations. In this study, the Situation Actor Process-Learning Action Performance (SAP-LAP) Hills framework has been used to describe learning from the relationships between the variables.
*Research limitations/implications*The case study has also revealed some relevant facts for policymakers. Supportive government policy, entrepreneurial growth, and global competitiveness have been the strategic variables for the telecom industry, and low R&D investment has been the most significant barrier to the growth of the telecom ecosystem. This study provides the foundation for one of the least studied areas in smartphones.
*Originality/value*The case study technique has been used to study the impact of telecom tower radiation on consumer perception. Regulatory authorities are primarily concerned with tower regulations and the effect of EMF on the impact on human life. Government policy provides precautionary guidelines for the service provider and smartphone manufacturers. The trust towards the regulatory authority plays an essential part in producing public confidence. The regulatory authority guidelines have a significant impact on the performance of telecommunications companies. Therefore, the government needs to make strict regulations for smartphone manufacturers and telecom companies to protect their users.

<https://doi.org/10.1108/jamr-10-2024-0398>

Bioinspired Multifunctional Carbon Platforms Decorated with MoS₂/Au Nanohybrids for Integrated Antibacterial and Electromagnetic Shielding Performance,

Tang, Y. N., Luo, K. J., Li, P. D., Fan, G. H. and Liu, Y., *Small*, 2026.

*The dilemma of biological contamination and radiation pollution deriving from the widely used implantable monitor equipment and wearable electronics promotes the growing demand for integrated biological and electromagnetic protection materials. This work proposes Oxalis-mimicking nanosheet arrays of MoS₂/Au on carbon cloth (CC@MoS₂/Au) to exert a "kill three birds with one stone" effect. First, the biomimetic architecture imparts the planar substrate with mechano-bactericidal property, which is dependent on attractive interactions between sharp edges and adhered bacteria. Second, the integration of MoS₂/Au nanohybrids triggers a photo-bactericidal mode, and the coupling of Au nanoparticles guarantees smooth fulfillment for higher photocatalytic efficacy. Such a synergistic action allows for a nearly 100% inactivation efficiency toward *E. coli* and *S. aureus*. Third, the engineered CC@MoS₂/Au exhibits electromagnetic interference shielding effectiveness exceeding 40 dB in X band, equivalent to 99.99% impeding of incident waves. This work reported here to design of multifunctional platforms with antibacterial and electromagnetic interference shielding performance, which may create a powerful support to mitigate the issues of biological contamination and electromagnetic pollution in the field of modern healthcare. <https://doi.org/10.1002/sml.202514332>*

Biomass-derived lightweight composite aerogels: Preparation and full Ku-band broadband electromagnetic wave absorption performance,

Wang, X. R., Gao, Y. X., Qi, J. W., Zhang, Q., Lyu, X., Pan, L. Y., Yang, Y., Li, J., Zhang, C. Y. and Zhao, G. D., *Materials Today Chemistry*, Mar 2026, Vol. 52.

With the rapid popularization of wireless communication technologies, electromagnetic (EM) pollution has increasingly disrupted the stable operation of precision electronic equipment and even posed risks to public health. Against this context, electromagnetic wave absorption (EMW) materials, as a core solution to mitigate EM pollution, have driven continuous advancement in related research fields. In this work, a Kapok Fiber/N-doped Reduced Graphene Oxide/Layered Magnetic Hydroxide (KF/N-RGO/LDH) aerogel was synthesized via an electrostatic self-assembly method-this preparation route not only simplifies operation steps but also facilitates the uniform combination of components. The experimental findings reveal that when the composite is calcined at 800 degrees C, it achieves an absorption bandwidth of 6.25 GHz with a thickness of merely 2.20 mm, which fully covers the Ku band (12.00-18.00 GHz) and X band (11.75-12.00 GHz), thereby exhibiting excellent multi-band EMW absorption capabilities. The outstanding performance of the KF/N-RGO/LDH aerogel stems from its suitable impedance matching and the synergistic integration of multiple loss mechanisms. Furthermore, as a biopolymerbased material, KF/N-RGO/LDH presents a promising strategy perfectly aligning with the contemporary goals of sustainable development and green manufacturing. <https://doi.org/10.1016/j.mtchem.2026.103407>