TECHNOLOGIE 5G

Bulletin de veille scientifique : Septembre 2024

Objectifs : réaliser une veille scientifique sur la technologie 5G

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Généralités

Effects of website-based risk communication of radio-frequency electromagnetic fields on general public.

Yamaguchi-Sekino S, Kamegai K, Ikuyo M, Taki M, Onishi T, Watanabe S. *Front Public Health*. 2024;12:1438986.

BACKGROUND: Radio-frequency electromagnetic fields (RF-EMFs) are utilized in communications and appliances and are indispensable in daily life. However, some people have concerns about the adverse health effects of RF-EMFs; therefore, effective risk communication (RC) is needed in this field. OBJECTIVE: In this study, we investigate public attitudes towards RF-EMFs and examine the impact of RC via a website on these attitudes and objective knowledge. METHODS: Three web surveys were conducted over 10 weeks with the same participants. The questionnaires were conducted at three different time points with 5-week intervals: baseline survey (T1), RC evaluation survey (T2), and follow-up survey (T3). Participants of T2 were randomly recruited from among those of T1, and participants of T3 were randomly selected from among the T2 respondents. Approximately half of the respondents in each of T2 and T3 were assigned to the control group. Twelve items regarding attitudes toward RF-EMFs and objective knowledge were evaluated in all surveys (T1-T3). After removing low-engagement data, the number of valid answers was 782 in T3. Differences between T1 and T2 (Sub T1-T2) and T1 and T3 (Sub T1-T3) were analyzed. Participant selection was randomized and the authors were blind to this selection until analysis. RESULTS: Four clusters were identified: Cluster 1 (Non-anxious, 25.0%), Cluster 2 (Anxious, 16.0%), Cluster 3 (Low-interest, 40.5%), and Cluster 4 (High-interest, 18.5%). A decrease in subjective RF-EMF exposure levels was noted in Cluster 2 immediately after website viewing. Temporary increases and decreases in health concerns about RF-EMF usage activities were observed in Clusters 1 and 2, respectively, immediately after viewing. Clusters 1 and 3 showed a temporal decrease in needs for RF-EMF usage activities at T2 but it returned to the baseline level 5 weeks later. Cluster 4 was less responsive to the risk communication. Subanalysis stratified by gender and age showed fluctuations in responses, especially in Clusters 1 and 2. CONCLUSION: We demonstrate the effectiveness of RF-EMF risk communication via websites, particularly for Cluster 2. The results of this study showed that offering objective and comprehensible information through a website can significantly reduce concerns and perceived risks related to RF-EMFs.

[Lien vers l'article](#)

Technologie 5G

Performances et sécurité

Exploring the potential of 5G uplink communication: Synergistic integration of joint power control, user grouping, and multi-learning Grey Wolf Optimizer.

Sikkanan S, Kumar C, Manoharan P, Ravichandran S. *Sci Rep*. 2024 Sep 13;14(1):21406.

Non-orthogonal Multiple Access (NOMA) techniques offer potential enhancements in spectral efficiency for 5G and 6G wireless networks, facilitating broader network access. Central to realizing optimal system performance are factors like joint power control, user grouping, and decoding order. This study investigates power control and user grouping to optimize spectral efficiency in NOMA uplink systems, aiming to reduce computational difficulty. While previous research on this integrated optimization has identified several near-optimal solutions, they often come with considerable system and computational overheads. To address this, this study employed an improved Grey Wolf Optimizer (GWO), a nature-inspired metaheuristic optimization method. Although GWO is effective, it can sometimes converge prematurely and might lack diversity. To enhance its performance, this study introduces a new version of GWO, integrating Competitive Learning, Q-learning, and Greedy Selection. Competitive learning adopts agent competition, balancing exploration and exploitation and preserving diversity. Q-learning guides the search based on past experiences, enhancing adaptability and preventing redundant exploration of sub-optimal regions. Greedy selection ensures the retention of the best solutions after each iteration. The synergistic integration of these three components substantially enhances the performance of the standard GWO. This algorithm was used to manage power and user-grouping in NOMA systems, aiming to strengthen system performance while restricting computational demands. The effectiveness of the proposed algorithm was validated through numerical evaluations. Simulated outcomes revealed that when applied to the joint challenge in NOMA uplink systems, it surpasses the spectral efficiency of conventional orthogonal multiple access. Moreover, the proposed approach demonstrated superior performance compared to the standard GWO and other state-of-the-art algorithms, achieving reduced system complexity under identical constraints.

Lien vers l'article

Machine-learning-aided method for optimizing beam selection and update period in 5G networks and beyond.

Marenco L, Hupalo LE, Andrade NF, de Figueiredo FAP. *Sci Rep*. 2024 Aug 29;14(1):20103.

Finding the optimal beam pair and update time in 5G systems operating at mmWave frequencies is time-intensive and resource-demanding. This intricate procedure calls for the proposal of more intelligent approaches. Therefore, this work proposes a machine learning-based method for optimizing beam pair selection and its update time. The method is structured around three main modules: spatial characterization of beam pair service areas, training of a machine learning model using collected beam pair data, and an algorithm that uses the decision function of the trained model to compute the optimal update time for beam pairs based on the spatial position and velocity of user equipment. When the machine learning model is deployed in a network with a single gNB equipped with a 8×8 UPA and one UE equipped with a 1×2 UPA in an mmWave scenario simulated in NS3, improvements in SINR and throughput up to 407% , were observed. Improvements are gathered because of a

reduction of 85.7% in beam pair selections because of an increase of approximately 1543% in the effective time between successive beam pair searches. This method could offer real-time optimization of the beam pair procedures in 5G networks and beyond.

Lien vers l'article

Survey on 5G Physical Layer Security Threats and Countermeasures.

Harvanek M, Bolcek J, Kufa J, Polak L, Simka M, Marsalek R. *Sensors (Basel)*. 2024 Aug 26;24(17).

With the expansion of wireless mobile networks into both the daily lives of individuals as well as into the widely developing market of connected devices, communication is an increasingly attractive target for attackers. As the complexity of mobile cellular systems grows and the respective countermeasures are implemented to secure data transmissions, the attacks have become increasingly sophisticated on the one hand, but at the same time the system complexity can open up expanded opportunities for security and privacy breaches. After an in-depth summary of possible entry points to attacks to mobile networks, this paper first briefly reviews the basic principles of the physical layer implementation of 4G/5G systems, then gives an overview of possible attacks from a physical layer perspective. It also provides an overview of the software frameworks and hardware tool-software defined radios currently in use for experimenting with 4G/5G mobile networks, and it discusses their basic capabilities. In the final part, the paper summarizes the currently most promising families of techniques to detect illegitimate base stations-the machine-learning-based, localization-based, and behavior-based methods.

Lien vers l'article

EAIA: An Efficient and Anonymous Identity-Authentication Scheme in 5G-V2V.

Du Q, Zhou J, Ma M. *Sensors (Basel)*. 2024 Aug 20;24(16).

Vehicle Ad-hoc Networks (VANETs) have experienced significant development in recent years, playing a crucial role in enhancing the driving experience by enabling safer and more efficient inter-vehicle interactions through information exchange. Vehicle-to-Vehicle (V2V) communication is particularly vital as it not only helps to prevent collisions and improve traffic efficiency but also provides essential situational awareness to drivers or autonomous driving systems. Communication is typically supported by roadside units (RSUs); however, in practical applications, vehicles may exceed the communication range of RSUs, thus exposing them to various malicious attacks. Additionally, considering the limited computational resources of onboard units (OBUs) in vehicles, there is a high demand for designing lightweight security protocols that support V2V communication. To address this issue, this paper proposes an efficient anonymous V2V identity-authentication protocol tailored for scenarios that lack RSU support. The proposed protocol was formally assessed using the Scyther tool, demonstrating its capability to withstand major typical malicious attacks. Performance evaluations indicate that the proposed protocol is efficient in terms of communication and computational overhead, making it a viable solution for V2V communication.

Lien vers l'article

Decentralized System Synchronization among Collaborative Robots via 5G Technology.

Celik AE, Rodriguez I, Ayestaran RG, Yavuz SC. *Sensors (Basel)*. 2024 Aug 20;24(16).

In this article, we propose a distributed synchronization solution to achieve decentralized coordination in a system of collaborative robots. This is done by leveraging cloud-based computing and 5G technology to exchange causal ordering messages between the robots, eliminating the need for centralized control entities or programmable logic controllers in the system. The proposed solution is described, mathematically formulated, implemented in software, and validated over realistic network conditions. Further, the performance of the decentralized solution via 5G technology is compared to that achieved with traditional coordinated/uncoordinated cabled control systems. The results indicate that the proposed decentralized solution leveraging cloud-based 5G wireless is scalable to systems of up to 10 collaborative robots with comparable efficiency to that from standard cabled systems. The proposed solution has direct application in the control of producer-consumer and automated assembly line robotic applications.

Lien vers l'article

Antennes

Experimental investigations of dual functional substrate integrated waveguide antenna with enhanced directivity for 5G mobile communications.

Sathishkumar N, Palanisamy S, Natarajan R, V RA, Ouahada K, Hamam H. *Heliyon*. 2024 Sep 15;10(17):e36929.

Antennas with higher gain and efficiency deliver superior performance across a wide frequency range. Achieving these characteristics at high frequencies while keeping a compact size necessitates sophisticated design approaches. This research presents a substrate-integrated waveguide (SIW) cavity-backed slotted patch antenna (SPA) tailored for the 28 GHz and 34 GHz frequency bands. Additionally, a linear tapered slot antenna is designed with a compact profile of 27.5 mm × 7.5 mm × 0.254 mm. The SIWs are implemented using vias on the outer profile of the antenna, and circular and rectangular slots are etched on the radiating surface. The goal of optimizing the antenna geometry is to enhance return loss within the desired frequency bandwidth, which means the Genetic Algorithm (GA) will determine the optimal antenna shape to achieve lower return loss than the original design within this bandwidth. The antenna exhibits dual resonance at 28 GHz and 38 GHz in the millimeter-wave range, providing an impedance bandwidth of 211 MHz (27.72 GHz-27.94 GHz) at 28 GHz and 127 MHz (37.88 GHz-37.98 GHz) centered at 38 GHz. The proposed antenna demonstrates gains of 8.04 dBi and 9.72 dBi at these operating bands. A prototype of the antenna is fabricated on RT/duroid 5880 and its characteristics are measured. The overall VSWR of the antenna ranges from 1 to 2, with a radiation efficiency of 94 %. The proposed antenna achieves dual-band performance with increased directivity and stable gain, exhibiting enhanced electric field distribution, radiation patterns, and reflection coefficient (S11), all of which contribute to a comprehensive understanding of the antenna's performance. This study compares the designed antenna's performance to that of the fabricated prototype. The proposed antenna is ideal for 5G applications due to its small size, broad spectral coverage, and excellent gain.

Lien vers l'article

Architecture réseau

Aucun article dans ce bulletin.

Efficacité énergétique

Aucun article dans ce bulletin.

Autres équipements

Aucun article dans ce bulletin.

Applications médicales et industrielles de la 5G

Applications industrielles

EAIA: An Efficient and Anonymous Identity-Authentication Scheme in 5G-V2V.

Du Q, Zhou J, Ma M. *Sensors (Basel)*. 2024 Aug 20;24(16).

Vehicle Ad-hoc Networks (VANETs) have experienced significant development in recent years, playing a crucial role in enhancing the driving experience by enabling safer and more efficient inter-vehicle interactions through information exchange. Vehicle-to-Vehicle (V2V) communication is particularly vital as it not only helps to prevent collisions and improve traffic efficiency but also provides essential situational awareness to drivers or autonomous driving systems. Communication is typically supported by roadside units (RSUs); however, in practical applications, vehicles may exceed the communication range of RSUs, thus exposing them to various malicious attacks. Additionally, considering the limited computational resources of onboard units (OBUs) in vehicles, there is a high demand for designing lightweight security protocols that support V2V communication. To address this issue, this paper proposes an efficient anonymous V2V identity-authentication protocol tailored for scenarios that lack RSU support. The proposed protocol was formally assessed using the Scyther tool, demonstrating its capability to withstand major typical malicious attacks. Performance evaluations indicate that the proposed protocol is efficient in terms of communication and computational overhead, making it a viable solution for V2V communication.

Lien vers l'article

Applications médicales

Implementing telemedicine with 5G technologies in a nursing home for reducing emergency admissions- study protocol of a mixed-methods study.

Lubasch JS, Eder PA, Kaiser C, Klausen AD, Overheu D, Partheymüller A, et al. *BMC Health Serv Res*. 2024 Sep 23;24(1):1110.

BACKGROUND: By transmitting various types of data, telemedical care enables the provision of care where physicians and patients are physically separated. In nursing homes, telemedicine has the potential to reduce hospital admissions in nonemergency situations. In this study, telemedicine devices were implemented with the new 5G mobile communications standard in selected wards of a large nursing home in Northwest Germany. The main aim of this study is to investigate which individual and organizational factors are associated with the use of telemedicine devices and how users perceive the feasibility and implementation of such devices. Moreover, it is investigated whether the telemedical devices help to reduce the number of emergency admissions. METHODS: Telemedicine devices are implemented over an 18-month period using a private 5G network, and all users receive training. This study uses qualitative and quantitative methods: To assess the individual and organizational factors associated with the use of telemedicine devices, survey data from employees before and after the implementation of these devices are compared. To assess the perception of the implementation process as well as the feasibility and usability of the telemedical devices, the nursing staff, physicians, medical assistants and residents are interviewed individually. Moreover, every telemedicine consultation is evaluated with a short survey. To assess whether the number of emergency admissions

decreased, data from one year before implementation and one year after implementation are compared. The data are provided by the integrated dispatch centre and emergency medical services (EMS) protocols. The interview data are analysed via structured qualitative content analysis according to Kuckartz. Survey data are analysed using multivariable regression analysis. DISCUSSION: Learnings from the implementation process will be used to inform future projects implementing telemedicine in care organizations, making the final telemedicine implementation and care concept available to more nursing homes and hospitals. Moreover, the study results can be used to provide use cases for appropriate and targeted application of telemedicine in nursing homes and to define the role of 5G technologies in these use cases. If the intervention is proven successful, the results will be used to promote 5G network rollout. TRIAL REGISTRATION: German Clinical Trials Register - trial registration number: DRKS00030598.

Lien vers l'article

Evaluation (Mesure des niveaux d'exposition)

Méthodes d'évaluation

A comprehensive review of 5G NR RF-EMF exposure assessment technologies: fundamentals, advancements, challenges, niches, and implications.

Korkmaz E, Aerts S, Coesoij R, Bhatt CR, Velghe M, Colussi L, et al. *Environ Res*. 2024 Nov 1;260:119524.

This review offers a detailed examination of the current landscape of radio frequency (RF) electromagnetic field (EMF) assessment tools, ranging from spectrum analyzers and broadband field meters to area monitors and custom-built devices. The discussion encompasses both standardized and non-standardized measurement protocols, shedding light on the various methods employed in this domain. Furthermore, the review highlights the prevalent use of mobile apps for characterizing 5G NR radio network data. A growing need for low-cost measurement devices is observed, commonly referred to as "sensors" or "sensor nodes", that are capable of enduring diverse environmental conditions. These sensors play a crucial role in both microenvironmental surveys and individual exposures, enabling stationary, mobile, and personal exposure assessments based on body-worn sensors, across wider geographical areas. This review revealed a notable need for cost-effective and long-lasting sensors, whether for individual exposure assessments, mobile (vehicle-integrated) measurements, or incorporation into distributed sensor networks. However, there is a lack of comprehensive information on existing custom-developed RF-EMF measurement tools, especially in terms of measuring uncertainty. Additionally, there is a need for real-time, fast-sampling solutions to understand the highly irregular temporal variations EMF distribution in next-generation networks. Given the diversity of tools and methods, a comprehensive comparison is crucial to determine the necessary statistical tools for aggregating the available measurement data.

Lien vers l'article

Evaluation population générale

Evaluation of electric field (E) exposure levels and its relationship with the sleep quality of residents around the BTS antennas in Sabzevar, Iran.

Malvandi H, Fallahi M, Saghi MH, Hassanzadeh N. *Radiat Prot Dosimetry*. 2024 Sep 19;200(15):1405-15.

Mobile devices and base transceiver station (BTS) are the main sources of human exposure to radio frequency electromagnetic fields (RF-EMFs). Therefore, the aim of the present study was to evaluate the levels of exposure to RF-EMF in three different time intervals and three different distances from BTS antennas in Sabzevar. Additional goals were to investigate the electric field (E) difference between different microenvironments, between the suburbs and downtown, and evaluating the sleep quality of residents around BTS antennas at different distances. The results showed significant differences between the values of E Avg and E max Avg at different times (T1, T2, and T3), different distances (50, 100, and 300 m) from BTS antennas, and between BTS antennas located in the suburbs and downtown. No significant differences were observed between the values of E Avg and E max Avg in terms of microenvironments. Poor sleep quality (>5) was recorded in the residents around the BTS antennas at different distances, and a significant difference was observed between the sleep quality of the

residents at a distance of <100 m compared to the residents at a distance of >300 m. The recorded levels of E in all places and times were below the human safety limits set by the Iranian National Standardization Organization, the Information and Communication Technologies Authority and the International Commission on Non-Ionizing Radiation Protection, indicating the absence of potential risk due to exposure to E in the study area.

Lien vers l'article

Risques professionnels

Aucun article dans ce bulletin.

In silico

Aucun article dans ce bulletin.

In vitro

Aucun article dans ce bulletin.

Sur l'animal

Research on the safety risks of microwave irradiation on motion balance perception in electric power environments.

Qin J, Chen H, Qiao Q, Zhang W, Zhu C, Cheng J, et al. *Sci Total Environ*. 2024 Nov 20;952:175936.

To the microwave irradiation safety hazards caused by the co-construction of towers in smart grids, this paper investigates the effects of microwave irradiation in the power environment on the biological motion balance perception function. Firstly, simulation of microwave signals in the electric power environment, i.e., low-frequency harmonics and high-frequency carriers, were realized by signal modulation and applied in four types of behavior testing scenarios. Then, determining rats as target organisms to replace workers and randomly dividing into groups in proportion: open field, rotating rod fatigue, beam walking and forced swimming. Configuring radar with various parameters to match the electric power irradiation scene and stimulate rats, monitoring the abnormal behavior by image processing module, including posture, motion trajectory, distance, and other features. The experimental result showed that exposed to microwaves induce rats motor ability decline, balance perception imbalance, together with paralysis within long-term exposure, and its locomotor activity, coordination, posture control and reaction time all exhibit varying degrees of weakening. These findings indicate that microwave irradiation in electric power environment may pose significant health and safety risks for worker.

Lien vers l'article

Effects of High Temperature and High Humidity on the Degree of Ocular Damage Caused by 60 GHz Millimeter Wave Exposure.

Kojima M, Tasaki T, Kamijo T, Hada A, Suzuki Y, Ikehata M, et al. *Health Phys*. 2024 Sep 2.

Millimeter waves (MMW) are pervasive in society; however, studies on the biological effects of MMW exposure are usually performed in laboratory settings not reflecting global environmental diversity. We investigated the effects of a 6-min exposure to 60 GHz MMW (wavelength, 5.0 mm) at incident power densities of 200 and 300 mW cm-2 in eyes (exposed right eyes vs. unexposed left eyes) under

various ambient temperature/relative humidity environments (24 °C/50%, 45 °C/20%, and 45 °C/80%) using an in vivo rabbit model. Correlations were examined with adverse ocular events, including corneal epithelial damage (assessed using fluorescein staining), corneal opacity (evaluated by slit-lamp microscopy), and corneal thickness (measured via optical coherence tomography). Our findings indicate that higher temperatures and humidity tend to exacerbate MMW-induced ocular damage, albeit not significantly in the present study. Further research with a larger sample size is warranted. Incident power density emerged as a factor that was directly linked to the ocular damage threshold. High ambient temperature and humidity tended to exacerbate ocular damage from MMW exposure, although the effect was secondary. Ocular damage in a high-temperature (45 °C), high-humidity (80%) environment was increased to the same extent as that by incident power density increased by approximately 100 mW cm-2 in an ocular damage model in a standard environment (24 °C, 50%). In a high-humidity environment, the internal ocular tissue temperature increased at a high ambient temperature of 45 °C, suggesting that the eyeball may respond differently compared to other tissues.

Lien vers l'article

Sur l'homme

A Systematic Review on the In Vivo Studies on Radiofrequency (100 kHz-300 GHz) Electromagnetic Field Exposure and Co-Carcinogenesis.

Pinto R, Ardoino L, Giardullo P, Villani P, Marino C. *Int J Environ Res Public Health*. 2024 Aug 2;21(8).

In this systematic review, the potential role of in vivo RF-EMF exposure combined with the administration of well-known carcinogens in tumor promotion/progression is assessed. A total of 25 papers were included in the review. Each paper was assessed for Risk of Bias and for the attribution of the quality category. A meta-analysis was conducted on 18 studies, analyzing data for nine different organs/tumors to assess the potential increased risk for the onset of tumors as well as the effects on survival. A descriptive review was performed for the remaining seven eligible papers. In most cases, the results of the meta-analysis did not reveal a statistically significant difference in tumor onset between the sham and co-exposed samples. There was a numerically small increase in the risk of malignant tumors observed in the kidney and liver, as well as benign lung tumors. The level of evidence for health effects indicated "inadequate" evidence for an association between in vivo co-exposure to RF-EMF and known carcinogens and the onset of malignant or benign tumors in most of the analyzed tissues. Nevertheless, the limited number of eligible papers/studies for most of the analyzed tissues suggests that these results cannot be considered definitively conclusive.

Lien vers l'article

The effect of exposure to radiofrequency electromagnetic fields on cognitive performance in human experimental studies: Systematic review and meta-analyses.

Pophof B, Kuhne J, Schmid G, Weiser E, Dorn H, Henschenmacher B, et al. *Environ Int*. 2024 Sep;191:108899.

BACKGROUND: The objective of this review is to evaluate the associations between short-term exposure to radiofrequency electromagnetic fields (RF-EMF) and cognitive performance in human experimental studies. METHODS: Online databases (PubMed, Embase, Scopus, Web of Science and EMF-Portal) were searched for studies that evaluated effects of exposure to RF-EMF on seven domains

of cognitive performance in human experimental studies. The assessment of study quality was based on the Risk of Bias (RoB) tool developed by the Office of Health Assessment and Translation (OHAT). Random effects meta-analyses of Hedges's g were conducted separately for accuracy- and speed-related performance measures of various cognitive domains, for which data from at least two studies were available. Finally, the certainty of evidence for each identified outcome was assessed according to Grading of Recommendations Assessment, Development, and Evaluation (GRADE). RESULTS: 57,543 records were identified and 76 studies (80 reports) met the inclusion criteria. The included 76 studies with 3846 participants, consisting of humans of different age, sex and health status from 19 countries, were conducted between 1989 and 2021. Quantitative data from 50 studies (52 reports) with 2433 participants were included into the meta-analyses. These studies were performed in 15 countries between 2001 and 2021. The majority of the included studies used head exposure with GSM 900 uplink. None of the meta-analyses observed a statistically significant effect of RF-EMF exposure compared to sham on cognitive performance as measured by the confidence interval surrounding the Hedges's g or the significance of the z-statistic. For the domain Orientation and Attention, subclass Attention - Attentional Capacity RF-EMF exposure results in little to no difference in accuracy (Hedges's g 0.024, 95 % CI [-0.10; 0.15], I(2) = 28 %, 473 participants). For the domain Orientation and Attention, subclass Attention - Concentration / Focused Attention RF-EMF exposure results in little to no difference in speed (Hedges's g 0.005, 95 % CI [-0.17; 0.18], I(2) = 7 %, 132 participants) and probably results in little to no difference in accuracy; it does not reduce accuracy (Hedges's g 0.097, 95 % CI [-0.05; 0.24], I(2) = 0 %, 217 participants). For the domain Orientation and Attention, subclass Attention - Vigilance RF-EMF exposure probably results in little to no difference in speed and does not reduce speed (Hedges's g 0.118, 95 % CI [-0.04; 0.28], I(2) = 41 %, 247 participants) and results in little to no difference in accuracy (Hedges's g 0.042, 95 % CI, [-0.09; 0.18], I(2) = 0 %, 199 participants). For the domain Orientation and Attention, subclass Attention - Selective Attention RF-EMF exposure probably results in little to no difference in speed and does not reduce speed (Hedges's g 0.080, 95 % CI [-0.09; 0.25], I(2) = 63 %, 452 participants); it may result in little to no difference in accuracy, but it probably does not reduce accuracy (Hedges's g 0.178, 95 % CI [-0.02; 0.38], I(2) = 68 %, 480 participants). For the domain Orientation and Attention, subclass Attention - Divided Attention RF-EMF exposure results in little to no difference in speed (Hedges's g -0.010, 95 % CI [-0.14; 0.12], I(2) = 5 %, 307 participants) and may result in little to no difference in accuracy (Hedges's g -0.089, 95 % CI [-0.35; 0.18], I(2) = 53 %, 167 participants). For the domain Orientation and Attention, subclass Processing Speed - Simple Reaction Time Task RF-EMF exposure results in little to no difference in speed (Hedges's g 0.069, 95 % CI [-0.02; +0.16], I(2) = 29 %, 820 participants). For the domain Orientation and Attention, subclass Processing Speed - 2-Choice Reaction Time Task RF-EMF exposure results in little to no difference in speed (Hedges's g -0.023, 95 % CI [-0.13; 0.08], I(2) = 0 %, 401 participants), and may result in little to no difference in accuracy (Hedges's g -0.063, 95 % CI [-0.38; 0.25], I(2) = 63 %, 117 participants). For the domain Orientation and Attention, subclass Processing Speed - >2-Choice Reaction Time Task RF-EMF exposure results in little to no difference in speed (Hedges's g -0.054, 95 % CI [-0.14; 0.03], I(2) = 0 %, 544 participants) and probably results in little to no difference in accuracy (Hedges's g -0.129, 95 % CI [-0.30; 0.04], I(2) = 0 %, 131 participants). For the domain Orientation and Attention, subclass Processing Speed - Other Tasks RF-EMF exposure probably results in little to no difference in speed and does not reduce speed (Hedges's g 0.067, 95 % CI [-0.12; 0.26], I(2) = 38 %, 249 participants); it results in little to no difference in accuracy (Hedges's g 0.036, 95 % CI [-0.08; 0.15], I(2) = 0 %, 354 participants). For the domain Orientation and Attention, subclass Working Memory - n-back Task (0-3-back) we found Hedges's g ranging from -0.090, 95 % CI [-0.18; 0.01] to 0.060, 95 % CI [-0.06; 0.18], all I(2) = 0 %, 237 to 474 participants, and conclude that RF-EMF exposure results in little to no difference in both speed and accuracy. For the domain Orientation and Attention, subclass Working Memory - Mental Tracking RF-EMF exposure results in little to no difference in accuracy (Hedges's g -0.047, 95 % [CI -0.15; 0.05], I(2) = 0 %, 438 participants). For the domain Perception, subclass Visual and Auditory Perception RF-EMF exposure may result in little to no difference in speed (Hedges's g -0.015, 95 % CI [-0.23; 0.195], I(2) = 0 %, 84 participants) and probably results in little to no difference in accuracy (Hedges's g 0.035, 95 % CI [-0.13; 0.199], I(2) = 0 %, 137 participants). For the domain Memory,

subclass Verbal and Visual Memory RF-EMF exposure probably results in little to no difference in speed and does not reduce speed (Hedges's g 0.042, 95 % CI [-0.15; 0.23], I(2) = 0 %, 102 participants); it may result in little to no difference in accuracy (Hedges's g -0.087, 95 % CI [-0.38; 0.20], I(2) = 85 %, 625 participants). For the domain Verbal Functions and Language Skills, subclass Verbal Expression, a meta-analysis was not possible because one of the two included studies did not provide numerical values. Results of both studies did not indicate statistically significant effects of RF-EMF exposure on both speed and accuracy. For the domain Construction and Motor Performance, subclass Motor Skills RF-EMF exposure may reduce speed, but the evidence is very uncertain (Hedges's g -0.919, 95 % CI [-3.09; 1.26], I(2) = 96 %, 42 participants); it probably results in little to no difference in accuracy and does not reduce accuracy (Hedges's g 0.228, 95 % CI [-0.01; 0.46], I(2) = 0 %, 109 participants). For the domain Concept Formation and Reasoning, subclass Reasoning RF-EMF exposure results in little to no difference in speed (Hedges's g 0.010, 95 % CI [-0.11; 0.13], I(2) = 0 %, 263 participants) and probably results in little to no difference in accuracy and does not reduce accuracy (Hedges's g 0.051, 95 % CI [-0.14; 0.25], I(2) = 0 %, 100 participants). For the domain Concept Formation and Reasoning, subclass Mathematical Procedures RF-EMF exposure results in little to no difference in speed (Hedges's g 0.033, 95 % CI [-0.12; 0.18], I(2) = 0 %, 168 participants) and may result in little to no difference in accuracy but probably does not reduce accuracy (Hedges's g 0.232, 95 % CI [-0.12; +0.59], I(2) = 86 %, 253 participants). For the domain Executive Functions there were no studies. DISCUSSION: Overall, the results from all domains and subclasses across their speed- and accuracy-related outcome measures according to GRADE provide high to low certainty of evidence that short-term RF-EMF exposure does not reduce cognitive performance in human experimental studies. For 16 out of 35 subdomains some uncertainty remains, because of limitations in the study quality, inconsistency in the results or imprecision of the combined effect size estimate. Future research should focus on construction and motor performance, elderly, and consideration of both sexes. OTHER: This review was partially funded by the WHO radioprotection programme. The protocol for this review was registered in Prospero reg. no. CRD42021236168 and published in Environment International (Pophof et al. 2021).

Lien vers l'article

The effect of exposure to radiofrequency fields on cancer risk in the general and working population: A systematic review of human observational studies - Part I: Most researched outcomes.

BACKGROUND: The objective of this review was to assess the quality and strength of the evidence provided by human observational studies for a causal association between exposure to radiofrequency electromagnetic fields (RF-EMF) and risk of the most investigated neoplastic diseases. METHODS: Eligibility criteria: We included cohort and case-control studies of neoplasia risks in relation to three types of exposure to RF-EMF: near-field, head-localized, exposure from wireless phone use (SR-A); far-field, whole body, environmental exposure from fixed-site transmitters (SR-B); near/far-field occupational exposures from use of hand-held transceivers or RF-emitting equipment in the workplace (SR-C). While no restrictions on tumour type were applied, in the current paper we focus on incidence-based studies of selected "critical" neoplasms of the central nervous system (brain, meninges, pituitary gland, acoustic nerve) and salivary gland tumours (SR-A); brain tumours and leukaemias (SR-B, SR-C). We focussed on investigations of specific neoplasms in relation to specific exposure sources (i.e. E-O pairs), noting that a single article may address multiple E-O pairs. INFORMATION SOURCES: Eligible studies were identified by literature searches through Medline, Embase, and EMF-Portal. Risk-of-bias (RoB) assessment: We used a tailored version of the Office of Health Assessment and Translation (OHAT) RoB tool to evaluate each study's internal validity. At the summary RoB step, studies were classified into three tiers according to their overall potential for bias (low, moderate and high). DATA

SYNTHESIS: We synthesized the study results using random effects restricted maximum likelihood (REML) models (overall and subgroup meta-analyses of dichotomous and categorical exposure variables), and weighted mixed effects models (dose-response meta-analyses of lifetime exposure intensity). Evidence assessment: Confidence in evidence was assessed using the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) approach. RESULTS: We included 63 aetiological articles, published between 1994 and 2022, with participants from 22 countries, reporting on 119 different E-O pairs. RF-EMF exposure from mobile phones (ever or regular use vs no or non-regular use) was not associated with an increased risk of glioma [meta-estimate of the relative risk (mRR) = 1.01, 95 % CI = 0.89-1.13), meningioma (mRR = 0.92, 95 % CI = 0.82-1.02), acoustic neuroma (mRR = 1.03, 95 % CI = 0.85-1.24), pituitary tumours (mRR = 0.81, 95 % CI = 0.61-1.06), salivary gland tumours (mRR = 0.91, 95 % CI = 0.78-1.06), or paediatric (children, adolescents and young adults) brain tumours (mRR = 1.06, 95 % CI = 0.74-1.51), with variable degree of across-study heterogeneity (I(2) = 0 %-62 %). There was no observable increase in mRRs for the most investigated neoplasms (glioma, meningioma, and acoustic neuroma) with increasing time since start (TSS) use of mobile phones, cumulative call time (CCT), or cumulative number of calls (CNC). Cordless phone use was not significantly associated with risks of glioma [mRR = 1.04, 95 % CI = 0.74-1.46; I(2) = 74 %) meningioma, (mRR = 0.91, 95 % CI = 0.70-1.18; I(2) = 59 %), or acoustic neuroma (mRR = 1.16; 95 % CI = 0.83-1.61; I(2) = 63 %). Exposure from fixed-site transmitters (broadcasting antennas or base stations) was not associated with childhood leukaemia or paediatric brain tumour risks, independently of the level of the modelled RF exposure. Glioma risk was not significantly increased following occupational RF exposure (ever vs never), and no differences were detected between increasing categories of modelled cumulative exposure levels. DISCUSSION: In the sensitivity analyses of glioma, meningioma, and acoustic neuroma risks in relation to mobile phone use (ever use, TSS, CCT, and CNC) the presented results were robust and not affected by changes in study aggregation. In a leave-one-out meta-analyses of glioma risk in relation to mobile phone use we identified one influential study. In subsequent meta-analyses performed after excluding this study, we observed a substantial reduction in the mRR and the heterogeneity between studies, for both the contrast Ever vs Never (regular) use (mRR = 0.96, 95 % CI = 0.87-1.07, I(2) = 47 %), and in the analysis by increasing categories of TSS ("<5 years": mRR = 0.97, 95 % CI = 0.83-1.14, I(2) = 41 %; "5-9 years ": mRR = 0.96, 95 % CI = 0.83-1.11, I(2) = 34 %; "10+ years": mRR = 0.97, 95 % CI = 0.87-1.08, I(2) = 10 %). There was limited variation across studies in RoB for the priority domains (selection/attrition, exposure and outcome information), with the number of studies evenly classified as at low and moderate risk of bias (49 % tier-1 and 51 % tier-2), and no studies classified as at high risk of bias (tier-3). The impact of the biases on the study results (amount and direction) proved difficult to predict, and the RoB tool was inherently unable to account for the effect of competing biases. However, the sensitivity meta-analyses stratified on bias-tier, showed that the heterogeneity observed in our main meta-analyses across studies of glioma and acoustic neuroma in the upper TSS stratum (I(2) = 77 % and 76 %), was explained by the summary RoB-tier. In the tier-1 study subgroup, the mRRs (95 % CI; I(2)) in long-term (10+ years) users were 0.95 (0.85-1.05; 5.5 %) for glioma, and 1.00 (0.78-1.29; 35 %) for acoustic neuroma. The time-trend simulation studies, evaluated as complementary evidence in line with a triangulation approach for external validity, were consistent in showing that the increased risks observed in some case-control studies were incompatible with the actual incidence rates of glioma/brain cancer observed in several countries and over long periods. Three of these simulation studies consistently reported that RR estimates > 1.5 with a 10+ years induction period were definitely implausible, and could be used to set a "credibility benchmark". In the sensitivity meta-analyses of glioma risk in the upper category of TSS excluding five studies reporting implausible effect sizes, we observed strong reductions in both the mRR [mRR of 0.95 (95 % CI = 0.86-1.05)], and the degree of heterogeneity across studies (I(2) = 3.6 %). CONCLUSIONS: Consistently with the published protocol, our final conclusions were formulated separately for each exposure-outcome combination, and primarily based on the line of evidence with the highest confidence, taking into account the ranking of RF sources by exposure level as inferred from dosimetric studies, and the external coherence with findings from time-trend simulation studies (limited to glioma in relation to mobile phone use). For

near field RF-EMF exposure to the head from mobile phone use, there was moderate certainty evidence that it likely does not increase the risk of glioma, meningioma, acoustic neuroma, pituitary tumours, and salivary gland tumours in adults, or of paediatric brain tumours. For near field RF-EMF exposure to the head from cordless phone use, there was low certainty evidence that it may not increase the risk of glioma, meningioma or acoustic neuroma. For whole-body far-field RF-EMF exposure from fixed-site transmitters (broadcasting antennas or base stations), there was moderate certainty evidence that it likely does not increase childhood leukaemia risk and low certainty evidence that it may not increase the risk of paediatric brain tumours. There were no studies eligible for inclusion investigating RF-EMF exposure from fixed-site transmitters and critical tumours in adults. For occupational RF-EMF exposure, there was low certainty evidence that it may not increase the risk of brain cancer/glioma, but there were no included studies of leukemias (the second critical outcome in SR-C). The evidence rating regarding paediatric brain tumours in relation to environmental RF exposure from fixed-site transmitters should be interpreted with caution, due to the small number of studies. Similar interpretative cautions apply to the evidence rating of the relation between glioma/brain cancer and occupational RF exposure, due to differences in exposure sources and metrics across the few included studies. OTHER: This project was commissioned and partially funded by the World Health Organization (WHO). Co-financing was provided by the New Zealand Ministry of Health; the Istituto Superiore di Sanità in its capacity as a WHO Collaborating Centre for Radiation and Health; and ARPANSA as a WHO Collaborating Centre for Radiation Protection. REGISTRATION: PROSPERO CRD42021236798. Published protocol: [(Lagorio et al., 2021) DOI https://doi.org/10.1016/j.envint.2021.106828].

Lien vers l'article

Letter to the Editor, Environment International 'Available evidence shows adverse symptoms from acute non-thermal RF-EMF exposure'. Comment on: Bosch-Capblanch X et al., The effects of radiofrequency electromagnetic fields exposure on human self-reported symptoms: A systematic review of human experimental studies, Envir Int. vol. 187, May 2024, 108612.

Bevington M. *Environ Int*. 2024 Sep;191:108888.

Lien vers l'article

Reproduction

Short and long-term 2100 MHz radiofrequency radiation causes endoplasmic reticulum stress in rat testis.

Kirimlioglu E, Oflamaz AO, Hidisoglu E, Ozen S, Yargicoglu P, Demir N. *Histochem Cell Biol*. 2024 Oct;162(4):311-21.

Long-term radiofrequency radiation (RFR) exposure, which adversely affects organisms, deteriorates testicular functions. Misfolding or unfolding protein accumulation in the endoplasmic reticulum (ER) initiates an intracellular reaction known as ER stress (ERS), which activates the unfolded protein response (UPR) for proteostasis. Since both RFR exposure and ERS can cause male infertility, we hypothesized that RFR exposure causes ERS to adversely affect testicular functions in rats. To investigate role of ERS in mediating RFR effects on rat testis, we established five experimental groups in male rats: control, short-term 2100-megahertz (MHz) RFR (1-week), short-term sham (sham/1-week), long-term 2100-MHz RFR (10-week), and long-term sham (sham/10-week). ERS markers Grp78 and phosphorylated PERK (p-Perk) levels and ERS-related apoptosis markers Chop and caspase 12 were investigated by immunohistochemistry, immunoblotting, and quantitative real-time polymerase chain reaction (qPCR). Long-term RFR exposure increased Grp78, p-Perk, and Chop levels, while short-term RFR exposure elevated Chop and caspase 12 levels. Chop expression was not observed in spermatogonia and primary spermatocytes, which may protect spermatogonia and primary spermatocytes against RFR-induced ERS-mediated apoptosis, thereby allowing transmission of genetic material to next generations. While short and long-term RFR exposures trigger ERS and ERS-related apoptotic pathways, further functional analyses are needed to elucidate whether this RFR-induced apoptosis has long-term male infertility effects.

Lien vers l'article

Exposure to Radiofrequency Induces Synaptic Dysfunction in Cortical Neurons Causing Learning and Memory Alteration in Early Postnatal Mice.

Kim JH, Seok JY, Kim YH, Kim HJ, Lee JK, Kim HR. *Int J Mol Sci*. 2024 Aug 6;25(16).

The widespread use of wireless communication devices has necessitated unavoidable exposure to radiofrequency electromagnetic fields (RF-EMF). In particular, increasing RF-EMF exposure among children is primarily driven by mobile phone use. Therefore, this study investigated the effects of 1850 MHz RF-EMF exposure at a specific absorption rate of 4.0 W/kg on cortical neurons in mice at postnatal day 28. The results indicated a significant reduction in the number of mushroom-shaped dendritic spines in the prefrontal cortex after daily exposure for 4 weeks. Additionally, prolonged RF-EMF exposure over 9 days led to a gradual decrease in postsynaptic density 95 puncta and inhibited neurite outgrowth in developing cortical neurons. Moreover, the expression levels of genes associated with synapse formation, such as synaptic cell adhesion molecules and cyclin-dependent kinase 5, were reduced in the cerebral cortexes of RF-EMF-exposed mice. Behavioral assessments using the Morris water maze revealed altered spatial learning and memory after the 4-week exposure period. These findings underscore the potential of RF-EMF exposure during childhood to disrupt synaptic function in the cerebral cortex, thereby affecting the developmental stages of the nervous system and potentially influencing later cognitive function.

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Dispositifs médicaux implantables

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