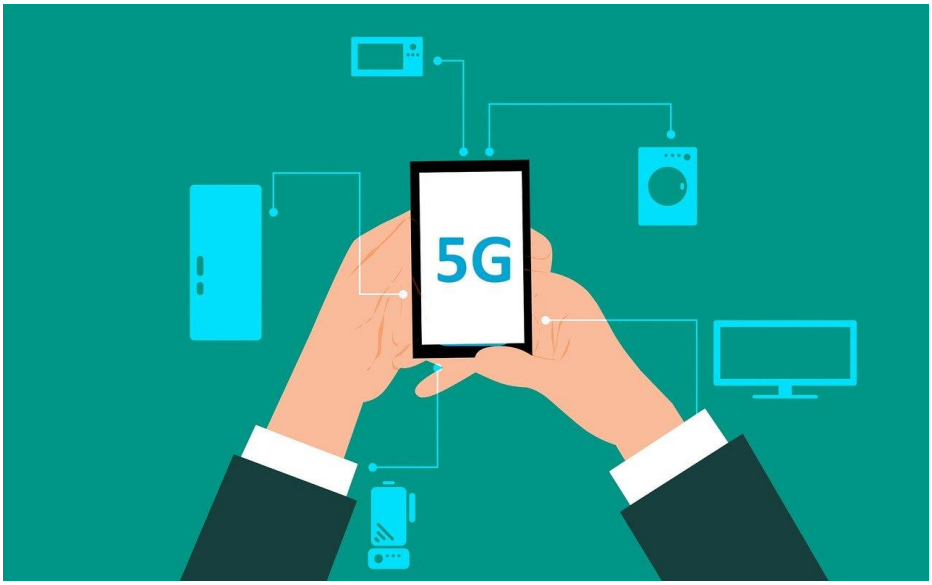
TECHNOLOGIE 5G

Bulletin de veille scientifique : Novembre 2024



Objectifs : réaliser une veille scientifique sur la technologie 5G

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Généralités

The exposure of nonhuman living organisms to mobile communication emissions: A survey to establish European stakeholders' policy option preferences.

Recuero Virto L, Thielens A, Czerwiński M, Froidevaux J. *Risk Anal*. 2024 Nov;44(11):2554-68.

There is an unprecedented exposure of living organisms to mobile communications radiofrequency electromagnetic field (RF-EMF) emissions. Guidelines on exposure thresholds to limit thermal effects from these emissions are restricted to humans. However, tissue heating can occur in all living organisms that are exposed. In addition, exposure at millimetric frequencies used by 5G may impact surface tissues and organs of plants and small-size species. It is also expected that the addition of 5G to existing networks will intensify radiofrequency absorption by living organisms. A European Parliament report proposed policy options on the effects of RF-EMF exposure of plants, animals, and other living organisms in the context of 5G: funding more research, implementing monitoring networks, accessing more information from operators on antennas and EMF emissions, and developing compliance studies when antennas are installed. However, there is no evidence on the preferences of relevant stakeholders regarding these policy options. This paper reports the findings of a survey of key European stakeholders' policy option preferences based on the European Parliament's report. It reveals a broad consensus on funding more research on the effects of exposure of plants, animals, and other living organisms to EMFs. It also highlights the need for deliberation concerning the other policy options that could provide solutions for regulatory authorities, central administrations, the private sector, nongovernmental associations and advocates, and academics. Such deliberation would pave the way for effective solutions, focusing on long-term output from funding research, and enabling short-term socially and economically acceptable actions for all parties concerned.

Lien vers l'article

The European Union assessments of radiofrequency radiation health risks - another hard nut to crack (Review).

Nyberg R, McCredden J, Hardell L. *Rev Environ Health*. 2024 Dec 17;39(4):707-19.

In 2017 an article was published on the unwillingness of the WHO to acknowledge the health effects associated with the use of wireless phones. It was thus stated that the WHO is 'A Hard Nut to Crack'. Since then, there has been no progress, and history seems to be repeating in that the European Union (EU) is following in the blind man's footsteps created by the WHO. Despite increasing evidence of serious negative effects from radiofrequency radiation on human health and the environment, the EU has not acknowledged that there are any risks. Since September 2017, seven appeals by scientists and medical doctors have been sent to the EU requesting a halt to the roll-out of the fifth generation of wireless communication (5G). The millimeter waves (MMW) and complex waveforms of 5G contribute massively harmful additions to existing planetary electromagnetic pollution. Fundamental rights and EU primary law make it mandatory for the EU to protect the population, especially children, from all kinds of harmful health effects of wireless technology. However, several experts associated with the WHO and the EU have conflicts of interest due to their ties to industry. The subsequent prioritizing of economic interests is resulting in human and planetary health being compromised. Experts must make an unbiased evaluation with no conflicts of interest. The seven appeals to the EU have included requests for immediate protective action, which have been ignored. On the issue of wireless radiation and the health of citizens, the EU seems to be another hard nut to crack.

Lien vers l'article

PFAS et 5G : que dire aux patientes et patients sur ces deux thèmes scientifiques d'actualité ?

Lüthi E, Vernez D, Cornuz J. *Rev Med Suisse*. 2024 Nov 6;20(894):2069-72.

Issues such as PFAS and 5G are regularly in the media spotlight like this of Nutri-Score which is discussed in a second article. The model of the physician possessing all medical knowledge is evolving. Patients now come to consultations with information from a variety of sources, some of which are exhaustive, some of which are not. How can we keep our knowledge up to date on recent scientific topics that are regularly in the spotlight and evolving? Where can we, as a healthcare professionals, find reliable, up-to-date information to discuss the subject during the consultation? This article summarizes information from a variety of solid sources, which we hope will serve as a knowledge base for your discussions.

Lien vers l'article

The concept of effective coverage radius use of the unlicensed high-frequency range in the operation of the 5G network.

Kovtun V, Grochla K, Zaitseva E, Levashenko V. *Heliyon*. 2024 Nov 15;10(21):e39825.

Economic expediency encourages mobile operators to deploy 5G networks in places with a high concentration of speed-demanding subscribers. In such conditions, sharp fluctuations in the volume of traffic with regulated requirements for the quality of service are inevitable. Note that 5G operates in the millimeter range. Accordingly, the quality of traffic service is affected both by the number of subscribers simultaneously initiating requests from one sector of coverage, and by the appearance of obstacles opaque to radio radiation in the space between the subscriber device and the base station. Effective smoothing of 5G traffic fluctuations, taking into account these disturbing factors, is an urgent task. The goal of this research is to evaluate the service quality parameters in a target area characterized by a specific user density. It takes into account that if the declared QoS requirements for connection speed for users in a network segment deployed within the licensed frequency range for 5G are not met, they can utilize a network segment deployed in the unlicensed high-frequency range for 5G under conditions of free competition. The metric being studied is the probability of session loss in the licensed network segment and the achievable transmission speed in the unlicensed network segment. Based on this, a method for assessing the density of base station deployment in the unlicensed network segment necessary to support the specified user density in the licensed network segment with defined QoS guarantees in terms of bandwidth is formalized. The experiment results showed that the probability of losing sessions with regulated requirements for the quality of service in both network segments, in addition to the base station placement density and subscriber devices, is significantly affected by the minimum data transfer rate, the intensity of obstacles, and the value of the Contention Window.

Lien vers l'article

5G NR sub-THz fiber-wireless integrated systems using polarization multiplexing-multiband technique and self-polarization diversity scheme.

Cheng MC, Lu HH, Lin HM, Hayle ST, Huang XH, Hsu WW, et al. *Sci Rep*. 2024 Nov 2;14(1):26380.

Fifth generation (5G) new radio (NR) fiber-wireless integrated systems using polarization multiplexing-multiband technique and self-polarization diversity scheme are successfully implemented. Polarization multiplexing-multiband technique is an effectual method to enhance the transmission capacity and spectral efficiency of systems. Self-polarization diversity scheme is an efficient scheme for polarization demultiplexing, in which an x-polarized (y-polarized) optical carrier with multiple x-polarized (y-polarized) optical signals can be detected using single-ended photodiodes. The transmission of 5G NR sub-terahertz (THz) signals through fiber-wireless integrated systems holds promise to afford high-speed and long-haul wired-wireless communications. It shows the robustness to achieve high aggregate data rates and lays the foundation to meet the evolving demands of future communication systems. Through an integrated medium of 20 km single-mode fiber, 1.6 km optical wireless, and 4/8/12 m 5G NR wireless, four 5G sub-THz 32-quadrature amplitude modulation-orthogonal frequency-division multiplexing signals at x- and y-polarizations are transmitted with good

transmission performance in terms of low bit error rates and error vector magnitudes. The successful transmission of sub-THz signals at different carrier frequencies and polarizations over fiber-wireless integrated systems proves system's ability to support cutting-edge 5G NR fiber-wireless integrated systems.

Lien vers l'article

An enhanced broadband class-J mode power amplifier for 5G smart meter applications.

Sridhar N, Senthilpari DC, R DM, Hin Yong DW. *F1000Res*. 2024;10:1099.

Background: With the tremendous increase in the usage of smart meters for industrial/ household purposes, their implementation is considered a crucial challenge in the Internet of Things (IoT) world, leading to a demand for emerging 5G technology. In addition, a large amount of data has to be communicated by smart meters efficiently, which needs a significant enhancement in bandwidth. The power amplifier (PA) plays a major role in deciding the efficiency and bandwidth of the entire communication system. Among the various modes of PAs, a newly developed Class-J mode PA has been proven to achieve high efficiency over a wide bandwidth by maintaining linearity. Methods: This paper proposes a Class-J mode PA design methodology using a CGH40010F-GaN device that operates at a 3.5 GHz frequency to meet the requirements of 5G wireless communication technology for the replacement of existing 4G/LTE technology used for advanced metering infrastructure (AMI) in smart grids. This research's main objective is to design the proper matching networks (M.Ns) to achieve Class-J mode operation that satisfies the bandwidth requirements of 5G smart grid applications. With the target impedances obtained using the load-pull simulation, lumped element matching networks are analyzed and designed in 3 ways using the ADS EDA tool. Results: The simulation results reveal that the proposed Class-J PA provides a maximum drain efficiency (D.E) of 82%, power added efficiency (PAE) of 67% with 13 dB small-signal gain at 3.5 GHz, and output power of 40 dBm (41.4 dBm peak) with a power gain of approximately 7 dB over a bandwidth of approximately 400 MHz with a 28 V power supply into a 50 Ω load. Conclusion: The efficiency and bandwidth of the proposed Class-J PA can be enhanced further by fine-tuning the matching network design to make it more suitable for 5G smart meter/grid applications.

Lien vers l'article

A Federated Reinforcement Learning Framework via a Committee Mechanism for Resource Management in 5G Networks.

Jeong J, Lee J. *Sensors (Basel)*. 2024 Oct 31;24(21).

This paper proposes a novel decentralized federated reinforcement learning (DFRL) framework that integrates deep reinforcement learning (DRL) with decentralized federated learning (DFL). The DFRL framework boosts efficient virtual instance scaling in Mobile Edge Computing (MEC) environments for 5G core network automation. It enables multiple MECs to collaboratively optimize resource allocation without centralized data sharing. In this framework, DRL agents in each MEC make local scaling decisions and exchange model parameters with other MECs, rather than sharing raw data. To enhance robustness against malicious server attacks, we employ a committee mechanism that monitors the DFL process and ensures reliable aggregation of local gradients. Extensive simulations were conducted to evaluate the proposed framework, demonstrating its ability to maintain cost-effective resource usage while significantly reducing blocking rates across diverse traffic conditions. Furthermore, the framework demonstrated strong resilience against adversarial MEC nodes, ensuring reliable operation

and efficient resource management. These results validate the framework's effectiveness in adaptive and efficient resource management, particularly in dynamic and varied network scenarios.

Lien vers l'article

Antennes

A dual-band high-gain beam steering antenna array for 5G sub-6 GHz base station.

Siddiqui SI, Bashir S, Khan A, Ghafoor S, Aziz I. *Sci Rep*. 2024 Nov 3;14(1):26517.

An antenna array having a size of 45 [Formula: see text] 40 cm(2) (5.7 [Formula: see text] 5 [Formula: see text](2)) and consisting of four pairs of printed U-shaped dipoles positioned above a metal reflector, for 5G Sub-6 GHz base station applications, is designed and tested. The array consists of eight excitation ports, one port for each dipole. Four parasitic square patches are etched on the bottom side of the dipole arms for producing radiations in 2.2 GHz and 3.8 GHz bands. The size of the reflector and height of the dipoles are optimized in order to enhance antenna gain up to 11.5 dB at 2.2 GHz and 14.5 dB at 3.8 GHz. Beam steering up to 20[Formula: see text] is achieved, using phase shifted simultaneous excitation of different ports. The proposed antenna array not only fulfills 5G base station requirements but is also simple and compact as it only requires eight ports to achieve dual-band, high-gain and beam steering operation in a single design. It also offers a unique feature of dual-sector coverage per panel, which results in an increased coverage capacity of the base station without increasing the system resources.

Lien vers l'article

Flexible four-port MIMO antenna for 5G NR-FR2 tri-band mmWave application with SAR analysis.

Sharma M, Perli BR, Matta L, Addepalli T, Sharma K, Sibai FN. *Sci Rep*. 2024 Nov 24;14(1):29100.

This paper introduces a compact, triband four-port Multiple Input Multiple Output (MIMO) antenna optimized for mmWave 5G and navigation services. The antenna is built on a Rogers RT Duroid 5880 substrate, with dimensions of 31 × 42 mm² and a thickness of 0.4 mm. It utilizes a 50 Ω microstrip line to feed a stub-type radiating patch, creating a dipole-loop type structure on the substrate's top side, with a full ground plane for narrowband. The antenna is initially designed for 38 GHz but was subsequently modified for triband performance by tapering the edges of the stub shape, enabling it to function across multiple frequency ranges. The tapered edges of the radiating patch enhance resonance across the three bands. To improve isolation and bandwidth, a parasitic element is strategically placed between the MIMO elements, results isolation greater than 30 dB at the 32 GHz and 38 GHz bands. The MIMO elements are mirror images placed adjacent to one another, while the other two elements are arranged 180º apart, ensuring compactness. The proposed antenna operates across three frequency bands: 27.76-28.15 GHz (n261), 32.02-32.46 GHz (part of n260 and n261), and 37.39-38.586 GHz (part of n260), offering enhanced resonance and improved isolation. The parasitic element reduces mutual coupling between adjacent elements, improving diversity parameters such as Envelope Correlation Coefficient (ECC) < 0.0010, Diversity Gain (DG) = 10 dB, Channel Capacity Loss (CCL) = 0.15 bits/sec/Hz, Total Active Reflection Coefficient (TARC) < -10 dB, and Mean Effective Gain (MEG) between - 3 and - 12 dB across all ports. Specific Absorption Rate (SAR) analysis for on-body applications confirms safe levels, with values below 1.6 W/kg at the resonating frequencies. Bending tests also show favourable results within the application bandwidth, further validating the antenna's

robustness. These technical improvements make the antenna highly suitable for integration into smart devices, defence navigation systems, mobile phones, and future 5G applications.

Lien vers l'article

Ultra-wideband microstrip folded antenna for wireless LAN, 5G and Internet of Things applications.

Pandey U, Singh P, Singh R, Kumar V, Ray K, Mallik S, et al. *Sci Rep*. 2024 Nov 26;14(1):29319.

This paper presents an ultra-wideband (UWB) microstrip antenna with a simple structure operating at 2.2-6 GHz bandwidth. The proposed antenna has been demonstrated for its suitability in UWB and multi-band applications, such as wireless local area network (WLAN), Wi-Fi, 5G, Internet of Things (IoT), etc. The antenna is shown to use a simple folded dipole antenna structure demonstrating an omnidirectional radiation pattern of gain 0.8 to 6 dBi throughout the frequency band. The antenna has strong gain at 2.4, 3.5 and 5.5 GHz. The measured results are shown to have a good agreement with the simulated results.

Lien vers l'article

Architecture réseau

Aucun article dans ce bulletin.

Efficacité énergétique

A Metasurface Glass for Energy Saving and 5G Mobile Communication Signal Enhancement.

Zheng J, Zheng H, Pang Y, Qu B, Xu Z. *Small*. 2024 Nov 26:e2408598.

Windows constitute a significant portion of the facade in buildings and modern ground transportation vehicles, such as commercial skyscrapers, high-speed trains, and subway systems. Traditional glass windows lack adequate thermal insulation and heat retention capabilities; Low-Emissivity (Low-E) glass can block external infrared radiation, it also impedes mobile communication signals, particularly those in the 5G Sub6G frequency band. This paper introduces an innovative metasurface glass designed to enhance 5G mobile communication signals within the interior of glass windows. Through simulation and experimental validation, this design has demonstrated a signal enhancement of over 10 dB within a 150 mm range before and after the focal point, and 100 mm in the vertical direction, compared to ordinary glass; at the focal point, the signal enhancement exceeds 15 dB. Furthermore, tests conducted across various real-world scenarios have confirmed that within areas covered by 5G signals, the RSRP of the signal at the focal point has increased by approximately 6-9 dB. In addition, the outer surface of this metasurface glass possesses low-emissivity characteristics, effectively blocking external infrared thermal radiation and reducing heat exchange with the interior of the glass window, thereby showing a significant advantage in maintaining a stable indoor temperature.

Lien vers l'article

Autres équipements

Aucun article dans ce bulletin.

Applications industrielles

Aucun article dans ce bulletin.

Applications médicales

Quantum-assisted federated intelligent diagnosis algorithm with variational training supported by 5G networks.

Araujo ARC, Okey OD, Saadi M, Adasme P, Rosa RL, Rodríguez DZ. *Sci Rep*. 2024 Nov 1;14(1):26333.

In the realm of intelligent healthcare, there is a growing ambition to reshape medical services through the integration of artificial intelligence (AI). However, conventional machine learning faces inherent challenges such as privacy issues, delayed updates, and protracted training times, particularly due to the hesitance of medical institutions to directly share sensitive data, with possible noises. In response to these concerns, a Quantum-Assisted Federated Intelligent Diagnosis Algorithm (β -QuAFIDA) is proposed, applied into real medical data. Leveraging the capabilities of the 5G mobile network, this approach works the connection between Internet of Medical Things (IoMT) devices through the 5G, synchronizing training and updating the server model without disrupting their real-world applications. In our quest to safeguard patient data and enhance training efficiency, our study employs an innovative heuristic approach marked by a nested loop structure. Specifically, the inner loop is dedicated to training the beta-variational quantum eigensolver (β -VQE) to approximate the expectation values of the proposed algorithm; the outer loop trains the β -QuAFIDA to reduce the relative entropy towards the target. This approach involves a balance between privacy considerations and the urgency of training. Results demonstrate that representations with low-rank attained through β -QuAFIDA offer an effective approach for acquiring low-rank states. This research signifies a step forward in the synergy between AI and 5G technologies, presenting a novel avenue for the advancement of intelligent healthcare.

Lien vers l'article

Application of 5G Remote Robotic-assisted Laparoscopy in Urological Surgery: A Small Sample Analysis.

Zhou F, Guo B, Lv H, Zhang X, Zhang Y, Feng B, et al. *Urology*. 2024 Nov 16.

OBJECTIVE: To evaluate the practical application and clinical safety of 5G remote robotics in urological surgery. METHODS: We conducted a comprehensive analysis of 14 cases of 5G remote domestic robot-assisted laparoscopic urological surgeries performed at our center from May 2023 to June 2024. Clinical data and network information were collected, and metrics such as operative time, blood loss, and complication rate were analyzed. We assessed the stability, accuracy, and safety of remote operations, as well as the acceptance and satisfaction of both doctors and patients with this technology. RESULTS: The 14 surgeries conducted at our center involved a master-slave distance of 52 km, with an average operative time of 83.3 minutes, an average blood loss of 23 mL, a conversion-to-

open-surgery rate of 0%, and no complications. During the surgeries, the 5G remote robotic system functioned stably, with a clear field of vision, an average download speed of 216.5 Mbps, an average upload speed of 86.6 Mbps, an average maximum latency of 129.3 ms, an average minimum latency of 20.7 ms, and a packet loss rate of 0%. These results indicate that the system can provide a highly accurate operational view and effective transfer of surgical skills. Both doctors and patients expressed general satisfaction with this technology, recognizing its significant contribution to the safety and effectiveness of the surgery. CONCLUSION: The 5G remote robot-assisted laparoscopic urological surgeries conducted at our center demonstrate that combining 5G technology with robotic ensures the stability, real-time performance, and safety of remote surgeries.

Lien vers l'article

Exploring the feasibility of home-delivered capsule endoscopy with 5G support: innovations and carbon footprint insights.

Jalayeri Nia G, Conway C, Ward F, Dungey S, Streames L, Liu BB, et al. *BMJ Open Gastroenterol*. 2024 Oct 31;11(1).

INTRODUCTION: Colorectal cancer (CRC) poses a significant global health threat, necessitating early detection. Traditional diagnostic tools like optical colonoscopy have limitations prompting our '5G-SUCCEEDS' initiative to explore a novel approach involving remote colon capsule endoscopy (CCE). METHODS: This prospective feasibility study was conducted at a single hospital in England. Between December 2022 and September 2023, we introduced a remote CCE service within the 5G-SUCCEEDS framework. We undertook a feasibility study of CCE in patients with low-risk/moderate-risk CRC stratified by faecal haemoglobin. Outcomes included carbon footprint analysis (outlined through three potential clinical pathways) and patient-reported outcomes through structured questionnaires and interviews. RESULTS: Among 25 participants, 88% expressed satisfaction with remote CCE. 82% were willing to have remote CCE if clinically indicated in future. CCE findings included adenomatous polyps (58%), normal results (17%) and diverticulosis (21%), with no cancers identified in this pilot. Notably, we found that the carbon footprint associated with delivery of CCE at home (pathway 3) was lower compared with CCE delivered in a clinical setting (pathway 2). A fully optimised, automated scaled-up pathway would combine the delivery and collection of CCE equipment within a local area to reduce the carbon footprint of the travel element by 75%. Moreover, the conversion rate into a colonoscopy pathway is not static and clinicians acknowledge that this could be as low as 28%. Carbon footprint is more favourable for home-delivered CCE in the optimised scenario, while less so when considering the need for additional procedures (colonoscopy conversion). CONCLUSION: The 5G-SUCCEEDS initiative highlights the feasibility and advantages of home-based diagnostics using CCE.

Lien vers l'article

A Mixed Reality-based Tele-Supervised Ultrasound Education Platform on 5G network compared to Direct Supervision: Prospective Randomized Pilot Trial.

Kim M, Son MH, Moon S, Cha WC, Jo IJ, Yoon H. *JMIR Serious Games*. 2024 Nov 20.

BACKGROUND: Ultrasound education is transitioning from in-person training to remote methods using mixed reality (MR) and 5G networks. Previous studies are mainly experimental, lacking randomized controlled trials in direct training scenarios. OBJECTIVE: This study aimed to compare an MR-based tele-supervised ultrasound education platform on private 5G networks with traditional in-person training for novice doctors. METHODS: Conducted at a tertiary academic hospital from November to December 2023, the prospective unblinded randomized controlled pilot study assigned doctors

without prior abdominal ultrasound education experience to either the tele-supervision group (TG; n = 20) or direct supervision group (DG; n = 20). Participants received a 15-min video lecture, conducted ultrasound on a phantom, and had 18 images scored by two blinded experts. Additionally, the TG received five minutes of training on basic operation of a head-mounted display (HMD). Communication between doctors in the TG and supervisors was facilitated through an HMD, whereas those in the DG interacted directly with supervisors. Primary outcomes were image quality scores, while secondary outcomes included procedure time, number of supervisor interventions, user experience using NASA-Task load index (NASA-TLX), System Usability Scale (SUS), and self-confidence through pre- and post-surveys. RESULTS: Image quality scores and procedure times showed no significant differences between the groups (TG: 66.8 ± 10.3 vs DG: 66.8 ± 10.4, P = .844; TG: 23.8 ± 8.0 min vs DG: 24.0 ± 8.1 min, P = .946). However, the TG engaged in more educational interventions (TG: 4.0 ± 2.5 vs DG: 0.8 ± 1.1, P <.001), reflecting a more interactive training environment. TG participants reported lower NASA-TLX scores for mental demand (43.8 ± 24.8 vs 60.6 ± 22.4, P = .03), effort (43.1 ± 22.9 vs 67.9 ± 17, P < .001), and frustration (26.9 ± 20.3 vs 45.2 ± 27.8, P = .022), indicating a reduced cognitive load compared the DG. The mean SUS score was also higher in the TG (66.6 ± 9.1 vs 60.2 ± 10.4, P =.046), suggesting better usability. Both groups showed significant improvements in confidence, with the TG showing notably greater improvement in abdominal ultrasound proficiency (Pre-education — TG: 1.6 ± 0.9 vs DG: 1.7 ± 0.9, P =.728; Post-education — TG: 3.8 ± 0.9 vs DG: 2.8 ± 1.0, P =.006). CONCLUSIONS: Although no significant differences in image quality scores were observed between groups, considerable differences in positive educational interactions, workload, and usability were evident. These findings emphasize the platform's potential to enhance the ultrasound training experience, suggesting more interactive and efficient learning. CLINICALTRIAL: ClinicalTrials.gov, NCT06171828.

Lien vers l'article

Remote proctoring during structural heart procedures: Toward a widespread diffusion of knowledge using mixed reality.

Ascione G, Rossini G, Schiavi D, Azzola Guicciardi N, Saccocci M, Buzzatti N, et al. *Catheter Cardiovasc Interv*. 2024 Nov;104(5):1037-43.

BACKGROUND: Despite its wide diffusion in surgical procedures, very few experiences are reported so far about the possible applications of remote proctoring (RP) in structural heart interventions. AIMS: Our aim was to demonstrate the feasibility, safety, and efficacy of RP during transcatheter edge-to-edge repair using a mixed reality-based head-mounted display (HMD). METHODS: Two users (a doctor and a proctor), wearing HMDs, were connected through a 5G network, allowing them to share audio and video signals. During the procedure, the proctor was located in a contiguous room, without any direct connection with the operator. The primary endpoint was noninferiority of HMD-mediated interaction if compared with direct in-person interaction. It was assessed using an operator-proctor interaction test based on six questions asked by the doctor to the proctor on six key procedural steps. RESULTS: Between September 2021 and April 2022, nine patients were enrolled in the study (15 clips delivered). The primary endpoint was reached in 9/15 clips implanted (60%). The first three failures were due to a chat software problem, and the others were linked with a 5G network malfunction. However, the HMD and its mixed reality tools were well tolerated by the operators, and no interference with the procedure was registered in any of the cases. CONCLUSIONS: In our experience, RP during structural heart interventions is feasible and efficacious. Wearing the HMD is comfortable and does not affect safety and effectiveness of interventional procedures. However, especially if considering a wide geographic use of this tool, a stable internet connection is imperative.

Lien vers l'article

The crucial role of 5G, 6G, and fiber in robotic telesurgery.

Dohler M, Saikali S, Gamal A, Moschovas MC, Patel V. *J Robot Surg*. 2024 Nov 16;19(1):4.

This paper explores the role of 5G-and future 6G networks-in advancing robotic telesurgery by minimizing latency and enhancing data reliability for real-time remote operations. With robotic telesurgery gaining prominence as a tool to democratize access to specialized surgical care, telecommunications infrastructure has become central to its feasibility and safety. Key elements include 5G's capacity for ultra-low latency and high data transfer rates, which support critical modalities such as kinesthetic, audiovisual, and tactile feedback in telesurgery. The paper outlines the differing latency demands of these modalities, noting that kinesthetic data are particularly sensitive, requiring ultra-low latency for effective surgeon feedback. In addition, the paper discusses the importance of network reliability and Quality-of-Service (QoS) agreements, alongside the potential for 6G networks to further reduce latency and integrate AI-driven predictive analytics. These advancements are positioned to not only broaden telesurgery's reach but also to enhance the precision and safety of procedures, setting the stage for a new paradigm in remote surgical care.

Lien vers l'article

Evaluation (Mesure des niveaux d'exposition)

Méthodes d'évaluation

Comparison of a radiofrequency electric and magnetic field source-based job-exposure matrix with personal radiofrequency exposure measurements.

Turuban M, Kromhout H, Vila J, de Vocht F, Vallbona-Vistós M, Baldi I, et al. *Ann Work Expo Health*. 2024 Nov 25;68(9):951-66.

OBJECTIVES: Assessing occupational exposure to radiofrequency electromagnetic fields (RF-EMF) presents significant challenges due to the considerable variability in exposure levels within and between occupations. This spatial and temporal variability complicates the reliable evaluation of potential health risks associated with RF-EMF exposure in the workplace. Accurate assessment methods are crucial to understand the extent of exposure and to evaluate potential health risks, especially given the potential for higher exposures in occupational settings compared to the general population. This study compares the historical RF-EMF exposure estimates in the INTEROCC RF-EMF job-exposure matrix (RF-JEM) with recent personal measurement data collected in 2 countries as part of the OccRF-Health study, to assess the broader applicability of the RF-JEM. METHODS: Weighted kappa (kw) coefficients and Spearman rank correlation tests were performed to assess the alignment between RF-JEM estimates and measurements for 8 h time-weighted average exposure intensity and prevalence estimates across various occupations. The comparisons were mainly based on 22 jobs having ≥5 measured workers in the OccRF-Health study. RESULTS: Poor agreement was found for both exposure prevalence and intensity between both methods (kw < 0.1). RF-JEM values likely overestimated exposure levels for both electric (E) and magnetic (H) fields (mean percentage difference >194%) compared to current personal measurements. CONCLUSIONS: Findings suggest that the INTEROCC-JEM likely overestimates current exposure intensity levels in the measured jobs. Adopting a semiquantitative JEM could also mitigate misclassification errors due to exposure variability, improving accuracy in exposure assessment. These findings indicate the need for more targeted personal measurements, including among highly exposed workers, and for potentially considering new exposure metrics to more accurately assess occupational RF-EMF exposures in occupational epidemiological research.

Lien vers l'article

Evaluation population générale

Estimates and measurements of radiofrequency exposures in smart-connected homes.

Joyner K, Milligan M, Knipe P. *Bioelectromagnetics*. 2024 Oct;45(7):329-37.

The aim of this research was to quantify the levels of radiofrequency electromagnetic energy (RF-EME) in a residential home/apartment equipped with a range of wireless devices, often referred to as internet of things (IoT) devices or smart devices and subsequently develop a tool that could be useful for estimating the levels of RF-EME in a domestic environment. Over the course of 3 years measurements were performed in peoples' homes on a total of 43 devices across 16 device categories. Another 12 devices were measured in detail in a laboratory setup. In all a total of 55 individual devices across 23 device categories were measured. Based on this measurement data we developed predictive

software that showed that even with a single device in 23 device categories operating near maximum they would, in total, produce exposures at a distance of 1 m of 0.17% of the ICNIRP (2020) public exposure limits. Measurements were also made in two separate smart apartments-one contained over 50 IoT devices and a second with over 100 IoT devices with the devices driven as hard as could reasonably be achieved. The respective 6-min average exposure level recorded were 0.0077% and 0.44% of the ICNIRP (2020) 30-min average public exposure limit.

Lien vers l'article

Risques professionnels

Aucun article dans ce bulletin.

Effets biologiques et sur la santé

In silico

The influence of eyelashes on electric field distribution and absorbed power density in the cornea under millimeter-wave exposure.

Foroughimehr N, Vilagosh Z, Yavari A, Wood A. *Bioelectromagnetics*. 2024 Dec;45(8):375-86.

As millimeter wave (MMW) technology, particularly in fifth-generation (5G) devices, gains prominence, there is a crucial need for comprehensive electromagnetic (EM) models of ocular tissues to understand and characterize EM exposure conditions accurately. This study employs numerical modeling to investigate the interaction between MMW and the cornea, aiming to characterize EM field distributions and absorption within an anatomically accurate eye model while considering the influence of eyelashes. Using the finite-difference time-domain (FDTD) method, we conduct simulations of EM radiation interactions from 20.0 to 100.0 GHz with a human eye model. Moreover, we analyze the temperature distribution increase within the eye model using a thermal sensor in XFdtd, employing a scheme based on the finite difference (FD) method. Our findings reveal a nonuniform distribution of the EM field, particularly intensified in corneal regions adjacent to eyelashes and eyelids. Despite similar EM field patterns, the presence or absence of eyelashes has minimal impact on temperature differences. However, the study highlights increased radiation absorption by the eyelid's epidermis at 100.0 GHz, reducing the rise in the cornea's temperature.

Lien vers l'article

In vitro

Protective effect of radiofrequency exposure against menadione-induced oxidative DNA damage in human neuroblastoma cells: The role of exposure duration and investigation on key molecular targets.

Sannino A, Allocca M, Scarfì MR, Romeo S, Zeni O. *Bioelectromagnetics*. 2024 Dec;45(8):365-74.

In our previous studies, we demonstrated that 20 h pre-exposure of SH-SY5Y human neuroblastoma cells to 1950 MHz, UMTS signal, at specific absorption rate of 0.3 and 1.25 W/kg, was able to reduce the oxidative DNA damage induced by a subsequent treatment with menadione in the alkaline comet assay while not inducing genotoxicity per se. In this study, the same cell model was used to test the same experimental conditions by setting different radiofrequency exposure duration and timing along the 72 h culture period. The results obtained in at least three independent experiments indicate that shorter exposure durations than 20 h, that is, 10, 3, and 1 h per day for 3 days, were still capable to exert the protective effect while not inducing DNA damage per se. In addition, to provide some hints into the mechanisms underpinning the observed phenomenon, thioredoxin-1, heat shock transcription factor 1, heat shock protein 70, and poly [ADP-ribose] polymerase 1, as key molecular players involved in the cellular stress response, were tested following 3 h of radiofrequency exposure in western blot and qRT-PCR experiments. No effect resulted from molecular analysis under the experimental conditions adopted.

Lien vers l'article

Genotoxicity of radiofrequency electromagnetic fields on mammalian cells in vitro: A systematic review with narrative synthesis.

Romeo S, Sannino A, Rosaria Scarfì M, Lagorio S, Zeni O. *Environ Int*. 2024 Nov;193:109104.

BACKGROUND: Over the last decades, great concern has been raised about possible adverse effects to human health due to exposures to radiofrequency electromagnetic fields (RF-EMF, 100 kHz - 300 GHz) emitted by wireless communication technologies. In 2011 the International Agency for Research on Cancer classified RF-EMF as possibly carcinogenic to humans, highlighting that the evidence was weak and far from conclusive. Updated systematic reviews of the scientific literature on this topic are lacking, especially for mechanistic studies. OBJECTIVES: To perform a systematic review of the scientific literature on genotoxic effects induced by RF-EMF in in vitro experimental models. The overall aim is to assess the confidence and level of evidence of the induced effects in mammalian cell cultures. METHODS: Full details regarding the eligibility criteria, information sources, and methods developed to assess risk of bias in the included study, are reported in our published protocol (Romeo et al. 2021). The databases NCBI PubMed, Web of Science, and EMF-Portal were used as information sources (last searched on 31st December 2022). In developing the systematic review, we followed the guidelines provided by the National Toxicology Program-Office of Health Assessment and Translation (NTP-OHAT), adapted to the evaluation of in vitro studies. A narrative synthesis of the body of evidence was performed by tabulating data classified according to meaningful groups (endpoints) and sub-groups (exposure parameters). This report, abstract included, conforms to the PRISMA 2020 (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guidelines. RESULTS: Out of 7750 unique records identified, 159 articles were eligible for inclusion. From the extracted data, we identified 1111 experiments (defined as independent specific combinations of diverse biological and electromagnetic parameters). The large majority (80%) of experiments reviewed did not show statistically significant genotoxic effects of RF-EMF exposures, and most "positive" studies were rated as of moderate to low quality, with negative ratings in the key bias domains. A qualitative evidence appraisal was conducted at the endpoint level, and then integrated across endpoints. DISCUSSION: To the best of our knowledge, this is the first systematic review of the scientific literature on genotoxic effects in mammalian cell cultures in relation to RF-EMF exposure, which confirms and strengthens conclusions from previous syntheses of this specific topic thanks to the use of transparently reported methods, pre-defined inclusion criteria, and formal assessment of susceptibility to bias. Limitations of the evidence included the frequent reporting of findings in graphical display only, and the large heterogeneity of experimental data, which precluded a meta-analysis. CONCLUSIONS: In the assessment restricted to studies reporting a significant effect of the exposure on the outcome, we reached an overall assessment of "low" confidence in the evidence that RF-EMF induce genotoxic effects in mammalian cells. However, 80% of experiments reviewed showed no effect of RF exposure on the large majority of endpoints, especially the irreversible ones, independently of the exposure features, level, and duration (moderate evidence of no effect). Therefore, we conclude that the analysis of the papers included in this review, although only qualitative, suggests that RF exposure does not increase the occurrence of genotoxic effects in vitro. FRAMEWORK AND FUNDING: This systematic review addresses one of the evidence streams considered in a larger systematic review of the scientific literature on the potential carcinogenicity of RF-EMF, performed by scientists from several Italian public research agencies. The project is supported by the Italian Workers' Compensation Authority (INAIL) in the framework of the CRA with the Istituto Superiore di Sanità "BRiC 2018/06 - Scientific evidence on the carcinogenicity of electromagnetic fields".

Lien vers l'article

Characterising core body temperature response of free-moving C57BL/6 mice to 1.95 GHz whole-body radiofrequency-electromagnetic fields.

Sylvester E, Deng C, McIntosh R, Iskra S, Frankland J, McKenzie R, et al. *Bioelectromagnetics*. 2024 Dec;45(8):387-98.

The present study investigated the core body temperature (CBT) response of free-moving adult male and female C57BL/6 mice, during and following a 2-h exposure to 1.95 GHz RF-EMF within custom-built reverberation chambers, using temperature capsules implanted within the intraperitoneal cavity and data continuously logged and transmitted via radiotelemetry postexposure. Comparing RF-EMF exposures (WBA-SAR of 1.25, 2.5, 3.75, and 5 W/kg) to the sham-exposed condition, we identified a peak in CBT within the first 16 min of RF-EMF exposure (+0.15, +0.31, +0.24, +0.37°C at 1.25, 2.5, 3.75, and 5 W/kg respectively; statistically significant at WBA-SAR ≥ 2.5 W/kg only), which largely dissipated for the remainder of the exposure period. Immediately before the end of exposure, only the CBT of the 5 W/kg condition was statistically differentiable from sham. Based on our findings, it is apparent that mice are able to effectively compensate for the increased thermal load at RF-EMF strengths up to 5 W/kg. In addition, the elevated CBT at the end of the exposure period in the 5 W/kg condition was statistically significantly reduced compared to the sham condition immediately after RF-EMF exposure ceased. This would indicate that measures of CBT following the end of an RF-EMF exposure period may not reflect the actual change in the CBT of mice caused by RF-EMF exposure in mice.

Lien vers l'article7

The effects of radiofrequency electromagnetic radiation emitted by mobile phones on rat parotid gland histology - an experimental study.

Matei LI, Neag MA, Mocan LP, Sufleţel RT, Cuţaş A, Onofrei MM, et al. *Eur Rev Med Pharmacol Sci*. 2024 Oct;28(20):4405-19.

OBJECTIVE: The advancement of telecommunication technology and devices promptly transformed mobile phones into indispensable objects in our day-to-day lives, but their biological effects remain unclear. Therefore, this study aimed to investigate the potential histopathological changes induced by mobile phone radiation in the parotid gland and the nearby tissues. MATERIALS AND METHODS: Thirty female Rattus Norvegicus rats were divided into three groups: group 1 (exposed for 30 days), group 2 (exposed for 60 days), and control group (non-exposed). Each subject was exposed to mobile phone radiation in the form of a phone call for two hours every day for their subsequent exposure time. The exposure was always directed towards the same side of the face throughout the whole exposure period. At the end of the exposure period, a comprehensive examination was conducted, including inspection of the orofacial structures, tissue sections of the parotid glands, overlying skin, oral mucosa, and cervical lymph nodes, as well as obtaining smears from the oral cavity. To highlight the presence of micronuclei within the exfoliated squamous cells of the oral epithelium, Feulgen stain was performed. RESULTS: The results showed a significant activation of the fibroblasts in the parotid gland septa, in both exposed experimental groups, compared to the control group. We also detected significant cervical lymph node reactive changes, hyperkeratosis of the oral epithelium, and activated fibroblasts in the dermis and oral mucosa lamina propria in both experimental groups. Dermal fibrosis and lamina propria fibrosis were significantly increased in the second experimental group, compared to the control group. Moreover, vascular congestion in the parotid gland, dermal, and lamina propria fibrosis were significantly increased in the second study group compared to the first one.

CONCLUSIONS: These findings suggest that exposure to mobile phone radiation may lead to pathological changes in the parotid gland and nearby tissues of experimental rats.

Lien vers l'article

Investigating the effect of radiofrequency electromagnetic field exposure on molecular pathways related to insulin resistance and adipogenesis in zebrafish embryos - A pilot study without quantitative exposure metrics.

Koç IY, Beler M, Ünal İ, Paker S, Emekli-Alturfan E, Alturfan AA, et al. *Sci Total Environ*. 2024 Dec 1;954:176038.

In recent years, obesity has become a global problem in children and adolescents, in parallel with the rapid increase in the use of information and communication technology. Recognizing the embryonic causes of obesity may help prevent adverse adult health outcomes. In our study, we hypothesized that radiofrequency-electromagnetic field (RF-EMF) exposure during embryogenesis would affect the molecular mechanisms related to adipogenesis and insulin resistance in zebrafish. To achieve this, we set up a system that emits RF-EMF in the 900 MHz band and subjected zebrafish embryos to its RF-EMF. We created two groups in which we exposed 30 min (EMF-30) and 60 min (EMF-60) per day, and a control group that was not exposed to RF-EMF. We ended the exposure at 96 hpf and analyzed the expression of lepa, ins, and pparg that are involved in the regulation of glucose and lipid metabolism. In addition, we analyzed oxidative stress parameters, embryonic development, and locomotor activity. We found decreased mRNA transcript abundance of lepa, ins, pparg, and activities of superoxide dismutase and acetylcholine esterase, along with increased lipid peroxidation (LPO), nitric oxide (NO), and glutathione S-transferase (GST). Locomotor activity increased in the EMF-30 group and decreased in the EMF-60 group. Our results showed that exposure to RF-EMF during the embryonic period disrupted the molecular pathways related to insulin resistance and adipogenesis in zebrafish. However, due to limited available resources, we were not able to appropriately quantify the actual RF exposure strength of the samples. Hence the results reported here should only be seen as preliminary, and further studies employing high quality exposure apparatus and dosimetry should be carried out in future.

Lien vers l'article

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