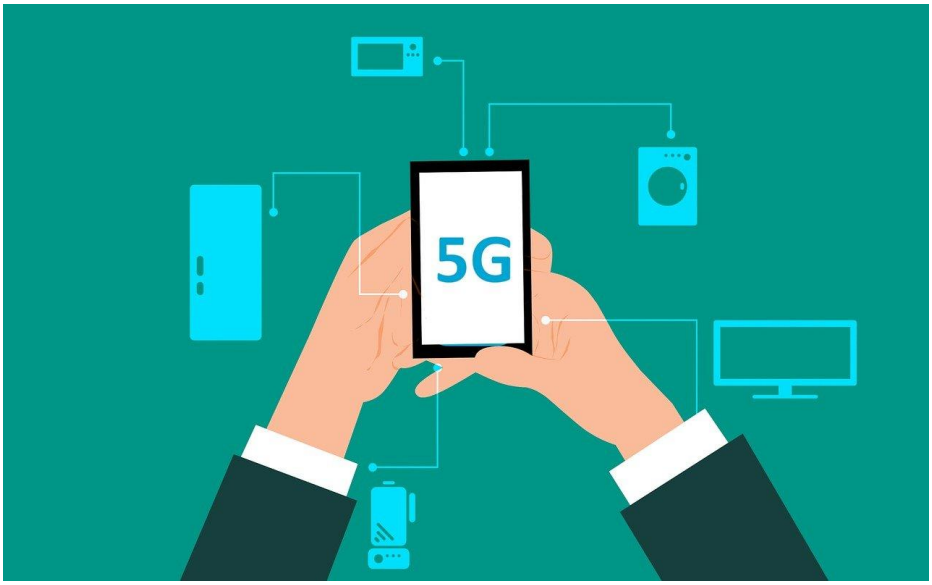
# TECHNOLOGIE 5G

## Bulletin de veille scientifique : Décembre 2025




Objectifs : réaliser une veille scientifique sur la technologie 5G

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## Généralités

**5G High Density Demand Dataset in Liverpool City Region, UK.**

Maheshwari MK, Raschellà A, Mackay M, Eiza MH, Wetherall J, Laing J. *Sci Data*. 2025 Dec 10;12(1):1992.

The wireless network data are a feasible way to understand the user behavior in a given environment and may be utilized for analysis, prediction and optimization. On the other hand, datasets from wireless service providers are not publicly available, and obtaining a dataset in real time is challenging. In this work, we present a 5G dense deployment dataset obtained from the Liverpool City Region High Density Demand (LCR HDD) project. The project involves network deployment and assessment at Salt & Tar and the ACC Arena event venues located in the city of Liverpool. Digital twin technology is considered to generate the dataset, which is inputted to a system level simulator for data modeling and analysis. The data set consists of 3, 000 users in the Salt & Tar venue and 12, 000 users in the ACC Arena venue with features including users' position, traffic type, Radio Unit (RU) association, Signal to Interference and Noise Ratio (SINR), Physical Resource Blocks (PRB), throughput, Block Error Rate (BLER), and a total length of 10, 000 samples. The dataset is validated through experimental measurements and is released in a simple format for easy access.

Lien vers l'article

### Performances et sécurité

**A dual mode approach based efficient relay-aided device-to-device communication in 5G mm-Wave cellular network.**

Sarma SS, Hazra R. *Sci Rep*. 2025 Dec 17;16(1):1637.

Relay aided device-to-device (D2D) communication has the potential to increase the capacity and coverage of the network thereby enhancing the quality of service (QoS). Thus, we propose a dual mode scheme (direct and relay mode) for a single cell where D2D and cellular users co-exist in an underlaying 5G mm-Wave cellular network which minimizes the interference. Direct mode operates at 2 GHz carrier frequency while relay mode employs full duplex amplify and forward (FDAF) relay strategy at 28 GHz frequency. The closed form expressions of performance metrices namely, spectral efficiency (SE) and energy efficiency (EE) are derived using stochastic geometry as a tool for both the modes to evaluate the system performance. Expressions for probability distribution function (PDF) and cumulative distribution function (CDF) are also derived. Simulation results suggest that the relay mode exhibits better performance than the direct mode in terms of SE and EE. With an increase in the D2D transmit power; the EE gradually increases to around 180 Mbps/J. The average data rate also increases to around 135 Kbps at D2D power of 250 mW with pathloss attenuation of 2.5. Further, simulation results validate the efficacy of the proposed scheme. Also, comparison of the proposed method with the existing methods depicts better performance of the proposed system.

Lien vers l'article

**Deep learning assisted LDPC decoding for 5G IoT networks in fading environments.**

Tera SP, Chinthaginjala R, Al-Turjman F, Ahmad S. *Sci Rep*. 2025 Oct 27;15(1):37469.

With the deployment of 5G networks, the Internet of Things (IoT) has experienced a transformative boost, enabling higher data rates, reduced latency, and the connection of millions of devices across applications like smart cities, healthcare, and industrial automation. However, in real-world scenarios, the performance of Low-Density Parity-Check (LDPC) codes, the preferred channel coding scheme in 5G, is severely affected by noise and fading environments, particularly colored noise, which distorts signals over certain frequency bands. Colored noise introduces correlation in the interference, unlike white noise, thereby posing a challenge in decoding, especially in fading channels such as Rayleigh, Rician, and Nakagami-m. In this work, we propose a novel approach that combines the Iterative Offset Min-Sum (OMS) algorithm with a Convolutional Neural Network (CNN) to enhance LDPC decoding efficiency in 5G-enabled IoT networks. Our proposed OMS-CNN hybrid architecture addresses the limitations imposed by colored noise in fading channels by employing deep learning techniques for accurate noise estimation and mitigation. Furthermore, the OMS algorithm mitigates the overestimation of noise correction, refining the output in iterative decoding steps. Through comprehensive simulations, the OMS-CNN decoder demonstrates substantial improvements over traditional decoding approaches. Specifically, it achieves a performance enhancement of 2.7 dB at a bit error rate (BER) of [Formula: see text] across a range of fading channels. The study examines the decoder's performance in environments characterized by Rayleigh, Rician, and Nakagami-m fading models, highlighting the robustness of the proposed solution under different channel conditions. Additionally, this research explores the influence of parameters such as the correlation coefficient of

the noise, the scaling factor in the cost function, and the number of iterations between the CNN and OMS decoding steps.

Lien vers l'article

**Correction: Deep learning assisted LDPC decoding for 5G IoT networks in fading environments.**

Tera SP, Chinthaginjala R, Al-Turjman F, Ahmad S. *Sci Rep*. 2025 Nov 26;15(1):42257.

The original version of this Article contained an error in the spelling of the author Sivarama Prasad Tera which was incorrectly given as Sivarama Prasad. In addition, Sivarama Prasad Tera was incorrectly affiliated with 'Department of Electronics and Electrical Engineering, Indian Institute of Technology, Guwahati, Assam 781039, India'. The correct affiliation is 'School of Electrical Engineering, Kore University of Enna, Enna, Italy'. The original Article has been corrected.

Lien vers l'article

**Hybrid quantum-classical stochastic programming for co-planning 5G base stations and photovoltaic power stations in urban communities.**

Xu Y, Han X, Luo R, Li Z. *Sci Rep*. 2025 Nov 28;15(1):42642.

The rapid deployment of Fifth-generation base stations (5G BSs) in urban communities has led to rising electricity costs for mobile network operators. Meanwhile, distributed photovoltaic power plants (PVs) provide a promising solution to offset energy expenses and reduce renewable energy curtailment. This study proposes a hybrid quantum-classical two-stage stochastic programming approach for the co-planning of BSs and PVs in urban communities. In the first stage, warm-start quantum annealing is employed to determine BS deployment locations and capacities. In the second stage, data envelopment analysis (DEA) is used to evaluate and improve the operational performance of the integrated BS-PV system. Case study results show that the proposed method reduces total planning costs to one-third compared to traditional experience-based strategies, enhances PV utilization by 12.53%, reduces electricity costs by 51.04%, and achieves over 5.4 times improvement in computational efficiency. These results demonstrate not only technical advantages but also practical value in supporting cost-effective and low-carbon urban infrastructure planning.

Lien vers l'article

**A Power-Aware 5G Network Slicing Scheme for IIoT Systems with Age Tolerance.**

Weng M, Bai Y, Xie X. *Sensors (Basel)*. 2025 Nov 14;25(22).

Network slicing has emerged as a pivotal technology in addressing the diverse customization requirements of the Industrial Internet of Things (IIoT) within 5G networks, enabling the deployment of multiple logical networks over shared infrastructure. Efficient resource management in this context is essential to ensure energy efficiency and meet the stringent real-time demands of IIoT applications. This study focuses on the scheduling problem of minimizing average transmission power while maintaining Age of Information (AoI) tolerance constraints within 5G wireless network slicing. To tackle this challenge, an improved Dueling Double Deep Q-Network (D3QN) is leveraged to devise intelligent slicing schemes that dynamically allocate resources, ensuring optimal performance in time-varying

wireless environments. The proposed improved D3QN approach introduces a novel heuristic-based exploration strategy that restricts action choices to the most effective options, significantly; reducing ineffective learning steps. The simulation results show that the method not only speeds up convergence considerably but also achieves lower transmit power while preserving strict AoI reliability constraints and slice isolation.

Lien vers l'article

**Pearson correlation-based clustering with collaborative task allocation in 5G Industrial Internet of Things divergent health networks.**

Vaithianathan K, Pernabas JB, Lamani MR, Venkatachalam K, Askar SS, Abouhawwash M. *Sci Rep*. 2025 Dec 8;15(1):43344.

Simultaneous task allocation is crucial for enhancing service quality in Industrial Internet of Things (IIoT) environments. The distribution and management of tasks remain among the biggest challenges in the IIoT era. Efficient allocation strategies are needed to enable transparent network configurations and maximize task throughput. Although recent methods address the dynamic management of objects, they often overlook the correlations between tasks and their associated functionalities. This paper introduces a novel Connected Harmonical Adaptive Task Allocation (CHATA) model for IIoT health networks to ensure fair task distribution. CHATA leverages similarity measures of object functionalities to identify the most suitable object to perform each task. Simulations conducted in NS-3 demonstrate that CHATA achieves up to 90% allocation efficiency in 5G Radio Access Technologies IIoT health environments and significantly outperforms recent approaches in task assignment performance.

Lien vers l'article

## Antennes

**Machine learning-optimized compact wearable frequency reconfigurable antenna for sub-6 GHz/mm-wave 5G integration.**

Salisu A, Elwanis MA, Elfergani I, Musa U, Alfares A, Gharbia I, et al. *Sci Rep*. 2025 Dec 29;15(1):44912.

Future 5G wireless systems will have substantial challenges in integrating the sub-6 GHz and millimeter-wave (mm-wave) bands due to their massive frequency ratios. This paper proposes a machine learning-optimized compact wearable frequency-reconfigurable antenna for sub-6 GHz/mm-wave 5G integration. Fabricated on a flexible Rogers Duroid substrate (27.8 × 14 × 0.508 mm(3)), the antenna initially employs a circular structure resonating at 28 GHz. Dual-band operation (3.5 GHz and 28 GHz) is achieved by etching an H-shaped slot into the rectangular patch. A PIN diode is employed to reconfigure the proposed antenna in the ON and OFF states. In the ON state, the antenna operates at 3.5 GHz and 28 GHz, achieving measured bandwidths of 25.4% and 73.2%, gains of 3.63 dBi and 5.25 dBi, and radiation efficiencies of 90.5% and 88%, respectively. In the OFF state, the antenna operates at 28 GHz, achieving a measured bandwidth of 72.9%, gain of 6.2 dBi, and a radiation efficiency of 89%. Bidirectional E-plane and omnidirectional H-plane radiation patterns are maintained across both bands. At 3.5 GHz, the specific absorption rate (SAR) value for 1 g and 10 g of human tissue is 0.438 W/kg and 0.0147 W/kg, while at 28 GHz, the SAR value is 0.801 W/kg and 1.09 W/kg, which comply with the FCC and ICNIRP standards. Bending tests (lap, chest, arm) demonstrate stable on-body

performance. The antenna's S(11) was predicted using a supervised ML regression framework. Among tested algorithms, the decision tree achieved state-of-the-art accuracy (R(2): 97.80%) with minimal errors (MAE: 0.72, MSE: 0.28, MSLE: 0.56, RMSLE: 0.81, RMSE: 0.66). The proposed antenna system is suitable for future 5G devices.

Lien vers l'article

**8 × 8 element MIMO antenna for unmanned aerial vehicles, V2X and 5G applications.**

Mishra B, Singh AK, Pandey A, Singh S, Sayeed SS, Yadav D. *Sci Rep*. 2025 Dec 29;16(1):780.

In this study, a compact (30 × 30 × 0.508 mm(3)) 8-port MIMO antenna for unmanned aerial vehicles (UAV), vehicle-to-everything (V2X) and 5G applications is designed, developed, tested and discussed. After a systematic study, an optimal single element of the proposed antenna is chosen from four steps (Step 1, Step 2, Step 3, Step 4). The geometry of the proposed antenna comprises eight circular radiating elements on the top plane of the substrate in which pentagon structure is etched out from each element to resonate it at 5.5 GHz. Stepped rectangular structure is removed from the ground plane underneath of each radiating elements. A dielectric substrate (RT/Duorid (5870 tm)) is used to fabricate the proposed antenna design with following specification: ε(r) = 2.33, h = 0.508 mm, loss tangent (tan δ = 0.0012). A unique structure of the proposed antenna geometry exhibits -10 dB wideband bandwidth of 1.32 GHz (5-6.32 GHz) and high isolation (> 30 dB) in entire band. A peak gain of 6.5 dB and 92% radiation efficiency have been achieved. Moreover, good degree of MIMO characteristics such as envelope correlation coefficient (ECC) (< 0.001), diversity gain (DG) (> 9.87 dB), channel capacity loss (CCL) (< 0.04 bits/s/Hz), channel capacity (37.6 bits/s/Hz) and mean effective gain (MEG) (-12 dB < MEG < -3 dB) have also been obtained. The antenna design was simulated through HFSS and fabricated & tested for further validation of results. Simulated results were found in strong concordance of experimental results.

Lien vers l'article

## Architecture réseau

Aucun article dans ce bulletin.

## Efficacité énergétique

**Ad hoc bandwidth requests and power conservation in 5G wireless networks with tiny cells.**

Rajesh A, Ravikumar CV, Sulthana SF, Kim TH, Shankar T, Srinivasulu A, et al. *Sci Rep*. 2025 Nov 28;15(1):42792.

The contention-based bandwidth request and power management mechanisms aim to improve the spectral efficiency and power consumption in Fifth Generation (5G) wireless networks to support massive Internet of Things (IoT) devices. However, when these mechanisms as combined together, they exhibit increased access delay with contention bandwidth request and response delay during power management. This tradeoff is due to the improper selection of contention window during

backoff mechanism, and the duration and position of listen interval during power management. Here, the suitability of message and code-based mechanism for single hop and two-hop 5G wireless relay networks has been investigated. In single hop network, the devices set their contention window either by message or code based base station assisted backoff along with combined cyclic binary exponent power saving mechanism. In two-hop wireless network, devices set their contention window by multi-layered bandwidth request with combined power saving class mechanism. Simulations are carried out under high mobility conditions to validate the proposed mechanisms.

Lien vers l'article

### Autres équipements

**Implementation of a compact diplexer based on a modified T-shaped step-impedance resonator (MTSIR) for 5G networks.**

Hazzazi F, Yahya SI, Babakhani F, Assaad M, Chaudhary MA, Hussin FA, et al. *Sci Rep*. 2025 Dec 11;16(1):1676.

In this paper, a microstrip diplexer with a very compact size is presented for 5G networks. The proposed diplexer operates at 3.5 GHz and 4.2 GHz, which fall within the 5G extended C-band (3.3-4.2 GHz) allocation, showing potential for next generation wireless applications. The design of this diplexer utilizes two similar filters with different sizes. In designing the filters, T-shaped resonators, meandered lines, and coupled lines are used to form a novel structure called the modified T-shaped step-impedance resonator (MTSIR). The proposed diplexer employs two modified T-shaped step-impedance resonators (MTSIRs) to achieve compact size, low insertion loss, and high isolation in the 5G extended C-band, while maintaining a very low frequency ratio of 1.2. The proposed diplexer operates at a frequency of 3.5 GHz with an insertion loss of 0.5 dB. The second channel of the diplexer operates at a frequency of 4.2 GHz with an insertion loss of 0.8 dB. The designed diplexer features a very compact size of 18.2 mm × 10.9 mm, corresponding to a normalized size of 0.16 λg × 0.28 λg.

Lien vers l'article

### Applications industrielles

**Fulfilment of the promises of 5G according to business and industry stakeholders in Europe and the United Kingdom.**

Hulls PM, Castaño-Vinyals G, Röösli M, Joseph W, Polańska K, Politański P, et al. *Sci Rep*. 2025 Nov 27;15(1):42383.

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

Lien vers l'article

### Applications médicales

**5G-Enabled Smart Prosthetic Hand: Connectivity Analysis and Assessment.**

Karaali O, Farag H, Dosen S, Stefanovic C. *Annu Int Conf IEEE Eng Med Biol Soc*. 2025 Jul;2025:1-6.

In this paper, we demonstrate a proof-of-concept implementation of a framework for the development of edge-connected prosthetic systems. The framework is composed of a bionic hand equipped with a camera and connected to a Jetson device that establishes a wireless connection to the edge server, processing the received video stream and feeding back the inferred information about the environment. The hand-edge server connection is obtained either through a direct 5G link, where the edge server also functions as a 5G base station, or through a WiFi link. We evaluate the latency of closing the control loop in the system, showing that, in a realistic usage scenario, the connectivity and computation delays combined are well below 125 ms, which falls into the natural control range. To the

best of our knowledge, this is the first analysis showcasing the feasibility of a 5G-enabled prosthetic system.

Lien vers l'article

**Effectiveness of a 5G Local Area Network-Based Digital Microscopy Interactive System: Quasi-Experimental Design.**

Xu J, Sha J, Jia S, Li J, Xu L, Shao Z. *JMIR Med Educ*. 2025 Dec 24;11:e70256.

BACKGROUND: Technological innovation is reshaping the landscape of medical education, bringing revolutionary changes to traditional teaching methods. In this context, the upgrade of the teaching model for microscopy, as one of the core skills in medical education, is particularly important. Proficiency in microscope operation not only affects medical students' pathology diagnosis abilities but also directly impacts the precision of surgical procedures and laboratory analysis skills. However, current microscopy pedagogy faces dual challenges: on one hand, traditional teaching lacks real-time image sharing capabilities, severely limiting the effectiveness of immediate instructor guidance; on the other hand, students find it difficult to independently identify technical flaws in their operations, leading to inefficient skill acquisition. Although whole-slide imaging-based microscopy system technology has partially addressed the issue of image visualization, it cannot replicate the tactile feedback and physical interaction experience of the real world. The breakthrough development of 5G communication technology-with its ultrahigh transmission speed and ultralow latency-provides an innovative solution to this teaching challenge. Leveraging this technological advantage, Tongji University's biology laboratory has pioneered the deployment of a 5G local area network (LAN)-supported digital interactive microscopy system, creating a new model for microscopy education. OBJECTIVE: This study aims to investigate the efficacy of an innovative 5G LAN-powered interactive digital microscopy system in enhancing microscopy training efficiency, evaluated through medical students' academic performance and learning experience. METHODS: Using a quasi-experimental design, we quantify system effectiveness via academic performance metrics and learning experience dimensions. A total of 39 students enrolled in the biology course were randomly assigned to 2 groups: one using traditional optical microscopes (control) and the other using the digital microscopy interactive system (DMIS). Their academic performance was evaluated through a knowledge test and 3 laboratory reports. A 5-point Likert-scale questionnaire was used to gather feedback on students' learning experiences. In addition, the DMIS group was required to evaluate the specific functions of the system. RESULTS: In the knowledge test, no statistical difference was found between the 2 groups; however, the DMIS group scored significantly higher in Lecture 2 (P<.05). In the laboratory reports, the DMIS group performed significantly better than the control group (mean 90.33, SD 2.63 vs mean 80.53, SD 3.52, P<.001). Questionnaire results indicated that the DMIS group has a positive evaluation of the system and expressed greater confidence in its future application. For the evaluation of the laboratory lectures, the DMIS group received higher evaluations on the course content and self-efficacy (P<.05), and higher satisfaction with the laboratory lectures (P<.05). CONCLUSIONS: Overall, the digital microscope interactive system enhances students' learning experiences and improves their academic performance. It offers various interactive functions to facilitate the organization of teaching activities and promote immediate feedback in the classroom. Thus, it is a promising tool for microscopy laboratory teaching.

Lien vers l'article

**Framework for effective collaboration in telemedicine-based healthcare consortium in the 5G era: a case study in China.**

Wan M, Wang Y, Qiao Y, Shukla N. *BMC Health Serv Res*. 2025 Dec 5;25(1):1583.

BACKGROUND: A telemedicine-based healthcare consortium is a hierarchical healthcare system comprising a telemedicine center and medical institutions at all levels, ensuring patients access to high-quality, convenient medical resources. It channels high-quality healthcare resources to rural areas, reduces patient costs, and enhances service quality. In the 5G era, the development of telemedicine-based healthcare consortia has significantly reshaped the collaboration mode and relationship between each medical institution. Moreover, the introduction of advanced information technologies such as 5G technology and blockchain has improved the scheduling efficiency of physicians and patients, enhanced information flow, and reduced the treatment cost of patients. To facilitate the sustainable operation of the telemedicine-based healthcare consortium, the aim of this paper is to develop a framework for effective collaboration in a telemedicine-based healthcare consortium in the 5 G era. METHODS: The proposed framework consists of four stages: (1) conducting a literature review and analyzing China's documents to examine the context and operations of the telemedicine-based healthcare consortium in China, (2) performing field research to identify key collaboration challenges, (3) designing several potential collaboration mechanisms, and (4) developing a novel mathematical model from an operations research perspective, followed by validation through data analysis. RESULTS: The designed collaboration mechanisms could ensure sufficient capacity, real-time information transmission, and revenue share in the telemedicine-based healthcare consortium. The optimal mechanism-integrated model outperforms the current fixed price model from the perspective of treatment costs for patients in the telemedicine center and the total cost of patient referral. 5 G-powered information technology could further enhance collaboration mechanisms and efficiency. CONCLUSION: The proposed framework provides useful support for the improvement of telemedicine-based consortiums' operation efficiency and service quality. The decision-makers should keep strengthening the construction of information platforms to achieve information sharing, construct tight physician-patient collaboration, and explore appropriate economic collaboration methods. Building on this foundation, advanced operations research methodologies should be proactively applied in the telemedicine-based consortiums' operation.

Lien vers l'article

**Breast density classification using frequency-based features in microwave imaging.**

Taghipour-Gorjikolaie M, Khalesi B, Khalid B, Ghavami N, Badia M, Ghavami M, et al. *Sci Rep*. 2025 Nov 27;15(1):45445.

Breast cancer remains one of the leading causes of death among women worldwide. One major challenge in early and accurate detection is breast density. High breast density not only obscures tumors on current imaging modalities, making them harder to identify, but also significantly increases the likelihood of diagnostic errors, both by medical professionals and automated detection systems. As a result, accurately classifying the breast density is crucial, and can lead to better, more tailored screening approaches and reduce the chances of error. This is especially critical for younger women, who are usually excluded from national screenings due to concerns such as radiation exposure. Microwave imaging offers a promising solution to this problem. Unlike traditional imaging methods, it uses safe, non-ionizing radiation, making it suitable for women of all ages. Beyond its safety, microwave imaging has the potential not only to detect breast cancer, but also to classify breasts into high or low density. This dual capability allows for more personalized and accurate cancer detection based on breast density, improving outcomes and reducing diagnostic uncertainty. Our microwave

imaging prototype called MammoWave works by scanning the breast using a wide range of low-power electromagnetic signals captured from multiple positions around the breast. This approach provides a rich set of data that helps create an internal map of breast tissue without exposing patients to harmful radiation. This technique makes it possible to extract frequency-based characteristics from both the spatial and spectral domains, taking advantage of not just the signal's magnitude but also its phase information. These rich features can offer deeper insights into tissue composition and improve the accuracy of breast density classification. Our analysis shows that by fusing features from both the magnitude and phase of the signals-and focusing on approximately the first 40 components of the fast Fourier transform (FFT)-it's possible to achieve an accuracy of around 70% in classifying breast density using a support vector machine (SVM) with a radial basis function (RBF) kernel. Furthermore, instead of using the full frequency range (1 to 9 GHz), selecting specific sub-bands (1, 3, 4, 5, and 6 GHz) can improve the accuracy to approximately 73%. Importantly, the results also reveal that when breast density is correctly identified and taken into account, the performance of machine learning models in detecting breast cancer improves significantly boosting specificity and sensitivity by around 10% and 5%, respectively for low-density breasts, and by 15% and 10% respectively for high-density breasts.

Lien vers l'article

**Mental health monitoring in 5G Edge-Enabled Cognitive IoT with Temporal Shift Transformer and integrated Stackelberg Game Theory and Nomadic People Optimizer.**

Pavithra M, Ramya G. *Sci Rep*. 2025 Dec 18;15(1):44065.

This research proposes an innovative framework for mental health monitoring in 5G Edge-Enabled Cognitive internet of things (IoT) environments, integrating Stackelberg Game Theory and the Nomadic People Optimizer (NPO) algorithm. The temporal shift transformer is introduced as a key component for effective prediction of mental health. The Stackelberg Game Theory ensures strategic decision-making between the central authority and decentralized agents, optimizing resource allocation and enhancing the overall system's performance. The Nomadic People Optimizer algorithm contributes to the efficiency of the decision-making process, providing an adaptive and dynamic solution for personalized mental health monitoring. The framework aims to address the challenges associated with nomadic lifestyles, leveraging 5G edge capabilities for real-time data processing and analysis. Personalized recommendations are provisioned based on the insights derived from cognitive processing, offering tailored interventions during critical mental health situations. According to experimental data, the suggested framework outperforms baseline models like CNN, GRU, and ResNet-50 + LSTM by achieving 96.38% accuracy, 96.2% F1 score, and 97.2% specificity. Additionally, real-time alert creation with an end-to-end latency of less than 46 ms is made possible by the integration of 5G edge computing, guaranteeing prompt mental health treatments. The proposed approach demonstrates promising results in terms of accuracy, adaptability, and scalability, showcasing its potential to revolutionize mental health care for nomadic populations within the evolving landscape of cognitive IoT and 5G technologies.

Lien vers l'article

**Clinical Imaging of Microwave Mammography.**

Kuwahara Y, Fujii K. *J Vis Exp*. 2025 Nov 14(225).

Breast cancer is the most common malignancy among women, and early detection and treatment are critical for improving clinical outcomes. X-ray mammography remains the standard screening modality;

however, it has several limitations, including radiation exposure, patient discomfort, and reduced sensitivity in women with dense breast tissue. Microwave imaging, a non-ionizing technique, has emerged as a promising alternative. We have developed a device that reconstructs breast tissue structures by solving the inverse scattering problem and is currently undergoing clinical trials. This system generates three-dimensional tomographic images without the use of contrast agents and without causing pain during examination. To date, 24 breast cancer patients have been imaged, with an accuracy of 86% for tumors ≥ 1 cm in diameter, and 58% when tumors < 1 cm are included. In this article, we present a detailed protocol for device preparation, clinical imaging, and data processing, along with representative imaging results from selected patients.

Lien vers l'article

## Evaluation (Mesure des niveaux d'exposition)

### Méthodes d'évaluation

Aucun article dans ce bulletin.

### Evaluation population générale

**RF-EMF exposure in the transition to 5G: A multi-dimensional measurement campaign in the Peloponnese Region of Greece.**

Zarbouti D, Athanasiadou G, Tsoulos G, Christopoulos T, Tsoulos V, Chaloulakos N, et al. *Environ Monit Assess*. 2025 Dec 9;198(1):27.

5G is currently under development in Greece, with operators adopting different strategies and rollout schedules. Meanwhile, 4G has reached a highly mature stage, supporting the initial deployment of 5G through NSA (Non-Standalone) architecture. Cellular service is provided by a combination of systems: the legacy 2G system operational mainly in rural areas, the advanced 4G, and the emerging 5G systems, 3G was phased out in 2023. This transitional phase renders the cellular landscape both dynamic and region-specific. Recurrent, large-scale measurement campaigns are essential to effectively track networks development. This study presents findings from a year-long EMF measurement campaign (July 2023-June 2024) in the Peloponnese Region of Greece. Using frequency-selective equipment, the campaign combined spatially distributed short-term ground measurements with long-term monitoring at fixed locations. Data was analyzed by service type (e.g. cellular, WiFi), cellular system (2G/3G/4G/5G), and network operator. All measured electric field values remained well below the stringent Greek safety limits; the highest ground-level measurement was approximately 18 times lower than the limit. The 900 MHz band was identified as the dominant contributor to EMF exposure, followed by the 1800 MHz band used by 4G and 2G networks. 4G contributed the most (53%), while 5G impact was only 3%, reflecting its early stage of deployment in the region. Long-term monitoring revealed peak exposure between 15:00 and 21:00, coinciding with increased network usage. The findings provide reassurance regarding public safety, highlight the value of combining spatial and temporal analysis, and offer baseline data for future studies as 5G networks continue to expand.

Lien vers l'article

**Visualizing radiofrequency electromagnetic field exposure through Voronoi-based maps.**

Arribas E, Ramirez-Vazquez R, Escobar I. *Environ Sci Pollut Res Int*. 2025 Oct;32(46):26415-28.

Measuring the exposure of radiofrequency electromagnetic fields in a city is a very laborious task. To simplify this process for a city of 200 thousand inhabitants, Voronoi diagrams were used. The city was divided into cells based on the Euclidean distance to a point on the map, and each cell was assigned the value of the electric field measured at that point using a personal exposimeter. The number of cells varied from five to 30 and, finally, one 100. The maps obtained are commented on, using a palette of four uniform colors for the cells, to facilitate their perception. The more cells are considered, the smaller the cells will be. A stabilization of the process is observed as the points within the city map

increase. The colors represent the RMS (root mean square) electric field measured at each seed point, extended geometrically to its Voronoi cell for visualization purposes. The colors of the areas remain the same; and in some other areas, cells appear with slightly distinct colors, due to the addition of new measured points. Some cells change color due to these new measurements of the new points. In this study, the predominant color is green, which is the measured field at the seed point was 1.9 V/m RMS (while the maximum allowed by the ICNIRP guidelines is 61.4 V/m). There are three cells in the city with E values above 3.9 V/m, reaching the highest value of 11.4 V/m. The entire city is within the recommended maximum. The Voronoi diagram method is shown to be useful and interesting for the presentation of radiofrequency electromagnetic fields exposure measurements in a medium-sized city. The Voronoi cells do not contain information about the intracell spatial variation of the electric field; each polygon represents the RMS value measured at its generating point (seed), offering a discrete visualization of the spatial distribution of the measurements and illustrating how the electric field levels vary across the study area.

Lien vers l'article

## Risques professionnels

Aucun article dans ce bulletin.

### In silico

Aucun article dans ce bulletin.

### In vitro

**Radiofrequency radiation-induced gene expression.**

Lai H, Levitt BB. *Rev Environ Health*. 2025 Dec 17;40(4):695-719.

Genes are differentially expressed in cells in response to changes in the internal or external environment. The response is generally an adaptive mechanism to the environmental challenge to restore cell functions to homeostasis. There are numerous studies reporting changes in gene expression in cells exposed to radiofrequency radiation (RFR), the type of energy emitted by wireless communication devices. The major genes affected are those involved in: repair of damaged proteins, response to stress, oxidative changes, apoptosis, DNA damage detection and repair, and changes in neural functions. Gene expression data supports the notion that RFR is a stressor that causes oxidative changes and DNA and protein damage in cells under different exposure conditions, in many biological systems. Changes in all these significant gene expression effects are supported by results of other biological studies of RFR exposure in the literature. They should be considered in the setting of RFR-exposure guidelines.

Lien vers l'article

### Sur l'animal

**Conceptualization and Realization of a Vibrating Intrinsic Reverberation Chamber for Plant Exposure to Radio Frequency Electromagnetic Fields.**

Oppermann L, Weidemeier M, Schäfer CC, Win YN, Matthes MS. *Bioelectromagnetics*. 2025 Dec;46(8):e70036.

The increasing use of mobile communication devices and wireless data transfer leads to public concerns about potential negative impacts on the living world, resulting from the emitted radio frequency-electromagnetic fields (RF-EMF). In order to provide knowledge-based information on how RF-EMF might affect biological organisms, well-controlled studies are needed, where the actual electric field parameters are monitored over time and at the location of the tested organisms. Such controlled studies are scarce, particularly regarding the assessment of potential effects of RF-EMF on plant growth and health. Here, we report the implementation of a vibrating intrinsic reverberation chamber (VIRC) inside a walk-in plant growth chamber for controlled RF-EMF studies on plants. The designed VIRC functions as a mode-stirred reverberation chamber and allows real-time monitoring of the electric field over the entire time of plant exposure within a defined working volume where the plants are placed. We demonstrate that the electric field inside the designed VIRC is stable and statistically

uniform, that is, spatially homogeneous and isotropic, over multiple exposure times, various field strengths, and when loaded with different plant species. Therefore, it is a suitable setup for controlled experiments assessing the effects of RF-EMF on plants. Using the VIRC, we show that repeated short-term exposures (30 min) of rose cuttings to RF-EMF (900 MHz, 5 V/m) do not affect shoot growth or leaf development compared to sham exposure (0 V/m). The VIRC was designed for a frequency of 900 MHz and electric field strength ranging from 0 to 40 V/m. The concept, however, can be adapted to different RF-EMF exposure requirements.

Lien vers l'article

**Flora and fauna: how nonhuman species interact with natural and man-made EMF at ecosystem levels and public policy recommendations.**

Levitt BB, Lai HC, Manville AM, 2nd, Scarato T. *Front Public Health*. 2025;13:1693873.

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

Lien vers l'article

**Exposure to 5G-NR electromagnetic fields affects larval development of Aedes aegypti mosquito.**

De Borre E, De Massia C, Boone MN, Müller P, Thielens A. *Sci Rep*. 2025 Dec 25;16(1):2972.

Telecommunication networks, including 5G New Radio (5G-NR), emit these fields and consequently expose many insects. To quantify the potential effect of RF-EMF exposure on insects, a study was

designed examining the development of the Aedes aegypti mosquito, a major vector of dengue and other pathogens, as model organism exposed to RF-EMFs at 3.6 GHz. A custom exposure setup, a reverberation chamber, was designed, built, and characterized. Numerical simulations made it possible to calculate doses received by the larvae during the exposure. Larvae were reared on two feeding regimes, differing in nutritional value, and exposed for 5 days. At an RF exposure level of 46.2 V/m and absorbed power of 1.2 [Formula: see text]W, a slower development occurred, especially for weakened larvae. At an RF exposure level of 182.6 V/m and 18.7 [Formula: see text]W absorbed power, dielectric heating changed development timing and adult size.

Lien vers l'article

## Sur l'homme

**Millimeter-wave high frequency 5G (26 GHz) electromagnetic fields do not modulate human brain electrical activity.**

Michelant L, Baz T, Carrie A, Hugueville L, Lévêque P, Selmaoui B. *Environ Res*. 2026 Jan 15;289:123349.

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

Lien vers l'article

**The Effect of 5G Mobile Phone Electromagnetic Exposure on Corticospinal and Intracortical Excitability in Healthy Adults: A Randomized Controlled Pilot Study.**

Torkan A, Zoghi M, Foroughimehr N, Jaberzadeh S. *Brain Sci*. 2025 Oct 22;15(11).

BACKGROUND: Research on the impact of 5G mobile phone electromagnetic exposure on corticospinal excitability and intracortical mechanisms is still poorly understood. OBJECTIVE: This randomized controlled pilot study explored the effects of 5G mobile phone exposure at 3.6 GHz (power density: 0.0030 W/m(2)) on corticospinal excitability and intracortical mechanisms in healthy adults. METHODS: Nineteen healthy participants (mean age: 36.5 years) were exposed to 5G mobile phone exposure for 5 and 20 min, approximating the typical duration of a phone call. Corticospinal excitability, intracortical facilitation, short intracortical inhibition, and long intracortical inhibition using single- and

paired-pulse transcranial magnetic stimulation assessed before and immediately after exposure were performed. RESULTS: A two-way repeated-measures ANOVA revealed no significant interactions between exposure condition (5 min, 20 min, sham) and time (pre vs. post) for CSE, ICF, SICI, or LICI (all $p > 0.15$). Bayesian analyses yielded Bayes factors close to 1, indicating inconclusive evidence for both the null and alternative hypotheses. CONCLUSION: Short-term exposure to 5G mobile phone electromagnetic fields did not produce detectable changes in corticospinal or intracortical excitability. Bayesian evidence was similarly inconclusive (Bayes factors ≈ 1), suggesting that the data provide limited support for either the presence or absence of a detectable effect. Any potential influence of 5G exposure on neural function is therefore likely to be subtle with the present methods. As a pilot study, these findings should be interpreted cautiously and underscore the need for further research using more sensitive outcome measures, extended exposure durations, and vulnerable populations.

Lien vers l'article

**Exposure to radiofrequency electromagnetic fields and IARC carcinogen assessment: Risk of Bias preliminary literature assessment for 10 key characteristics of human carcinogens.**

Simkó M, Repacholi MH, Foster KR, Mattsson MO, Croft RJ, Scarfi MR, et al. *Mutat Res Rev Mutat Res*. 2025 Jul-Dec;796:108545.

This is the first assessment of evidence needed to determine whether exposure to radiofrequency electromagnetic fields (RF-EMF) exposures, below the levels recommended in the ICNIRP (2020) guidelines, can influence any of the ten key characteristics (KCs) of human carcinogens developed by the International Agency for Research on Cancer (IARC). We define the 10 KCs and their relevance to carcinogenesis; review in vivo and in vitro studies relevant to the KCs; and conduct a risk of bias (RoB) analysis using 6 criteria. We did not include KC studies on genotoxicity or oxidative stress since Romeo et al. (2024) and Meyer et al. (2024) recently published relevant systematic reviews, but note their respective conclusions. From the other 8 KCs we identified 119 in vitro and 40 in vitro measurements of in vivo studies through 30 June 2023, with 38 % reporting statistically significant effects of exposure. We identified a strong association between the quality of study and outcome, with those meeting more RoB criteria less likely to report statistically significant effects. Effects were reported over the entire frequency range, exposure levels, and biological endpoints with no apparent pattern of exposure parameters resulting in effects. Only KC10 (alters cell proliferation, cell death or nutrient supply) has sufficient studies to analyse, but the other KCs had few studies and diverse endpoints. A few relatively high-quality positive studies require follow-up through additional targeted studies. The heterogeneity and overall poor study quality suggest the need for high-quality studies on these endpoints, preferably adhering to standards such as the Organization for Economic Co-operation and Development [28].

Lien vers l'article

**Towards a Planetary Health Impact Assessment Framework: Exploring Expert Knowledge and Artificial Intelligence for a RF-EMF Exposure Case-Study.**

Stefanopoulou M, Sonnenschein TS, de Gannes FP, Scheider S, Vermeulen R, Röösli M, et al. *Bioelectromagnetics*. 2025 Dec;46(8):e70038.

While recent WHO systematic reviews have comprehensively assessed the direct health effects of radiofrequency electromagnetic field (RF-EMF) exposure, its potential indirect impacts on human health via ecosystem disruption remain unstudied. Therefore, we propose a Planetary Health Impact

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

Lien vers l'article

**Modulation of brain functional connectivity in healthy young adults following GSM radiofrequency exposure: A magnetoencephalography and magnetic resonance imaging study.**

Iranfar S, Wallace J, Selmaoui B, Yahia-Cherif L. *Neuroscience*. 2025 Dec 15;591:103-9.

In our previous study, we showed that acute exposure to mobile phone radiofrequency electromagnetic fields at 900 MHz modulates the magnetoencephalographic rhythms of alpha band power in healthy participants. The aim of the present study was to investigate whether the scope of this effect extends to the modulation of brain functional connectivity. To this end, healthy young individuals were exposed to Global System for Mobile Communications (GSM) signals at a frequency of 900 MHz, modulated at 217 Hz with a maximum power of 2 W. The pre- and post-exposure magnetoencephalographic recordings were normalized and used to calculate brain functional connectivity using the corrected imaginary phase-locking value. Our data revealed significant alterations in intra-hemispheric brain functional connectivity during real GSM-900 MHz exposure compared with the sham session. Specifically, regions in the right hemisphere-including the transverse temporal, entorhinal, insula, and posterior cingulate-were modulated by the exposure. These findings suggest that GSM radiofrequency electromagnetic fields may influence neural communication and brain functional connectivity, potentially affecting cognitive processes. Further studies are needed to explore the underlying mechanisms and assess the long-term implications for neural health.

Lien vers l'article

## Reproduction

**Male Reproductive and Cellular Damage After Prenatal 3.5 GHz Radiation Exposure: One-Year Postnatal Effects.**

Gelenli Dolanbay E, Mert T, Caliskan Bender G, Bektas H, Uslu U, Fernandez-Rodriguez CE, et al. *Ann N Y Acad Sci*. 2025 Dec;1554(1):140-52.

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

Lien vers l'article

**Altered development in rodent brain cells after 900 MHz radiofrequency exposure.**

Bodin R, Godin L, Mougin C, Lecomte A, Larrigaldie V, Feat-Vetel J, et al. *Neurotoxicology*. 2025 Dec;111:103312.

Health risks related to 900 MHz 2 G frequency exposure remain inconclusive under current regulatory standards. Research into potential long-term effects is ongoing, particularly as the use of mobile networks and wireless devices increases. This study investigates the effects of non-thermal exposure levels of mobile phone 900 MHz radiofrequency electromagnetic field (RF-EMF) on rodent neurodevelopment. In vivo, the effects of pre- and post-natal 0.08 and 0.4 W/kg specific absorption rate (SAR) exposure were assessed for their impact on the proteomic profile at postnatal day 0 (PND 0). Brain-derived neurotrophic factor (BDNF), BrdU+ proliferative cells, synaptogenesis, and oxidative stress in the hippocampus and cortex of rat pups were studied at PND 8 and PND 17. Effects of the lowest SAR (0.08 W/kg) were assessed in vitro to afford mechanistic data regarding neural stem cells (NSCs) differentiation. In vivo results showed a decrease in BDNF level and BrdU+ proliferative cells with a decrease in synapse balance (excitatory synapses/inhibitory synapses). In vitro, at 0.08 W/kg there was an increase in Ki-67 + proliferative cells, apoptosis, and double-strand DNA breaks in NSCs. A lower ratio of B1 cells (primary progenitors of NSCs) among total cerebral cells and a higher ratio of oligodendrocyte progenitor cells and astrocytes were observed in the exposed NSCs. Our findings suggest that key cellular events for brain ontogenesis are likely to undergo changes with RF-EMF 900 MHz exposure during early development. These support the hypothesis that the developing central nervous system is vulnerable to RF-EMF exposures in rodents at regulatory thresholds.

Lien vers l'article

**Behaviour and reproduction of Drosophila melanogaster exposed to 3.6 GHz radio-frequency electromagnetic fields.**

De Boose P, Ribas FO, Bell D, Bouga M, De Borre E, Fröhlich J, et al. *PLoS One*. 2025;20(12):e0336228.

Insects are exposed to radio-frequency electromagnetic fields emitted by wireless telecommunication networks. A part of these fields will be absorbed by these insects. This absorption might have biological effects, depending on the amount of absorbed power. It is currently unknown at what level of absorption this might occur. To investigate this, we used RF dosimetry of adult Drosophila melanogaster flies, which we combined with two assays studying the locomotor activity and fecundity of D. melanogaster exposed to electromagnetic fields at 3.6 GHz. To perform dosimetry, we created a 3D digital twin of an adult fly using micro-CT scans of a female D. melanogaster. We used this model in numerical EM simulations to estimate the absorbed power in the fly as a function of RF frequency in the far field of an antenna and during the two experimental assays at 3.6 GHz. In the behavioural experiments, no effects were found on the locomotor activity for a 5-day exposure to RF field values between 5.4 and 9 V/m, which correspond to 3.56 nW to 9.88 nW absorbed power. We also did not find any effects on fecundity, at an absorption level of 1.91 mW for 48h at 3.6 GHz. In our future work, we aim to investigate possible exposure effects at higher frequencies and exposures, and for immature stages.

Lien vers l'article

## Dispositifs médicaux implantables

Aucun article dans ce bulletin.