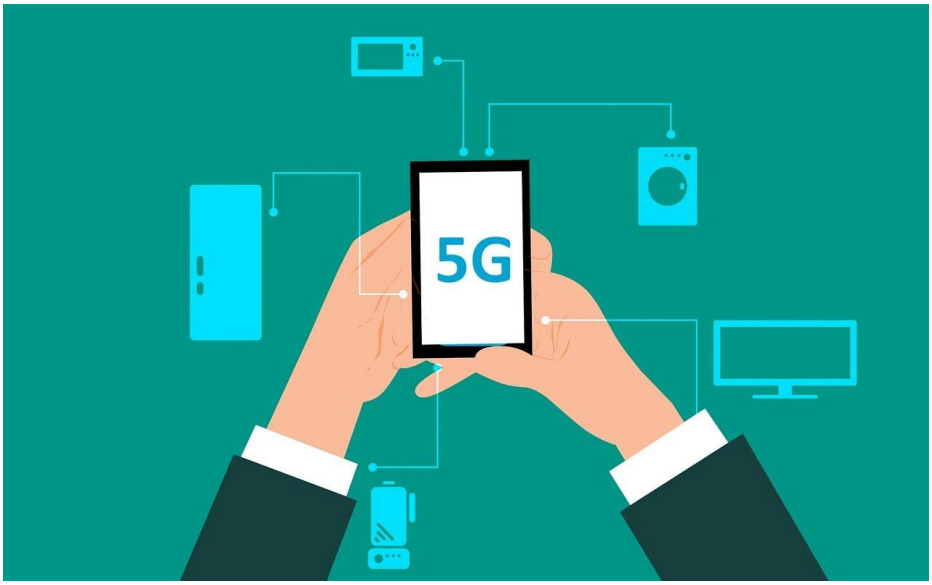
TECHNOLOGIE 5G

Bulletin de veille scientifique : Janvier 2026



Objectifs : réaliser une veille scientifique sur la technologie 5G

La validation des informations fournies (exactitude, fiabilité, pertinence par rapport aux principes de prévention, etc.) est du ressort des auteurs des articles signalés dans la veille. Les informations ne sont pas le reflet de la position de l'INRS. Les éléments issus de cette veille sont fournis sans garantie d'exhaustivité. Les liens mentionnés dans le bulletin donnent accès aux documents sous réserve d'un abonnement à la ressource.

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Généralités

RF-EMF Risk Perception and Trust in Radiation Protection Authorities: A Comparative Study on Precautionary Information in Germany and Greece.

Eggeling-Böcker M, Karabetsos E, Christopoulou M, Link SC, Abacioglu F, Boehmert C. *Bioelectromagnetics*. 2026 Jan;47(1):e70042.

This study investigates how different types of precautionary information affect risk perception and trust in national radiation protection authorities regarding radio-frequency electromagnetic fields (RF-EMF) from mobile communications, with a specific focus on 5G networks. A total of 2169 participants (1040 in Germany, 1129 in Greece) were randomly assigned to one of three conditions: (1) basic information, (2) simple precautionary information regarding possibilities to reduce personal RF-EMF exposure while using a mobile phone, and (3) conceptual precautionary information, including an explanation distinguishing "precaution" from "prevention" (1 × 3 factorial design). Contrary to the expectation that simple precautionary messages lead to higher risk perception and lower trust compared to basic messages, this was only the case for general conditional risk perception assuming that no precautions are taken, but not for affective risk perception, trust, or general conditional risk perception assuming that precautions are taken. Notably, providing a more elaborate explanation of the precaution/prevention distinction did not decrease risk perception or increase trust compared to giving simple precautionary information only, and even increased risk perception compared to basic information. This suggests limited benefit in emphasizing this conceptual nuance of precaution. Considering other variables, precautionary information increased feelings of self-efficacy and perception of message consistency. The findings reveal significant country differences: Greek participants reported higher perceived risks and lower trust than German participants. Gender differences also emerged, with women expressing higher risk perception and less trust than men. In contrast to the previous literature, the results suggest that precautionary information concerning personal mobile phone use can be communicated without leading to higher public concern about RF-EMF exposure from mobile communications. However, we found some evidence that adding conceptual explanations to precautionary information leads to higher risk perception. The results also show that considering sociocultural and individual differences in risk communication can be relevant. Possible explanations for the findings and implications for risk communicators are discussed.

Lien vers l'article

U.S. policy on wireless technologies and public health protection: regulatory gaps and proposed reforms.

Scarato T. *Front Public Health*. 2025;13:1677583.

The current U.S. regulatory framework governing non-ionizing radiofrequency radiation (RFR) used in all wireless technology is outdated and lacks adequate protection, oversight, and enforcement. The U.S. Federal Communications Commission (FCC) was given regulatory jurisdiction by the U.S. Congress in 1996 over RFR exposure standards setting even though FCC has no in-house expertise regarding health or environmental effects from RFR. FCC is a licensing/engineering entity that relies on other government agencies for guidance on ambient exposures and devices. However, all relevant civilian public health and environmental agencies have been defunded from non-ionizing radiation research activities and oversight. Thus, current regulations have remained unchanged since 1996. Human exposure limits are designed to protect against short-term high-intensity effects, not today's long-term chronic low-intensity exposures. Scientific evidence indicates that children's thinner skulls, unique

physiology, and more conductive tissues result in significantly higher RFR absorption rates deeper into critical brain regions, which are still in development and thus more sensitive to environmental insults. However, current policies offer no safeguards for children/pregnancy or vulnerable populations. Growing research also indicates risks to wildlife, especially pollinators. In 2021, a U.S. federal court mandated that the FCC show proper review of growing scientific evidence, after a cursory FCC re-approval of limits in 2019, but FCC has yet to respond. This paper explores regulatory infrastructure deficiencies, including the absence of monitoring/oversight, premarket safety testing, post-market surveillance, emissions compliance/enforcement, occupational safety, and wildlife protection. Compliance tests for cell phones do not reflect real-world consumer use and can therefore camouflage exposures that exceed even FCC's outdated limits. Other countries enforce stricter limits, robust monitoring, transparency measures, and compliance programs with additional policies to protect children. Also discussed is the chronic revolving door between FCC leadership and the wireless industry, resulting in a state of regulatory capture. Policy recommendations for common-sense reforms are made for reinvigorating independent research, developing science-based safety limits, ensuring pre- and post-market surveillance, and improving oversight/enforcement, as well as implementing risk mitigation to reduce exposures to children, vulnerable groups, and wildlife.

Lien vers l'article

Performances et sécurité

Resilience enhancement strategies for distribution networks considering the coordination of 5G base stations and multiple flexible resources.

Wang H, Ge J, Zhao Y, Gu J, Li C, Liu C. *Sci Rep*. 2026 Jan 16;16(1):5481.

In recent years, the increasing frequency of extreme natural disasters has significantly exposed the vulnerability of distribution networks. To address this challenge, this study proposes a resilience enhancement strategy that integrates 5G base stations with multiple flexible resources. First, a disaster scenario modeling framework is developed by considering typhoon wind speed, line outage probability, and renewable generation curtailment, and representative scenarios are extracted using Latin Hypercube Sampling (LHS) and K-means++ clustering. Subsequently, a coordinated optimization model is established with the objectives of minimizing critical load loss and economic cost, in which the energy storage of 5G base stations is utilized not only to guarantee communication loads but also to participate in system dispatch. Meanwhile, distributed generation, electric vehicles, and mobile energy storage systems are coordinately scheduled, combined with network reconfiguration to achieve complementary utilization of multiple resources. The bi-objective problem is then reformulated into a mixed-integer second-order cone programming (MISOCP) model using second-order cone relaxation and the weighted-sum method, and efficiently solved. Finally, case studies conducted on a modified IEEE 33-bus system demonstrate that, compared with uncoordinated operation under extreme disaster conditions, the proposed strategy reduces critical load loss by 84.6%, decreases economic losses by 76.9%, and improves the comprehensive objective value by 83.7%. Furthermore, by coordinating 5G base stations with mobile energy storage to support islanded areas, the overall comprehensive objective is further improved by 89.1%.

Lien vers l'article

A secure group-based authentication protocol for IoVT in 5G-enabled smart transportation and road safety systems.

Singh G, Sharma S, Saudagar AKJ, Kumar S. *Sci Rep*. 2026 Jan 16;16(1):2212.

The Internet of Vehicular Things (IoVT) is evolving rapidly, connecting vehicles, infrastructure, and other smart systems via the Internet. This connectivity enhances safety, efficiency, and data-driven services but also introduces significant security and privacy risks. To tackle these challenges, this paper proposes a lightweight, group-based authentication and key agreement (AKA) protocol tailored for 5G-enabled IoVT networks. The protocol achieves essential security goals, including mutual authentication, key confirmation, forward and backward secrecy, subscriber privacy, and session unlinkability. Its security has been formally validated using the AVISPA tool and BAN logic, showing strong resistance against common cryptographic attacks. Performance evaluations indicate that the proposed protocol can reduce signaling overhead by up to 47.3%, lower bandwidth consumption by up to 32.3%, and significantly decrease computational costs compared to the standard EPS-AKA protocol. Overall, these results highlight a secure, efficient, and scalable solution suitable for next-generation 5G-based IoVT systems.

Lien vers l'article

Fast solution of 5G channel path loss in substation based on improved ray tracing method.

Chi Z, Zhendong Z, Yi L, Zhiyu S, Yuening Y. *Sci Prog*. 2026 Jan-Mar;109(1):368504251413963.

Due to the high frequency of fifth-generation (5G) signals, which leads to an extremely large computational scale when traditional algorithms solve the channel path loss, it is necessary to seek a fast solution method for the 5G channel path loss in substations in order to achieve a fast adaptation of the channel to the signal receiver and to ensure the reception quality of the 5G signals. Aiming at the problem that traditional algorithms suffer from extremely high computational complexity when dealing with the dyadic reflection-diffraction coefficients, a method based on singular value decomposition is proposed to reduce the dimensionality of the channel matrix for solution. Firstly, the ray tube model is used to divide the channel, and the incident angle information within the channel matrix is chunked through the nodes to discard the duplicates and those that contribute very little to the channel path loss. Then, matrix dimensionality reduction is achieved by the singular value decomposition algorithm, and the dimensionality-reduced channel matrix is substituted into the sum-vector inverse wrap-around coefficient solution formula to achieve the fast solution of 5G channel path loss. Finally, a comparison of the computational results of the proposed algorithm with those of the traditional algorithm is carried out by taking the 5G base station antenna of AAU5270E as an example and using the computational results of the experimental measurement data as a benchmark. The results show that the accuracy loss of the method proposed in the paper is only 1.31%, the compression of the data is 84.89, and the order of magnitude of the computation is 10(5) lower than that of the traditional algorithm. Future research could further integrate real-time channel data to achieve dynamic adaptive optimization, while extending this dimensionality reduction framework to high-dimensional complex channel modeling such as the sixth generation (6G), thereby promoting the continuous development of the algorithm in terms of real-time performance and generalization capability.

Lien vers l'article

Antennes

Compact integrated self-multiplexing antenna for sub-6 GHz and millimeter wave 5G frequency spectrum.

Srivastava G, Kumar A, Rana S, Kumar V, Mohan A, Kumar S, et al. *Sci Rep*. 2026 Jan 16;16(1):5457.

This paper presents a compact integrated self-multiplexing antenna capable of operating across both the sub-6 GHz and millimeter-wave bands of the 5G frequency spectrum. The sub-6 GHz unit elements are alternately arranged with different structural dimensions to achieve eight distinct operating frequencies within the sub-6 GHz spectrum. Between each pair of sub-6 GHz unit elements, millimeter-wave unit elements of varying dimensions are incorporated to generate radiations at eight distinct frequencies in the millimeter-wave band. The first eight ports (P(1)–P(8)) operate at eight distinct frequencies of sub-6 GHz spectrum, whereas the remaining eight ports (P(9)–P(16)) are designed to radiate at eight distinct millimeter-wave frequencies. Electromagnetic waves in the sub-6 GHz spectrum are obtained by means of exciting TE(110) mode in the modified eighth-mode substrate integrated waveguide (EMSIW) cavity resonators, while millimeter-wave radiation is achieved through the hybrid TE(730) and TE(750) modes of the EMSIW cavity resonators. The inter-port isolations better than 40 dB and 20 dB are obtained across the sub-6 GHz and millimeter-wave spectrum, respectively.

This integrated placement of millimeter-wave elements efficiently utilizes the available substrate area while maintaining high inter-port isolation across the entire frequency spectrum. The design antenna system has an overall footprint of 0.425[Formula: see text], where [Formula: see text] corresponds to the guided wavelength at the lowest operating frequency. Owing to its compact dimensions, simple integrated design and excellent performance, the proposed self-multiplexing antenna emerges as a promising candidate for multiband communication systems operating in sub-6 GHz and millimeter-wave 5G spectrum.

Lien vers l'article

Mobile phone MIMO antenna array miniaturization-based low SAR research in the combined EMF.

Hou WQ, Li YX, Luo MF, Zhou WY, Lu M. *PLoS One*. 2026;21(1):e0340681.

Due to the diversification of media functions of mobile phones, users can make calls and access the internet simultaneously, which has significantly increased the usage time of mobile phones. The exposure dose of the users in the combined electromagnetic fields (EMF) should be further quantified to better evaluate the public exposure safety. Different from most conventional EMF safety studies that only focus on a single frequency, this work not only discusses the mobile phone simultaneously operated in fourth-generation (4G) and fifth-generation (5G) mobile communications radiation impact on users, but also verifies that the miniaturized mobile phone multiple-input multiple-output (MIMO) antenna array can significantly reduce the specific absorption rate (SAR) absorbed by users. In this article, a miniaturized mobile phone MIMO antenna array is employed as the radiation source, and multi-pose human models are established to simulate the practical utilization of a smartphone. A systematic analysis of the SAR absorbed by the human model is conducted in both single and combined EMF scenarios. The results indicate that the peak SAR in various tissues under multi-frequency exposure is 1.02 to 15.85 times higher than that under single-frequency exposure.

Lien vers l'article

A low-profile compact dual-sense quad-port circularly polarized MIMO antenna for 5G mmWave networks.

Hayat B, Khan A, Ahmad S, Tian Y, Alabdulkreem E, Majeed A, et al. *Sci Rep*. 2026 Jan 17;16(1):5619.

The rapid growth of 5G millimeter-wave (mmWave) networks demands compact, low-profile, and efficient performance of multiple input multiple output (MIMO) antennas capable of supporting high data rates, reduced latency, and polarization diversity. This work presents a compact and low-profile dual-sense circularly polarized (CP) quad-port MIMO antenna particularly designed for use in 5G mmWave technology. The proposed single antenna employs a symmetric feed network incorporating a folded and stepped impedance microstrip line, a via-less coplanar waveguide (CPW)-fed monopole extension with an F-shaped patch, and a modified ground structure (MGS). This configuration enables efficient excitation of orthogonal modes for dual-sense CP across two distinct frequency bands. The four MIMO radiators, implemented on a single-layer low-cost substrate and arranged orthogonally, achieve high isolation through a cross-shaped isolator. The overall antenna size is [Formula: see text], where [Formula: see text] representing the free-space wavelength corresponding to 28 GHz. Simulated dual-sense impedance bandwidths are 26.08–28.41 GHz and 29.89–31.06 GHz, with isolation levels better than 21.5 dB and 18.4 dB, respectively. The antenna produces left hand circular polarization (LHCP) in the lower frequency band and right hand circular polarization (RHCP) in the upper frequency band, with axial ratio bandwidths (ARBW) below 3 dB at 27.53–28.16 GHz and 30.13–30.81 GHz. At

broadside, the antenna attains maximum gains of 5.9 dBic at 28 GHz and 4.0 dBic at 30.7 GHz, while maintaining radiation efficiencies above 80% across the operating frequency bands. An equivalent circuit model (ECM) is developed to clarify the operating principles. Close correspondence is observed between the simulated and experimental outcomes. Diversity performance is significantly enhanced, with low envelope correlation coefficient (ECC), balanced mean effective gain (MEG), high diversity gain (DG), and low channel capacity loss (CCL), ensuring reliable and high-capacity mmWave 5G communication.

Lien vers l'article

Circularly polarized millimeter-wave hemisphere DRA employing FSS polarizer and dielectric superstrate for 5G applications.

Alanazi MD, A AM, Ibrahim AA. *Sci Rep*. 2026 Jan 6;16(1):4424.

This paper presents a compact, wideband, high-gain circularly polarized (CP) hemispherical dielectric resonator antenna (HDRA) designed for millimeter-wave 5G applications. The proposed antenna employs a linearly polarized (LP) HDRA excited through an annular slot coupled to a 50-Ω microstrip feed, enabling efficient radiation at millimeter-wave frequencies. Wide impedance bandwidth from 20 to 28 GHz is achieved by overlapping multiple adjacent resonant modes of the HDRA. Circular polarization is realized by introducing a frequency-selective surface (FSS) superstrate positioned at an optimized distance above the antenna. To further enhance the axial-ratio bandwidth and gain, a 2 × 2 HDRA array with a sequential-phase feeding network and an additional dielectric superstrate is implemented. The antenna is fabricated and experimentally validated. Measured results demonstrate an impedance bandwidth of 33.3% (20-28 GHz), a peak realized gain of 11.8 dBi, and a 3-dB axial-ratio bandwidth of 31% (20.5-28 GHz). The proposed design offers a compact and efficient solution for millimeter-wave 5G and IoT applications.

Lien vers l'article

Staircase-Enhanced Magneto-Electric Dipole Antenna for Wideband CP 5G Applications with High-Gain Arrays.

Malhat H, Zakaria A, Qaddoumi N. *Sensors (Basel)*. 2025 Dec 16;25(24).

This paper presents a compact magneto-electric dipole (MED) antenna optimized for wideband circularly polarized (CP) radiation for 5G applications. It incorporates a staircase-shaped electric dipole with trimmed corners to excite orthogonal modes for enhanced CP performance. The proposed single-layer MED antenna achieves a 20.6% wide-impedance bandwidth (|S11| <-10 dB, 22.97-28.12 GHz) and 21.9% CP bandwidth (AR<3 dB, 22.23-27.83 GHz) with a compact footprint of 15×15×1.6mm3. There is a symmetrical radiation pattern with a co-to-cross polarization ratio >23 dB and a stable gain of 8.8 dBi. An equivalent circuit model is optimized via particle swarm optimization (PSO). The optimized MED antenna is utilized to investigate various CP-MIMO configurations and wideband sequential arrays. Next, a 1×2 CP-MIMO antenna system is developed, employing polarization diversity in parallel and mirror configurations. Isolation is improved by etching a ground slot between the MED elements, yielding isolation levels of below -20 dB and -23 dB, respectively. Further, a 2×2 CP-MIMO configuration is designed and evaluated. This arrangement demonstrates an envelope correlation coefficient (ECC) of 1×10-3 and a diversity gain of approximately 10 dB across the operating bandwidth. Finally, a sequential array is designed that applies a 90◦ sequential rotation and phase excitation to MED elements for high-gain CP 5G communications. Here, various array sizes are evaluated, with an

8×8 MED array providing CP radiation (AR≤1 dB) from 20 to 30 GHz with enhanced impedance and axial ratio bandwidths and stable gain with a peak value of 27.47 dBi.

Lien vers l'article

Retraction notice to "Experimental investigations of dual functional substrate integrated waveguide antenna with enhanced directivity for 5G mobile communications" [Heliyon 10 (2024) e36929].

Sathishkumar N, Palanisamy S, Natarajan R, V RA, Ouahada K, Hamam H. *Heliyon*. 2025 Dec;11(17):e44255.

[This retracts the article DOI: 10.1016/j.heliyon.2024.e36929.].

Lien vers l'article

Architecture réseau

Convolutional neural networks and mixture of experts for intrusion detection in 5G networks and beyond.

Ilias L, Doukas G, Lamprou V, Ntanos C, Askounis D. *Front Artif Intell*. 2025;8:1708953.

The advent of 6G/NextG networks offers numerous benefits, including extreme capacity, reliability, and efficiency. To mitigate emerging security threats, 6G/NextG networks incorporate advanced artificial intelligence algorithms. However, existing studies on intrusion detection predominantly rely on deep neural networks with static components that are not conditionally dependent on the input, thereby limiting their representational power and efficiency. To address these issues, we present the first study to integrate a Mixture of Experts (MoE) architecture for the identification of malicious traffic. Specifically, we use network traffic data and convert the 1D feature array into a 2D matrix. Next, we pass this matrix through a convolutional neural network (CNN) layer, followed by batch normalization and max pooling layers. Subsequently, a sparsely gated MoE layer is used. This layer consists of a set of expert networks (dense layers) and a router that assigns weights to each expert's output. Sparsity is achieved by selecting only the most relevant experts from the full set. Finally, we conduct a series of ablation experiments to demonstrate the effectiveness of our proposed model. Experiments are conducted on the 5G-NIDD dataset, a network intrusion detection dataset generated from a real 5G test network, and the NANCY dataset, which includes cyberattacks from the O-RAN 5G Testbed Dataset. The results show that our introduced approach achieves accuracies of up to 99.96% and 79.59% on the 5G-NIDD and NANCY datasets, respectively. The findings also show that our proposed model offers multiple advantages over state-of-the-art approaches.

Lien vers l'article

On Multi-Parameter Optimization and Proactive Reliability in 5G and Beyond Cellular Networks.

Ijaz A, Raza W, Riaz S, Imran A. *Sensors (Basel)*. 2025 Dec 17;25(24).

Ultra-dense heterogeneous cellular networks in 6G and beyond face an escalating vulnerability to cell outages stemming from complex issues like parameter misconfigurations, hidden conflicts among

Autonomous Network Functions (ANFs), multivendor incompatibility, and software/hardware failures. While ANF-based automated fault detection is a core capability for next-generation networks, existing solutions are predominantly reactive, identifying faults only after reliability is compromised. To overcome this critical limitation and maintain high service quality, a proactive fault prediction capability is essential. We introduce a novel Discrete-Time Markov Chain (DTMC)-based stochastic framework designed to model network reliability dynamics. This framework forecasts the transition of a cell from normal operation to suboptimal or degraded states, offering a crucial shift from reactive to proactive fault management. Our model rigorously quantifies the effects of fault arrivals, estimates the fraction of time the network remains degraded, and, uniquely, identifies sensitive parameters whose misconfigurations pose the most significant threat to performance. Numerical evaluations demonstrate the model's high applicability in accurately predicting both the timing and probable causes of faults. By enabling true anticipation and mitigation, this framework is a key enabler for significantly reducing the cell outage time and enhancing the reliability and resilience of next-generation wireless networks.

Lien vers l'article

Neural Network-Based Adaptive Resource Allocation for 5G Heterogeneous Ultra-Dense Networks.

Alhazmi AS, Arafah MA. *Sensors (Basel)*. 2025 Dec 11;25(24).

Increasing spectral bandwidth in 5G networks improves capacity but cannot fully address the heterogeneous and rapidly growing traffic demands. Heterogeneous ultra-dense networks (HUDNs) play a key role in offloading traffic across multi-tier deployments; however, their diverse base-station characteristics and diverse quality-of-service (QoS) requirements make resource allocation highly challenging. Traditional static resource-allocation approaches lack flexibility and often lead to inefficient spectrum utilization in such complex environments. This study aims to develop a joint user association-resource allocation (UA-RA) framework for 5G HUDNs that dynamically adapts to real-time network conditions to improve spectral efficiency and service ratio under high traffic loads. A software-defined networking controller centrally manages the UA-RA process by coordinating inter-cell resource redistribution through the lending of underutilized resource blocks between macro and small cells, mitigating repeated congestion. To further enhance adaptability, a neural network-adaptive resource allocation (NN-ARA) model is trained on UA-RA-driven simulation data to approximate efficient allocation decisions with low computational cost. A real-world evaluation is conducted using the downtown Los Angeles deployment. For performance validation, the proposed NN-ARA approach is compared with two representative baselines from the literature (Bouras et al. and Al-Ali et al.). Results show that NN-ARA achieves up to 20.8% and 11% higher downlink data rates in the macro and small tiers, respectively, and improves spectral efficiency by approximately 20.7% and 11.1%. It additionally reduces the average blocking ratio by up to 55%. These findings demonstrate that NN-ARA provides an adaptive, scalable, and SDN-coordinated solution for efficient spectrum utilization and service continuity in 5G and future 6G HUDNs.

Lien vers l'article

Efficacité énergétique

Aucun article dans ce bulletin.

Autres équipements

Aucun article dans ce bulletin.

Applications industrielles

Aucun article dans ce bulletin.

Applications médicales

Application of 5G technology in remote robotic surgery: a comprehensive assessment of system architecture, clinical benefits, and future challenges.

Li S, Bai X, Wang T, Wang T, Hu X, Duan B. *J Robot Surg*. 2026 Jan 12;20(1):168.

This narrative review synthesizes global advances is paving the way for remote robotic surgery (telerobotic surgery), enabling surgeons to perform precise procedures over long distances with real-time responsiveness. This review synthesizes global advances in this field, outlining the system architecture and discussing reported clinical outcomes from early series-such as reduced intraoperative blood loss and shorter hospital stays, as illustrated by preliminary clinical series, such as 29 successful remote nephrectomies over 1,775 km reported in a selected patient cohort with no major complications in the short term. Key milestones are highlighted, from early transatlantic experiments to recent ultra-long-range procedures in China. The technology also demonstrates transformative potential for surgical training and optimized resource allocation via hub-and-spoke models. However, current applications remain largely experimental, constrained by small sample sizes, a scarcity of rigorous randomized controlled trials (RCTs), and limited long-term data. Significant challenges persist, including network latency and instability-especially beyond 200 ms, which can impair precision-cybersecurity vulnerabilities, a steep surgeon learning curve, high costs, and unresolved ethical-legal concerns regarding liability and cross-border practice. As a cornerstone of digital healthcare, 5G telerobotic surgery holds substantial promise for expanding global access to expert surgical care, provided these technical, economic, and regulatory barriers can be overcome through collaborative standardization and targeted innovation.

Lien vers l'article

Safety and feasibility of robot-assisted remote radical gastrectomy for gastric cancer based on 5G communication technology (FUTURE-04): a prospective, single-arm clinical trial.

Guo H, Tian Y, Ding P, Yang J, Yang P, He J, et al. *Gastric Cancer*. 2026 Jan;29(1):238-49.

BACKGROUND: Telesurgery is gaining traction across surgical specialties. However, its use in radical gastrectomy for gastric cancer remains limited. This study evaluated the safety and feasibility of fifth-generation (5G) robot-assisted remote radical gastrectomy using the Toumai Endoscopic Surgery Robotic System. METHODS: In this prospective single-center single-arm clinical study, eligible patients underwent 5G remote radical gastrectomy over a distance of 15 km. The primary outcome was the incidence of intraoperative and postoperative complications. Secondary outcomes included surgical completion rate, operative duration, estimated blood loss, number of lymph nodes dissected, time to first flatus and diet, and hospital stay. RESULTS: Twenty-seven patients were enrolled between

September and December 2023. All surgeries were completed successfully, with no conversion and a 100% R0 resection rate. No intraoperative complications occurred. Postoperative complications occurred in 18.5% of patients, with no Clavien-Dindo grade ≥ III. The mean operative time was 192.6 ± 34.8 min, and mean blood loss was 35.9 ± 15.9 mL. Lymph nodes were dissected at an average of 38.4 ± 13.2 lymph nodes. Median time to first flatus and oral intake was 2.0 days, to liquid diet was 4.0 days, and hospital stay was 7.0 days. The 5G network was highly stable, with total delay of 226.2 ± 4.4 ms, round-trip delay of 31.6 ± 3.8 ms, and packet loss < 0.1%. CONCLUSIONS: The 5G robot-assisted remote radical gastrectomy using the Toumai system is safe and feasible for selected patients with gastric cancer. The integration of 5G and robotics may offer a promising telemedicine approach to surgical oncology.

Lien vers l'article

Evaluation (Mesure des niveaux d'exposition)

Méthodes d'évaluation

Aucun article dans ce bulletin.

Evaluation population générale

Aucun article dans ce bulletin.

Risques professionnels

Aucun article dans ce bulletin.

Effets biologiques et sur la santé

In silico

Aucun article dans ce bulletin.

In vitro

Aucun article dans ce bulletin.

Sur l'animal

Ameliorative Role of Coenzyme Q10 in RF Radiation-Associated Testicular and Oxidative Impairments in a 3.5-GHz Exposure Model.

Bektas H, Yildirim S, Cakir S, Dogu S, Altindag F. *Bioelectromagnetics*. 2026 Jan;47(1):e70043.

This study investigated the biological effects of GSM-modulated 3.5 GHz radiofrequency (RF) electromagnetic field exposure on male reproductive function and evaluated the potential protective role of Coenzyme Q10 (CoQ10). Twenty-eight adult male Wistar rats were allocated into four groups: Control, RF, CoQ10, and RF + CoQ10. Animals were exposed to RF for 2 h/day over 30 days, while CoQ10 was administered intraperitoneally at 10 mg/kg/day. Hormonal (testosterone, LH, FSH), biochemical (MDA, GSH, TAS, TOS), and histopathological assessments were performed. Specific absorption rate (SAR) simulations estimated a whole-body SAR of 0.16995 W/kg and a testis-specific SAR of 0.02669 W/kg. RF exposure significantly reduced testosterone, LH, and FSH levels, increased MDA and TOS concentrations, and induced degenerative changes in testicular histology. CoQ10 treatment partially ameliorated these alterations by restoring testosterone and TAS levels and reducing tissue damage. These results indicate that even low-SAR GSM-modulated 3.5 GHz RF exposure may negatively impact male reproductive health, and CoQ10 supplementation may confer partial protective effects. Because the exposure consisted of a GSM-modulated waveform, the results cannot be extrapolated to FR1 5G NR signals used in real communication systems. Further studies are needed to clarify mechanisms and assess biological relevance under real-world exposure conditions. Bioelectromagnetics. 00:00-00, 2026.

Lien vers l'article

Doxorubicin-induced cardiotoxicity under 28 GHz 5G-band electromagnetic radiation in rats: Insights into the mitigative role of vitamin C.

Rahimi A, Rafati A, Mortazavi SMJ, Edalat F, Jooyan N, Naseh M, et al. *Toxicol Appl Pharmacol*. 2026 Feb;507:117703.

Doxorubicin (DOX), an effective anthracycline chemotherapeutic agent, induces cardiotoxicity through oxidative stress, mitochondrial dysfunction, and activation of apoptotic pathways. As millimeter-wave frequencies used in fifth-generation (5G) communication systems continue to expand, experimental data on potential biological interactions under clinically relevant conditions remain limited. This study investigated whether short-term 28-GHz electromagnetic radiation (EMR) modifies the cardiac response to DOX and evaluated the potential protective role of vitamin C. Thirty male Sprague-Dawley rats were assigned to five groups (n = 6): Sham, DOX, DOX + Vit C, DOX + 5G, and DOX + 5G + Vit C. DOX (15 mg/kg intraperitoneally, six injections) induced cardiotoxicity, while vitamin C (250 mg/kg orally) was administered daily for 14 days. EMR exposure consisted of three 10-min cycles per day at 28 GHz for 14 days. Cardiac injury was assessed using electrocardiography, serum cTnI, oxidative markers (MDA, GSH, SOD, CAT), apoptotic and inflammatory gene expression (BAX, CASP3, BCL-2, TNF-α), and design-based stereology. DOX induced significant functional, biochemical, molecular, and structural alterations. Co-exposure to 28-GHz EMR amplified reductions in CAT ($p < 0.001$), and enhanced pro-apoptotic BAX gene expression ($p < 0.0001$), accompanied by QT interval prolongation ($p < 0.05$). Vitamin C provided partial protection across these endpoints. Under the specific short-term pre-clinical conditions tested, these findings indicate that 28-GHz EMR can modulate the severity of DOX-induced cardiotoxicity, while vitamin C confers modest attenuation. Further long-term and clinical studies are needed to clarify mechanisms and refine translational relevance.

Lien vers l'article

Sur l'homme

No measurable impact of acute 26 GHz 5G exposure on salivary stress markers in healthy adults.

Michelant L, Hugueville L, Lévêque P, Selmaoui B. *Environ Res*. 2026 Feb 1;290:123439.

The rapid deployment of fifth generation (5G) wireless networks has raised concerns about potential health effects associated with exposure to novel radiofrequency electromagnetic field (RF) frequencies, particularly the 26 GHz band which represents a new exposure scenario for the general population with limited prior use in telecommunications. However, evidence regarding the acute biological impact of these exposures remains limited and inconclusive. This study aimed to assess whether short-term exposure (26.5 min) of healthy adults to 5G RF at 26 GHz, at levels representative of real-world environmental conditions, affects salivary cortisol and alpha-amylase, two established biomarkers of stress and autonomic nervous system activity. Thirty-one participants completed a triple-blind, randomized protocol with electroencephalography recordings. A subset of sixteen participants from this group also participated in an exploratory protocol with cognitive testing and higher temporal sampling resolution (5 min intervals). Saliva samples were collected before, during, and after exposure in both protocols. RF exposure was delivered via a horn antenna at 2 V/m (head) and 1 V/m (torso), in line with upper-range environmental measurements. Statistical analyses revealed no significant differences in salivary cortisol or alpha-amylase concentrations between real and sham exposures. Descriptive examination of the exploratory cognitive protocol, with higher temporal sampling resolution, showed consistent temporal stability of both biomarkers in both conditions. These findings suggest that acute 5G RF exposure at 26 GHz, under controlled and realistic conditions,

does not elicit measurable changes in stress biomarkers. Further research is warranted to evaluate the effects of repeated or long-term exposures and to investigate potential impacts in vulnerable populations.

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Reproduction

Ameliorative Role of Coenzyme Q10 in RF Radiation-Associated Testicular and Oxidative Impairments in a 3.5-GHz Exposure Model.

Bektas H, Yildirim S, Cakir S, Dogu S, Altindag F. *Bioelectromagnetics*. 2026 Jan;47(1):e70043.

This study investigated the biological effects of GSM-modulated 3.5 GHz radiofrequency (RF) electromagnetic field exposure on male reproductive function and evaluated the potential protective role of Coenzyme Q10 (CoQ10). Twenty-eight adult male Wistar rats were allocated into four groups: Control, RF, CoQ10, and RF + CoQ10. Animals were exposed to RF for 2 h/day over 30 days, while CoQ10 was administered intraperitoneally at 10 mg/kg/day. Hormonal (testosterone, LH, FSH), biochemical (MDA, GSH, TAS, TOS), and histopathological assessments were performed. Specific absorption rate (SAR) simulations estimated a whole-body SAR of 0.16995 W/kg and a testis-specific SAR of 0.02669 W/kg. RF exposure significantly reduced testosterone, LH, and FSH levels, increased MDA and TOS concentrations, and induced degenerative changes in testicular histology. CoQ10 treatment partially ameliorated these alterations by restoring testosterone and TAS levels and reducing tissue damage. These results indicate that even low-SAR GSM-modulated 3.5 GHz RF exposure may negatively impact male reproductive health, and CoQ10 supplementation may confer partial protective effects. Because the exposure consisted of a GSM-modulated waveform, the results cannot be extrapolated to FR1 5G NR signals used in real communication systems. Further studies are needed to clarify mechanisms and assess biological relevance under real-world exposure conditions. Bioelectromagnetics. 00:00-00, 2026. © 2026 Bioelectromagnetics Society.

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