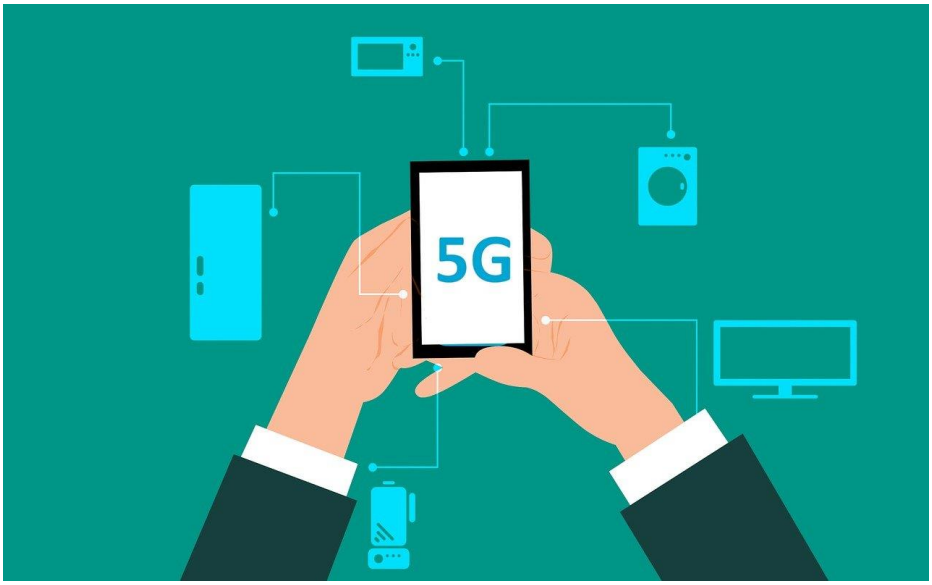
TECHNOLOGIE 5G

Bulletin de veille scientifique : Décembre 2024



Objectifs : réaliser une veille scientifique sur la technologie 5G

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Généralités

The risk spillover between geopolitical risk and China's 5G, semiconductor and rare earth industries.

Huang Q, Wang B, Lin J. *Heliyon*. 2024 Nov 30;10(22):e40048.

Spillover effect refers to the phenomenon that when an economic entity, industry or market encounters a change or shock, its impact is transmitted to other entities, industries or markets. In recent years, 5G, semiconductors and rare earths have successively become geopolitical battlegrounds. In this paper, sparrow search algorithm was used to optimize the parameters of variational mode decomposition (VMD), then use the optimized VMD to decompose the geopolitical risk (GPR), 5G, semiconductor and rare earth time series data, and exploit fuzzy c-means clustering algorithm to obtain low-frequency and high-frequency time series. Finally we investigated the connectedness between GPR and China's 5G, semiconductor, and rare earth industries based on TVP-VAR model in different cycles, as well as between these industries. The findings reveal that there exists risk spillover between GPR and the three industries, which is significantly enhanced under the impact of geopolitical events. In addition, there is heterogeneity in the risk spillover between GPR and these three industries in different cycles. Notably, in the short term, the GPR is the main source of risk, and in the long term, the semiconductor industry has the great impact on GPR, 5G and rare earth industries, indicating that the semiconductor industry has very important geopolitical significance.

Lien vers l'article

Microwave radiofrequencies, 5G, 6G, graphene nanomaterials: Technologies used in neurological warfare.

Deruelle F. *Surg Neurol Int*. 2024;15:439.

BACKGROUND: Scientific literature, with no conflicts of interest, shows that even below the limits defined by the International Commission on Non-Ionizing Radiation Protection, microwaves from telecommunication technologies cause numerous health effects: neurological, oxidative stress, carcinogenicity, deoxyribonucleic acid and immune system damage, electro-hypersensitivity. The majority of these biological effects of non-thermal microwave radiation have been known since the 1970s. METHODS: Detailed scientific, political, and military documents were analyzed. Most of the scientific literature comes from PubMed. The other articles (except for a few) come from impacted journals . The rare scientific documents that were not peer reviewed were produced by recognized scientists in their fields. The rest of the documentation comes from official sources: political (e.g., European Union and World Health Organization), military (e.g., US Air Force and NATO), patents, and national newspapers. RESULTS: (1) Since their emergence, the authorities have deployed and encouraged the use of wireless technologies (2G, 3G, 4G, WiFi, WiMAX, DECT, Bluetooth, cell phone towers/masts/base stations, small cells, etc.) in full awareness of their harmful effects on health. (2) Consequences of microwave radiation from communication networks are comparable to the effects of low-power directed-energy microwave weapons, whose objectives include behavioral modification through neurological (brain) targeting. Above 20 gigahertz, 5G behaves like an unconventional chemical weapon. (3) Biomedical engineering (via graphene-based nanomaterials) will enable brain-computer connections, linked wirelessly to the Internet of Everything through 5G and 6G networks (2030) and artificial intelligence, gradually leading to human-machine fusion (cyborg) before the 2050s. CONCLUSION: Despite reports and statements from the authorities presenting the constant deployment of new wireless communication technologies, as well as medical research into nanomaterials, as society's ideal future, in-depth research into these scientific fields shows, above all,

an objective linked to the current cognitive war. It could be hypothesized that, in the future, this aim will correspond to the control of humanity by machines.

Lien vers l'article

Use of Mobile Phones and Radiofrequency-Emitting Devices in the COSMOS-France Cohort.

Deltour I, Guida F, Ribet C, Zins M, Goldberg M, Schüz J. *Int J Environ Res Public Health*. 2024 Nov 14;21(11).

COSMOS-France is the French part of the COSMOS project, an international prospective cohort study that investigates whether the use of mobile phones and other wireless technologies is associated with health effects and symptoms (cancers, cardiovascular diseases, neurologic pathologies, tinnitus, headaches, or sleep and mood disturbances). Here, we provide the first descriptive results of COSMOS-France, a cohort nested in the general population-based cohort of adults named Constances. METHODS: A total of 39,284 Constances volunteers were invited to participate in the COSMOS-France study during the pilot (2017) and main recruitment phase (2019). Participants were asked to complete detailed questionnaires on their mobile phone use, health conditions, and personal characteristics. We examined the association between mobile phone use, including usage for calls and Voice over Internet Protocol (VoIP), cordless phone use, and Wi-Fi usage with age, sex, education, smoking status, body mass index (BMI), and handedness. RESULTS: The participation rate was 48.4%, resulting in 18,502 questionnaires in the analyzed dataset. Mobile phone use was reported by 96.1% (N = 17,782). Users reported typically calling 5-29 min per week (37.1%, N = 6600), making one to four calls per day (52.9%, N = 9408), using one phone (83.9%, N = 14,921) and not sharing it (80.4% N = 14,295), mostly using the phone on the side of the head of their dominant hand (59.1%, N = 10,300), not using loudspeakers or hands-free kits, and not using VoIP (84.9% N = 15,088). Individuals' age and sex modified this picture, sometimes markedly. Education and smoking status were associated with ever use and call duration, but neither BMI nor handedness was. Cordless phone use was reported by 66.0% of the population, and Wi-Fi use was reported by 88.4%. CONCLUSION: In this cross-sectional presentation of contemporary mobile phone usage in France, age and sex were important determinants of use patterns.

Lien vers l'article

Performances et sécurité

5G-based collaborative trajectory following modeling and enhancement in connected and automated airspace environment.

Huang X, Tian Y, Zhang N, Sun M, Li Z, Li J. *iScience*. 2024 Dec 20;27(12):111361.

In an emerging trajectory-based operation (TBO) environment within the advanced autonomous airspace, traffic operation along reference trajectories can function as trajectory-following mechanisms. However, 5G-based following dynamics still remain underexplored, limiting further utilization of lower-latency 5G technology other than data links. This limitation affects air traffic stability when encountering disturbance, preventing autonomous airspeed adjustment, and safe separation without air traffic controller interventions. Thus, this paper addresses these gaps by proposing a generalized 5G-based trajectory-following model to explore microscopic behaviors and traffic stability in a typically connected environment. Three key variables are identified based on the classical optimal velocity model: bi-directional attention distribution, air-to-air communication performance, and communication latency. Finally, the stability criterion is derived by the adopted perturbation method. Typical numerical simulations have verified the air traffic stability under various connectivity degrees. These findings can precisely identify the optimal connectivity, rational attention distribution, and their balance for enhancing stability.

Lien vers l'article

Optimizing 5G network performance with dynamic resource allocation, robust encryption and Quality of Service (QoS) enhancement.

Alashjaee AM, Kushwaha S, Alamro H, Hassan AA, Alanazi F, Mohamed A. *PeerJ Comput Sci*. 2024;10:e2567.

The International Telecommunication Union (ITU) predicts a substantial and swift increase in global mobile data traffic. The predictions suggest that this growth will vary from 390 EB (exabytes) to 5,016 EB (exabytes) from 2024 to 2030, accordingly. This work presents a new maximum capacity model (MCM) to improve the dynamic resource allocation, robust encryption, and Quality of Service (QoS) in 5G networks which helps to meet the growing need for high-bandwidth applications such as Voice over Internet Protocol (VoIP) and video streaming. Our proposed MCM model enhances data transmission by employing dynamic resource allocation, prioritised traffic management, and robust end-to-end encryption techniques, thereby guaranteeing efficient and safe data delivery. The encryption procedure is applied to the header cypher, while the output parameters of the payload are altered. This indicates that only the sender and recipient will possess exclusive knowledge of the final outcome. In result, the comparative analyses clearly show that the MCM model outperforms over conventional models in terms of QoS packet planner, QoS packet scheduler, standard packet selection, traffic management, maximum data rate, and bandwidth utilisation.

Lien vers l'article

Design and Fabrication of a Patch Antenna for 5G Wireless Communications from a Low-Permittivity LiAlSi(2)O(6)-Based Ceramic.

Xiong S, Zhu X, Zhu G, Chen D, Cui H, Liu L, et al. *ACS Appl Mater Interfaces*. 2025 Jan 8;17(1):1576-85.

A microwave dielectric ceramic based on lithium aluminum silicate (LiAlSi(2)O(6)) with ultralow permittivity was synthesized using the traditional solid-state reaction technique, and its dielectric characteristics at microwave frequencies are presented. The nominal LiAlSi(2)O(6) ceramic exhibited a relative permittivity of 3.95. To enhance the material properties, LiAlSi(2)O(6)-x wt % B(2)O(3) microwave dielectric ceramics were fabricated by incorporating a low-melting-point sintering aid (B(2)O(3)), achieving a relative density exceeding 94%. The resultant ceramics exhibited a relative permittivity (ε(r)) ranging from 3.95 to 4.42, a microwave quality factor (Q × f) between 24,720 and 28,990 GHz, and a resonant frequency temperature coefficient (τ(f)) varying from -45.9 to -20.6 ppm/°C. Additionally, the introduction of B(2)O(3) broadened the sintering temperature window and effectively lowered the optimal sintering temperature from 1400 to 1200 °C. Furthermore, LiAlSi(2)O(6) ceramics demonstrated a near-zero coefficient of thermal expansion (CTE) of 1.44 ppm/°C, which is advantageous for applications requiring high thermal stability. Based on LiAlSi(2)O(6)-2.0 wt % B(2)O(3) ceramics with ε(r) = 4.42, Q × f = 28,990 GHz, and τ(f) = -20.6 ppm/°C, a microstrip patch antenna was designed and fabricated. Testing of the antenna revealed exceptional performance, including a center frequency of 4.98 GHz, a bandwidth of 280 MHz (-10 dB), and a total efficiency reaching up to 93.7%. These findings underscore the promising potential of this material in advanced microwave and wireless communication applications.

Lien vers l'article

A Compact Ultra-Wideband Millimeter-Wave Four-Port Multiple-Input Multiple-Output Antenna for 5G Internet of Things Applications.

Sharma A, Sharma S, Sharma V, Wadhwa G, Kumar R. *Sensors (Basel)*. 2024 Nov 7;24(22).

This paper presents a compact design for a four-element multiple-input multiple-output (MIMO) antenna for millimeter-wave (mmWave) communications covering the bands of n257/n258/n261. The MIMO design covers the frequency range of 24.25-29.5 GHz, with a wide bandwidth of 5.25 GHz. The element of the MIMO antenna structure uses a single circular patch with an inset feed, and, in order to improve the reflection coefficient (S(11)), a half-disk parasitic patch is positioned on top of the circular patch. Moreover, to fine-tune the antenna's characteristics, two vertical stubs on the extreme ends of the ground plane are introduced. For this design, a Rogers RT/Duroid 5880 substrate with ultra-thin thickness is used. After the optimization of the design, the four-port MIMO antenna attained a tiny size, with the dimensions 16.2 mm × 16.2 mm × 0.254 mm. In terms of the MIMO parameters, the ECC (Envelop Correlation coefficient) is less than 0.002 and the DG (Diversity Gain) is greater than 9.99 dB in the mentioned band, which are within the tolerance limits. Also, in spite of the very small size and the four-port configuration, the achieved isolation between the neighboring MIMO elements is less than -23.5 dB.

Lien vers l'article

Architecture réseau

Aucun article dans ce bulletin.

Efficacité énergétique

Energy Efficiency for 5G and Beyond 5G: Potential, Limitations, and Future Directions.

Ichimescu A, Popescu N, Popovici EC, Toma A. *Sensors (Basel)*. 2024 Nov 20;24(22).

Energy efficiency constitutes a pivotal performance indicator for 5G New Radio (NR) networks and beyond, and achieving optimal efficiency necessitates the meticulous consideration of trade-offs against other performance parameters, including latency, throughput, connection densities, and reliability. Energy efficiency assumes it is of paramount importance for both User Equipment (UE) to achieve battery prologue and base stations to achieve savings in power and operation cost. This paper presents an exhaustive review of power-saving research conducted for 5G and beyond 5G networks in recent years, elucidating the advantages, disadvantages, and key characteristics of each technique. Reinforcement learning, heuristic algorithms, genetic algorithms, Markov Decision Processes, and the hybridization of various standard algorithms inherent to 5G and 5G NR represent a subset of the available solutions that shall undergo scrutiny. In the final chapters, this work identifies key limitations, namely, computational expense, deployment complexity, and scalability constraints, and proposes a future research direction by theoretically exploring online learning, the clustering of the network base station, and hard HO to lower the consumption of networks like 2G or 4G. In lowering carbon emissions and lowering OPEX, these three additional features could help mobile network operators achieve their targets.

Lien vers l'article

Autres équipements

Aucun article dans ce bulletin.

Applications médicales et industrielles de la 5G

Applications industrielles

Aucun article dans ce bulletin.

Applications médicales

Letter to the Editor on "Application of 5G Remote Robotic-Assisted Laparoscopy in Urological Surgery: A Small Sample Analysis".

Feng F, Xu Z. *Urology*. 2024 Dec 4.

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

Occupational exposure to radiofrequency electromagnetic fields and brain tumor risk: Application of the INTEROCC job-exposure matrix.

Turuban M, Kromhout H, Vila J, Vallbona-Vistós M, De Vocht F, Baldi I, et al. *Int J Cancer*. 2025 Feb 1;156(3):538-51.

Radiofrequency electromagnetic fields (RF-EMF, 100 kHz to 300 GHz) are classified by IARC as possibly carcinogenic to humans (Group 2B). This study evaluates the potential association between occupational RF-EMF exposure and brain tumor risk, utilizing for the first time, a RF-EMF job-exposure matrix (RF-JEM) developed in the multi-country INTEROCC case-control study. Cumulative and time-weighted average (TWA) occupational RF-EMF exposures were estimated for study participants based on lifetime job histories linked to the RF-JEM using three different methods: (1) by considering RF-EMF intensity among all exposed jobs, (2) by considering RF-EMF intensity among jobs with an exposure prevalence ≥ the median exposure prevalence of all exposed jobs, and (3) by considering RF-EMF intensity of jobs of participants who reported RF-EMF source use. Stratified conditional logistic regression models were used, considering various lag periods and exposure time windows defined a priori. Generally, no clear associations were found for glioma or meningioma risk. However, some statistically significant positive associations were observed including in the highest exposure categories for glioma for cumulative and TWA exposure in the 1- to 4-year time window for electric fields (E) in the first JEM application method (odds ratios [ORs] = 1.36, 95% confidence interval [95% CI] 1.08, 1.72 and 1.27, 95% CI 1.01, 1.59, respectively), as well as for meningioma for cumulative exposure in the 5- to 9-year time window for electric fields (E) in the third JEM application method (OR = 2.30, 95% CI 1.11, 4.78). We did not identify convincing associations between occupational RF-EMF exposure and risk of glioma or meningioma.

Lien vers l'article

In silico

Aucun article dans ce bulletin.

In vitro

The effects of radiofrequency electromagnetic field exposure on biomarkers of oxidative stress in vivo and in vitro: A systematic review of experimental studies.

Meyer F, Bitsch A, Forman HJ, Fragoulis A, Ghezzi P, Henschenmacher B, et al. *Environ Int*. 2024 Dec;194:108940.

BACKGROUND: Oxidative stress is thought to be related to many diseases. Furthermore, it is hypothesized that radiofrequency electromagnetic fields (RF-EMF) may induce excessive oxidative stress in various cell types and thereby have the potential to compromise human and animal health. The objective of this systematic review (SR) is to summarize and evaluate the literature on the relation between the exposure to RF-EMF in the frequency range from 100 kHz to 300 GHz and biomarkers of oxidative stress. METHODS: The SR framework was developed following the guidelines established in the WHO Handbook for Guideline Development and NTP/OHAT's Handbook for Conducting a Literature-Based Health Assessment. We used the latter handbook's methodology for implementing the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach for environmental health assessments. We searched the following databases up until June 30, 2023: PubMed, Embase, Web of Science Core Collection, Scopus, and the EMF-Portal. The reference lists of included studies and retrieved review articles were also manually searched. We rated Risk of Bias (RoB) using the OHAT RoB Rating Tool and assessed publication bias using funnel plots of included studies. We assessed the certainty of the evidence (high, moderate, low, or very low) for an association between RF-EMF and oxidative stress using an adapted version of the GRADE framework. Data were extracted according to a predefined set of forms developed in DistillerSR. Data were analysed after grouping them first as in vitro or in vivo and then according to outcome category, species category, and exposed tissue. We synthesized study results using a random effects meta-analysis when study characteristics were judged sufficiently similar to be combined and heterogeneity (I(2)) was lower than 75 %, otherwise we describe the findings narratively. RESULTS: Fifty-six (56) studies, 45 in vivo and 11 in vitro, in which cells (in vitro) or animals (in vivo) were exposed to frequencies in the range 800-2450 MHz, were included in the systematic review after eliminating 12,353 publications because they did not meet the criteria defined in the published protocol (Henschenmacher et al., 2022). Of 56 studies 52 studies with 169 individual results were included in the meta-analysis. Together, these studies examined six human in vitro samples and fifty animal samples, including rodents (mice, rats, hamsters, and guinea pigs, (n = 46)) and rabbits (n = 4). RF-EMF were predominantly applied as continuous wave exposures in these studies. The outcome biomarkers for modified proteins and amino acids were measured in n = 30 studies, for oxidized DNA bases in n = 26 studies, for oxidized lipids in n = 3 studies and hydrogen peroxide production in 2 studies. Outcomes were mostly measured in the brain (n = 22), liver (n = 9), cells (n = 9), blood (n = 6), and testis (n = 2). RoB in studies was high, mainly due to biases in exposure and outcome assessment. IN VIVO STUDIES: Brain: The effect on biomarkers for oxidized DNA bases in the rodent brain (five studies, n = 98) had an inconsistent effect, varying from a large decrease with a standardized mean difference (SMD) of -3.40 (95 % CI [-5.15, -1.64]) to a large increase

with an SMD of 2.2 (95 % CI [0.78, 3.62]). In the brain of rabbits (two studies, n = 44), the effect sizes also varied, from an SMD of -1.06 (95 % CI [-2.13, 0.00]) to an SMD of 5.94 (95 % CI [3.14, 8.73]). The effect on biomarkers for modified proteins and amino acids in the rodent brain (15 studies, n = 328) also varied from a large decrease with an SMD of -6.11 (95 % CI [-8.16, -4.06]) to a large increase with an SMD of 5.33 (95 % CI [2.49, 8.17]). The effect on biomarkers for oxidized lipids in the brain of rodents (one study, n = 56) also varied from a large decrease with SMD = -4.10 (95 % CI [-5.48, -2.73]) to SMD = 1.27 (95 % CI [0.45, 2.10]). Liver: The effect on biomarkers for oxidized DNA bases in the rodent liver (two studies, n = 26) was inconsistent with effect sizes in both directions: SMD = -0.71 (95 % CI [-1.80, 0.38]) and SMD = 1.56 (95 % CI [0.19, 2.92]). The effect on biomarkers for oxidized DNA bases in the rabbits' liver (two studies, n = 60) was medium with a pooled SMD of 0.39 (95 % CI [-0.79, 1.56]). Biomarkers for modified proteins and amino acids in the liver of rodents (six studies, n = 159) increased with a pooled SMD of 0.55 (95 % CI [0.06, 1.05]). Blood: The effect of RF-EMF on biomarkers for oxidized DNA bases in rodent blood (four studies, n = 104) was inconsistent, with SMDs ranging from -1.14 (95 % CI [-2.23, -0.06]) to 1.71 (95 % CI [-0.10, 3.53]). RF-EMF had no effect on biomarkers for modified proteins and amino acids in rodent blood (three studies, n = 40), with a pooled SMD of -0.08 (95 % CI [-1.32, 1.16]). There was a large increase in biomarkers for oxidized DNA bases in rodent plasma (two studies, n = 38) with a pooled SMD of 2.25 (95 % CI [1.27, 3.24]). Gonads: There was an increase in biomarkers for oxidized DNA bases in the rodent testis (two studies, n = 24) with a pooled SMD of 1.60 (95 % CI [0.62, 2.59]). The effect of RF-EMF on biomarkers for modified proteins and amino acids in the ovary of rodents (two studies, n = 52) was inconsistent with a medium effect, SMD = 0.24 (95 % CI [-0.74, 1.23])) and a large effect (SMD = 2.08 (95 % CI [1.22, 2.94])). Thymus: RF-EMF increased biomarkers for modified proteins and amino acids in the thymus of rodents (one study, n = 42) considerably with a pooled SMD of 6.16 (95 % CI [3.55, 8.76]). Cells: RF-EMF increased oxidized DNA bases in rodent cells with SMD of 2.49 (95 % CI [1.30, 3.67]) (one study, n = 27). There was a medium effect in oxidized lipids (one study, n = 18) but not statistically significant with SMD = 0.34 (95 % CI [-0.62, 1.29]). IN VITRO STUDIES: In in vitro studies in human cells (three studies, n = 110), there were inconsistent increases in biomarkers for oxidized DNA bases, where the SMDs varied between 0.01 (95 % CI [-0.59, 0.62]) and 7.12 (95% CI [0.06, 14.18]) in 4 results (2 of them statistically significant). In rodent cells (three studies, n = 24), there was a not statistically significant large effect in biomarkers for oxidized DNA bases with SMD = 2.07 (95 % CI [-1.38, 5.52]). The RF-EMF biomarkers for modified proteins and amino acids in human cells (one study, n = 18) showed a large effect with SMD = 1.07 (95 % CI [-0.05, 2.19]). In rodent cells (two studies, n = 24) a medium effect of SMD = 0.56 (95 % CI [-0.29, 1.41]) was observed. DISCUSSION: The evidence on the relation between the exposure to RF-EMF and biomarkers of oxidative stress was of very low certainty, because a majority of the included studies were rated with a high RoB level and provided high heterogeneity. This is due to inaccurate measurements of exposure and/or of measurement of oxidative stress biomarkers and missing information on the blinding of research personnel to exposure conditions or outcome measurements. There may be no or an inconsistent effect of RF-EMF on biomarkers of oxidative stress in the brain, liver, blood, plasma and serum, and in the female reproductive system in animal experiments but the evidence is of very low certainty. There may be an increase in biomarkers of oxidative stress in testes, serum and thymus of rodents but the evidence is of very low certainty. Future studies should improve experimental designs and characterization of exposure systems as well as the use of validated biomarker measurements with positive controls. Other: This review was partially funded by the World Health Organization. The protocol for this review is registered in PROSPERO (https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42021235573) and published in Environment International (https://doi.org/10.1016/j.envint.2021.106932) (Henschenmacher et al., 2022).

Lien vers l'article

Exposure to Radiofrequency Electromagnetic Fields Enhances Melanin Synthesis by Activating the P53 Signaling Pathway in Mel-Ab Melanocytes.

Kim JH, Kang DJ, Seok JY, Kim MH, Kim DS, Jeon SB, et al. *Int J Mol Sci*. 2024 Nov 20;25(22).

The skin is the largest body organ that can be physiologically affected by exposure to radiofrequency electromagnetic fields (RF-EMFs). We investigated the effect of RF-EMFs on melanogenesis; Mel-Ab melanocytes were exposed to 1760 MHz radiation with a specific absorption rate of 4.0 W/kg for 4 h/day over 4 days. Exposure to the RF-EMF led to skin pigmentation, with a significant increase in melanin production in Mel-Ab melanocytes. The phosphorylation level of cAMP response element binding protein (CREB) and the expression of microphthalmia-associated transcription factor (MITF), which regulate the expression of tyrosinase, were significantly increased in Mel-Ab after RF-EMF exposure. Interestingly, the expression of tyrosinase was significantly increased, but tyrosinase activity was unchanged in the RF-EMF-exposed Mel-Ab cells. Additionally, the expression of p53 and melanocortin 1 receptor (MC1R), which regulate MITF expression, was significantly increased. These results suggest that the RF-EMF induces melanogenesis by increasing phospho-CREB and MITF activity. Importantly, when Mel-Ab cells were incubated at 38 °C, the melanin production and the levels of tyrosinase significantly decreased, indicating that the increase in melanin synthesis by RF-EMF exposure is not due to a thermal effect. In conclusion, RF-EMF exposure induces melanogenesis in Mel-Ab cells through the increased expression of tyrosinase via the activation of MITF or the phosphorylation of CREB, which are initiated by the activation of p53 and MC1R.

Lien vers l'article

Sur l'animal

The effects of radiofrequency electromagnetic field exposure on biomarkers of oxidative stress in vivo and in vitro: A systematic review of experimental studies.

Meyer F, Bitsch A, Forman HJ, Fragoulis A, Ghezzi P, Henschenmacher B, et al. *Environ Int*. 2024 Dec;194:108940.

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characteristics were judged sufficiently similar to be combined and heterogeneity (I(2)) was lower than 75 %, otherwise we describe the findings narratively. RESULTS: Fifty-six (56) studies, 45 in vivo and 11 in vitro, in which cells (in vitro) or animals (in vivo) were exposed to frequencies in the range 800-2450 MHz, were included in the systematic review after eliminating 12,353 publications because they did not meet the criteria defined in the published protocol (Henschenmacher et al., 2022). Of 56 studies 52 studies with 169 individual results were included in the meta-analysis. Together, these studies examined six human in vitro samples and fifty animal samples, including rodents (mice, rats, hamsters, and guinea pigs, (n = 46)) and rabbits (n = 4). RF-EMF were predominantly applied as continuous wave exposures in these studies. The outcome biomarkers for modified proteins and amino acids were measured in n = 30 studies, for oxidized DNA bases in n = 26 studies, for oxidized lipids in n = 3 studies and hydrogen peroxide production in 2 studies. Outcomes were mostly measured in the brain (n = 22), liver (n = 9), cells (n = 9), blood (n = 6), and testis (n = 2). RoB in studies was high, mainly due to biases in exposure and outcome assessment. IN VIVO STUDIES: Brain: The effect on biomarkers for oxidized DNA bases in the rodent brain (five studies, n = 98) had an inconsistent effect, varying from a large decrease with a standardized mean difference (SMD) of -3.40 (95 % CI [-5.15, -1.64]) to a large increase with an SMD of 2.2 (95 % CI [0.78, 3.62]). In the brain of rabbits (two studies, n = 44), the effect sizes also varied, from an SMD of -1.06 (95 % CI [-2.13, 0.00]) to an SMD of 5.94 (95 % CI [3.14, 8.73]). The effect on biomarkers for modified proteins and amino acids in the rodent brain (15 studies, n = 328) also varied from a large decrease with an SMD of -6.11 (95 % CI [-8.16, -4.06]) to a large increase with an SMD of 5.33 (95 % CI [2.49, 8.17]). The effect on biomarkers for oxidized lipids in the brain of rodents (one study, n = 56) also varied from a large decrease with SMD = -4.10 (95 % CI [-5.48, -2.73]) to SMD = 1.27 (95 % CI [0.45, 2.10]). Liver: The effect on biomarkers for oxidized DNA bases in the rodent liver (two studies, n = 26) was inconsistent with effect sizes in both directions: SMD = -0.71 (95 % CI [-1.80, 0.38]) and SMD = 1.56 (95 % CI [0.19, 2.92]). The effect on biomarkers for oxidized DNA bases in the rabbits' liver (two studies, n = 60) was medium with a pooled SMD of 0.39 (95 % CI [-0.79, 1.56]). Biomarkers for modified proteins and amino acids in the liver of rodents (six studies, n = 159) increased with a pooled SMD of 0.55 (95 % CI [0.06, 1.05]). Blood: The effect of RF-EMF on biomarkers for oxidized DNA bases in rodent blood (four studies, n = 104) was inconsistent, with SMDs ranging from -1.14 (95 % CI [-2.23, -0.06]) to 1.71 (95 % CI [-0.10, 3.53]). RF-EMF had no effect on biomarkers for modified proteins and amino acids in rodent blood (three studies, n = 40), with a pooled SMD of -0.08 (95 % CI [-1.32, 1.16]). There was a large increase in biomarkers for oxidized DNA bases in rodent plasma (two studies, n = 38) with a pooled SMD of 2.25 (95 % CI [1.27, 3.24]). Gonads: There was an increase in biomarkers for oxidized DNA bases in the rodent testis (two studies, n = 24) with a pooled SMD of 1.60 (95 % CI [0.62, 2.59]). The effect of RF-EMF on biomarkers for modified proteins and amino acids in the ovary of rodents (two studies, n = 52) was inconsistent with a medium effect, SMD = 0.24 (95 % CI [-0.74, 1.23])) and a large effect (SMD = 2.08 (95 % CI [1.22, 2.94])). Thymus: RF-EMF increased biomarkers for modified proteins and amino acids in the thymus of rodents (one study, n = 42) considerably with a pooled SMD of 6.16 (95 % CI [3.55, 8.76]). Cells: RF-EMF increased oxidized DNA bases in rodent cells with SMD of 2.49 (95 % CI [1.30, 3.67]) (one study, n = 27). There was a medium effect in oxidized lipids (one study, n = 18) but not statistically significant with SMD = 0.34 (95 % CI [-0.62, 1.29]). IN VITRO STUDIES: In in vitro studies in human cells (three studies, n = 110), there were inconsistent increases in biomarkers for oxidized DNA bases, where the SMDs varied between 0.01 (95 % CI [-0.59, 0.62]) and 7.12 (95% CI [0.06, 14.18]) in 4 results (2 of them statistically significant). In rodent cells (three studies, n = 24), there was a not statistically significant large effect in biomarkers for oxidized DNA bases with SMD = 2.07 (95 % CI [-1.38, 5.52]). The RF-EMF biomarkers for modified proteins and amino acids in human cells (one study, n = 18) showed a large effect with SMD = 1.07 (95 % CI [-0.05, 2.19]). In rodent cells (two studies, n = 24) a medium effect of SMD = 0.56 (95 % CI [-0.29, 1.41]) was observed. DISCUSSION: The evidence on the relation between the exposure to RF-EMF and biomarkers of oxidative stress was of very low certainty, because a majority of the included studies were rated with a high RoB level and provided high heterogeneity. This is due to inaccurate measurements of exposure and/or of measurement of oxidative stress biomarkers and missing information on the blinding of research personnel to exposure conditions or outcome measurements.

There may be no or an inconsistent effect of RF-EMF on biomarkers of oxidative stress in the brain, liver, blood, plasma and serum, and in the female reproductive system in animal experiments but the evidence is of very low certainty. There may be an increase in biomarkers of oxidative stress in testes, serum and thymus of rodents but the evidence is of very low certainty. Future studies should improve experimental designs and characterization of exposure systems as well as the use of validated biomarker measurements with positive controls. Other: This review was partially funded by the World Health Organization. The protocol for this review is registered in PROSPERO (https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42021235573) and published in Environment International (https://doi.org/10.1016/j.envint.2021.106932) (Henschenmacher et al., 2022).

Lien vers l'article

Sur l'homme

Autonomous nervous system responses to environmental-level exposure to 5G's first deployed band (3.5 GHz) in healthy human volunteers.

Jamal L, Michelant L, Delanaud S, Hugueville L, Mazet P, Lévêque P, et al. *Exp Physiol*. 2024 Dec;109(12):2122-33.

Following the global progressive deployment of 5G networks, considerable attention has focused on assessing their potential impact on human health. This study aims to investigate autonomous nervous system changes by exploring skin temperature and electrodermal activity (EDA) among 44 healthy young individuals of both sexes during and after exposure to 3.5 GHz antenna-emitted signals, with an electrical field intensity ranging from 1 to 2 V/m. The study employed a randomized, cross-over design with triple-blinding, encompassing both 'real' and 'sham' exposure sessions, separated by a maximum interval of 1 week. Each session comprised baseline, exposure and postexposure phases, resulting in the acquisition of seven runs. Each run initiated with a 150 s segment of EDA recordings stimulated by 10 repeated beeps. Subsequently, the collected data underwent continuous decomposition analysis, generating specific indicators assessed alongside standard metrics such as trough-to-peak measurements, global skin conductance and maximum positive peak deflection. Additionally, non-invasive, real-time skin temperature measurements were conducted to evaluate specific anatomical points (hand, head and neck). The study suggests that exposure to 3.5 GHz signals may potentially affect head and neck temperature, indicating a slight increase in this parameter. Furthermore, there was a minimal modulation of certain electrodermal metrics after the exposure, suggesting a potentially faster physiological response to auditory stimulation. However, while the results are significant, they remain within the normal physiological range and could be a consequence of an uncontrolled variable. Given the preliminary nature of this pilot study, further research is needed to confirm the effects of 5G exposure.

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