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REVIEW

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The Impact of Electromagnetic Fields on Human Health: A Review

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Abstract

The electromagnetic field (EMF) is a physical concept consisting of electric and magnetic fields produced by the motion of charged particles and plays a ubiquitous role in modern society. EMFs are present in various forms, ranging from extremely low frequency (ELF) fields produced by power lines to radiofrequency (RF) fields emitted by wireless communication devices. While EMFs are essential for technologies like electricity generation, telecommunications, and medical imaging, concerns have been raised regarding their potential impact on human health. The literature has explored the relationships between EMF exposure and health outcomes, including cancer, reproductive health, and neurological disorders. Despite ongoing debate and inconclusive evidence, efforts are underway to mitigate exposure and establish regulatory guidelines. The effects of EMF on human health is a complex and multifaceted issue and research points to potential effects on various aspects of health, including neurological, reproductive and developmental effects. Although significant associations have not been found in some studies, growing evidence suggests that continuity in research is important in assessing and mitigating potential health risks associated with EMA exposure.

Keyword: Electromagnetic Field (EMF), Mobile Phone, Radiofrequency (RF), Microwave ovens, Base stations

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INTRODUCTION

Technology has the potential to affect human health in many ways. Base stations emitting radiofrequency waves, high voltage lines, television-radio transmitters and electrically operated devices create electromagnetic fields

(1,2). This electromagnetic field is known to be a biological risk factor (3–5). The Second World War was the period when the electronics industry developed very rapidly. Electromagnetic radiation has become widespread thanks to radar, medical applications and the development of satellite systems and devices used in daily life (6).

Electromagnetic radiation has created a new phenomenon called electromagnetic pollution over time. Ionizing radiations, such as X and gamma rays, which cause cancer as a result of genetic damage, have very high photon energy, sufficient to break atomic bonds and create ionization (7). On the other hand, non-ionizing radiation, which cannot break atomic bonds because it has weak photon energy, includes infrared radiation, ultraviolet radiation, radiofrequency (RF) and microwaves, and is emitted by mobile phones, wireless networks, computers and microwave ovens (8).

Electromagnetic field and Wi-Fi

EMF is a physical effect consisting of electric and magnetic fields in which charged particles exert a force on other charged particles around them. They exist in various forms, from extremely low frequency (ELF) fields generated by power lines and electrical devices to radiofrequency (RF) fields emitted by wireless communication devices such as mobile phones and Wi-Fi routers (9,10).

The electromagnetic field also plays a major role in the functioning of smartphones, power lines, home appliances and wireless communication systems such as WiFi. WiFi, a technology based on electromagnetic radiation, has made its use widespread by allowing wireless connection and communication. The deployment of WiFi networks has expanded significantly from local access networks to include larger, mesh networking technologies (11).

Although these areas are an important part of modern life, many concerns have been expressed about their potential effects on human health (12-14). The debate surrounding the health effects of EMFs is complex and ongoing (15). Although it has been suggested that EMFs may have negative effects on health when exposed to long-term or high levels, the scientific community has not reached a consensus on this issue (16).

However, in some studies, It has been reported that EMF exposure may have various negative effects on human health, such as being a carcinogenic factor, causing changes in brain physiology, and playing a role in the pathogenesis of some non-specific diseases (17).

Concerns have also been raised about the potential long-term health effects of continued exposure to EMFs due to the increasing prevalence of technologies such as in-vehicle wireless sensor networks and automotive radars

used for advanced driver assistance systems (18).

Electromagnetic field and mobile phone

One of the most widely studied sources of EMFs about human health is cell phones (19). They are widely used in various sectors, including health, education and communication (20). The possible impact of the use of mobile phones on human health is still being questioned. Several studies have investigated the impact of mobile phones on human health, with particular emphasis on the potential risks associated with prolonged exposure to electromagnetic waves (21). One of the main concerns is the emission of electromagnetic radiation from mobile phones, which has been classified as a possible human carcinogen (22).

These devices emit RF radiation, which has led to concerns about their potential to increase the risk of brain tumors, particularly among heavy users (23–25). While some studies have suggested a possible link between long-term cell phone use and certain types of brain tumors, the overall scientific evidence remains inconclusive (22).

However, there are studies showing that mobile phone RF radiation emissions may have harmful effects on cognitive functions and mental health (26). Additionally, the potential effects of mobile phone use on behaviors such as addiction and sleep disorders have also been investigated (27).

Mobile phone base stations should not be installed in public living and usage areas such as stadiums, kindergartens, hospitals, parks where children, patients and the elderly are more likely to be present due to the health risks they pose. The effects of mobile phones on human health are a complex and multifaceted issue that warrants further investigation. While concerns about the potential adverse health impacts associated with mobile phone use have been raised, there is also evidence supporting the feasibility and effectiveness of mobile-based services for healthcare delivery. As mobile phone usage continues to proliferate, it is essential to comprehensively understand the implications for human health and well-being (28).

Mobile phones have been leveraged to improve maternal health services, facilitate remote consultations, and enhance access to healthcare in low and middle-income countries (29).

In addition, the use of mobile phone reminders as appointment reminders in the follow-up of newly diagnosed HIV-positive patients reveals the potential of mobile technology to positively affect health outcomes (30).

Electromagnetic field and microwave oven

The microwave oven is a common kitchen appliance that uses electromagnetic radiation to heat and cook food (31). Overall, the study of microwave ovens and their magnetic fields encompasses a wide array of scientific and

practical considerations, ranging from food science and cooking processes to environmental and industrial applications. There are studies investigating the effects of electromagnetic radiation and cooking processes in microwave ovens on foods (31). Additionally, research has explored the non-uniform temperature distribution during microwave heating of food materials, highlighting the industrial applications of microwave energy (32). Concerns have been raised regarding the electromagnetic pollution of the environment due to leakage radiation from microwave ovens, emphasizing the need to understand the spatial and temporal changes in the electromagnetic field generated by these appliances (33). Additionally, in order to optimize the performance and safety of microwave ovens, there are studies on the measurement and controllability of electromagnetic radiation inside them. (31).

Electromagnetic field and base stations

Base stations are known as cellular transceiver stations and facilitate wireless communication by sending and receiving signals to and from mobile devices. Base stations are an important part of the infrastructure of telecommunications, but they have effects on human health in terms of exposure to electromagnetic fields (34). RF emitted by base stations while communicating with mobile devices are a type of non-ionising radiation, unlike ionising radiation. Since radiofrequency has low energy unlike ionising radiation, it is not known to directly cause DNA damage (35). Many countries have established safety guidelines and regulations on exposure to radiofrequency radiation. These guidelines aim to protect public health and are based on scientific research (36).

The possible health effects of exposure to electromagnetic fields emitted by base stations have been the subject of research. Studies are reporting that radiofrequency fields emitted from base stations can affect human cells and tissues (37,38). Exposure of people living close to base stations to high levels of non-ionising electromagnetic fields may have adverse health effects (39). Although possible links between radiofrequency radiation and adverse health outcomes such as headache, cancer, reproductive problems and neurological effects have been suggested, the evidence remains inconclusive. There is a significant correlation between some symptoms, particularly headache, and measured power density (40,41). There is also evidence that subjective symptoms and hypersensitivity to various electromagnetic field sources of numerous mobile phones and base stations have been reported (42,43). However some studies have reported inconsistencies between the possible consequences of electromagnetic fields emitted from cellular base stations on human health (44).

To better understand the possible health effects of exposure to electromagnetic fields from base stations, it is important to conduct comprehensive and rigorous research.

Studies have indicated that EMF exposure may lead to a range of health issues, including memory loss, fatigue, sleep disturbances, and headaches (45). Furthermore, long-term exposure to EMF has been associated with an increased risk of breast cancer in women, potentially linked to alterations in melatonin production (46). Concerns have also been raised about the potential impact of EMF on the central nervous system, with particular focus on the brain and the blood-brain barrier (47). Despite the uncertainty surrounding the health effects of EMFs, there are measures that individuals can take to minimize their exposure. These include using hands-free devices or speakerphone options when using cell phones, keeping electronic devices away from the body whenever possible, and limiting the use of wireless technology, especially near the body (48). In addition to individual efforts, regulatory agencies play a crucial role in setting guidelines and standards for EMF exposure. Organizations such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the World Health Organization (WHO) regularly review scientific literature and provide recommendations to protect public health (49).

CONCLUSION

In conclusion, the effects of EMFs on human health are a complex and multifaceted issue, with research indicating potential impacts on various aspects of health, including neurological, reproductive, and developmental effects. While some studies have not found significant associations, the growing body of evidence underscores the importance of continued research and vigilance in assessing and mitigating potential health risks associated with EMF exposure.

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REFERENCES

1. Samaila B, Abdullahi A, Yahaya M. Residential exposure to non-ionizing electromagnetic radiation from mobile base stations: a systematic review on biological effects assessment. Material Sci & Eng. 2023;7(2):44–52.

2. Yassin S, Musleh M, Abuzerr S. Electromagnetic radiation exposure from nearby cellular base stations in the Gaza Strip, Palestine: a concern for public health. Journal of Biosciences and Medicines. 2019;7(4):46–59.

3. Sonmez OF, Odaci E, Bas O, Kaplan S. Purkinje cell number decreases in the adult female rat cerebellum following exposure to 900 MHz electromagnetic field. Brain research. 2010;1356:95–101.

4. Odacı E, Hancı H, İkinci A, Sönmez OF, Aslan A, Şahin A, et al. Maternal exposure to a continuous 900-MHz electromagnetic field provokes neuronal loss and pathological changes in cerebellum of 32-day-old female rat offspring. Journal of chemical neuroanatomy. 2016;75:105–10.

5. İkinci A, Mercantepe T, Unal D, Erol HS, Şahin A, Aslan A, et al. Morphological and antioxidant impairments in the spinal cord of male offspring rats following exposure to a continuous 900 MHz electromagnetic field during early and mid-adolescence. Journal of chemical neuroanatomy. 2016;75:99–104.

6. Ibrahim IT, Al-Deen SM, Al-Nimer MS, Yahya AA. Assessment of Electromagnetic Hypersensitivity Syndrome in Subjects Lived Near Mobile Phone Base Station: Gender Based Study. 2023; 25(1):121-131.

7. Tokpinar A, Nisari M, Yilmaz S, Yay A, Yildiz OG, Balcioğlu E, et al. The effect of ionizing radiation on the fetal bone development in pregnant rats: Role of melatonin. Microscopy Research and Technique. 2024;87(1):95–104.

8. Kocaman A, Altun G, Kaplan AA, Deniz ÖG, Yurt KK, Kaplan S. Genotoxic and carcinogenic effects of non-ionizing electromagnetic fields. Environmental research. 2018;163:71–9.

9. Ramirez-Vazquez R, Escobar I, Vandenbosch GA, Vargas F, Caceres-Monllor DA, Arribas E. Measurement studies of personal exposure to radiofrequency electromagnetic fields: A systematic review. Environmental Research. 2023;218:114979.

10. Tumkaya L, Kalkan Y, Bas O, Yilmaz A. Mobile phone radiation during pubertal development has no effect on testicular histology in rats. 2016; 32(2):328-336.

11. Afanasyev M, Chen T, Voelker GM, Snoeren AC. Usage patterns in an urban WiFi network. IEEE/ACM Transactions on Networking. 2010;18(5):1359–72.

12. Aslan A, İkinci A, Baş O, Sönmez O, Kaya H, Odacı E. Long-term exposure to a continuous 900 MHz electromagnetic field disrupts cerebellar morphology in young adult male rats. Biotechnic & Histochemistry. 2017;92(5):324–30.

13. Kerimoğlu G, Hancı H, Baş O, Aslan A, Erol HS, Turgut A, et al. Pernicious effects of long-term, continuous 900-MHz electromagnetic field throughout adolescence on hippocampus morphology, biochemistry and pyramidal neuron numbers in 60-day-old Sprague Dawley male rats. Journal of chemical neuroanatomy. 2016;77:169–75.

14. Hardell L, Koppel T. Electromagnetic hypersensitivity close to mobile phone base stations–a case study in Stockholm, Sweden. Reviews on Environmental Health. 2023;38(2):219–28.

15. Kuzniar A, Laffeber C, Eppink B, Bezstarosti K, Dekkers D, Woelders H, et al. Semi-quantitative proteomics of mammalian cells upon short-term exposure to non-ionizing electromagnetic fields. PLoS One. 2017;12(2):e0170762.

16. Schuermann D, Mevissen M. Manmade electromagnetic fields and oxidative stress—biological effects and consequences for health. International journal of molecular sciences. 2021;22(7):3772.

17. Sieroń-Stołtny K, Pasek J, Cieślar G, Sieroń A. Influence of Electromagnetic Fields on Prooxidant/Antioxidant Balance in Rat Liver. Polish Journal of Environmental Studies. 2017;26(1).

18. Tognola G, Bonato M, Benini M, Aerts S, Gallucci S, Chiaramello E, et al. Survey of exposure to RF electromagnetic fields in the connected car. IEEE Access. 2022;10:47764–81.

19. Bas O, Sengul I, Bas OFM, Hanci H, Degermenci M, Sengul D, et al. Impressions of the chronic 900-MHz electromagnetic field in the prenatal period on Purkinje cells in male rat pup cerebella: is it worth mentioning? Revista da Associação Médica Brasileira. 2022;68:1383–8.

20. van Velthoven MH, Li Y, Wang W, Chen L, Du X, Wu Q, et al. Prevalence of mobile phones and factors influencing usage by caregivers of young children in daily life and for health care in rural China: a mixed methods study. PLoS One. 2015;10(3):e0116216.

21. Sajedifar J, Nassiri P, Monazzam MR, Shamsipour M, Ramezani R. The effect of battery charge levels of Mobile phone on the amount of Electromagnetic waves emission. Journal of Environmental Health Science and Engineering. 2019;17:151–9.

22. Prasad M, Kathuria P, Nair P, Kumar A, Prasad K. Mobile phone use and risk of brain tumours: a systematic review of association between study quality, source of funding, and research outcomes. Neurological Sciences. 2017;38:797–810.

23. Odaci E, Bas O, Kaplan S. Effects of prenatal exposure to a 900 MHz electromagnetic field on the dentate gyrus of

rats: a stereological and histopathological study. Brain research. 2008;1238:224–9.

24. Bas O, Odaci E, Kaplan S, Acer N, Ucok K, Colakoglu S. 900 MHz electromagnetic field exposure affects qualitative and quantitative features of hippocampal pyramidal cells in the adult female rat. Brain Research. 2009;1265:178–85.

25. Keleş Aİ, Yıldırım M, Gedikli Ö, Çolakoğlu S, Kaya H, Baş O, et al. The effects of a continuous 1-h a day 900-MHz electromagnetic field applied throughout early and mid-adolescence on hippocampus morphology and learning behavior in late adolescent male rats. Journal of Chemical Neuroanatomy. 2018 Dec 1;94:46–53.

26. Dwivedi R, Shakti Singh S, Rana S, Jakhar D, Kaur K, Poddar A, et al. Effect of Mobile Phone Emissions on HD-EEG Signals and Preventive Measures. 2021;

27. Mei S, Xu G, Gao T, Ren H, Li J. The relationship between college students' alexithymia and mobile phone addiction: Testing mediation and moderation effects. BMC psychiatry. 2018;18(1):1–7.

28. Chang LW, Kagaayi J, Arem H, Nakigozi G, Ssempijja V, Serwadda D, et al. Impact of a mHealth intervention for peer health workers on AIDS care in rural Uganda: a mixed methods evaluation of a cluster-randomized trial. AIDS and Behavior. 2011;15:1776–84.

29. Noordam AC, Kuepper BM, Stekelenburg J, Milen A. Improvement of maternal health services through the use of mobile phones. Tropical Medicine & International Health. 2011;16(5):622–6.

30. Kliner M, Knight A, Mamvura C, Wright J, Walley J. Using no-cost mobile phone reminders to improve attendance for HIV test results: a pilot study in rural Swaziland. 2014;

31. Vadivambal R, Jayas D. Non-uniform temperature distribution during microwave heating of food materials—A review. Food and bioprocess technology. 2010;3:161–71.

32. Panait DE, Jufa AC, Floroian L, Pascu AM, Badea M, Popa M, et al. Electromagnetic pollution of the environment due leakage radiation from microwave ovens. Mater Plast. 2019;56:82–6.

33. Kawahara Y, Bian X, Shigeta R, Vyas R, Tentzeris MM, Asami T. Power harvesting from microwave oven electromagnetic leakage. In 2013. p. 373–82.

34. Berg-Beckhoff G, Blettner M, Kowall B, Breckenkamp J, Schlehofer B, Schmiedel S, et al. Mobile phone base stations and adverse health effects: phase 2 of a cross-sectional study with measured radio frequency electromagnetic fields. Occupational and environmental medicine. 2009;66(2):124–30.

35. Mortazavi S, Motamedifar M, Namdari G, Taheri M, Mortazavi A, Shokrpour N. Non-linear adaptive phenomena which decrease the risk of infection after pre-exposure to radiofrequency radiation. Dose-Response. 2014;12(2):dose-response.

36. Valberg PA, van Deventer TE, Repacholi MH. Workgroup report: base stations and wireless networks—radiofrequency (RF) exposures and health consequences. Environmental health perspectives. 2007;115(3):416–24.

37. Taheri M, Mortazavi S, Moradi M, Mansouri S, Hatam G, Nouri F. Evaluation of the effect of radiofrequency radiation emitted from Wi-Fi router and mobile phone simulator on the antibacterial susceptibility of pathogenic bacteria Listeria monocytogenes and Escherichia coli. Dose-Response. 2017;15(1):1559325816688527.

38. Belpomme D, Hardell L, Belyaev I, Burgio E, Carpenter DO. Thermal and non-thermal health effects of low intensity non-ionizing radiation: An international perspective. Environmental pollution. 2018;242:643–58.

39. Blettner M, Schlehofer B, Breckenkamp J, Kowall B, Schmiedel S, Reis U, et al. Mobile phone base stations and adverse health effects: phase 1 of a population-based, cross-sectional study in Germany. Occupational and environmental medicine. 2009;66(2):118–23.

40. Hutter H, Moshammer H, Wallner P, Kundi M. Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations. Occupational and environmental medicine. 2006;63(5):307–13.

41. Levitt BB, Lai H. Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays. Environmental Reviews. 2010;18(NA):369–95.

42. Baliatsas C, van Kamp I, Kelfkens G, Schipper M, Bolte J, Yzermans J, et al. Non-specific physical symptoms in relation to actual and perceived proximity to mobile phone base stations and powerlines. BMC Public Health. 2011;11(1):1–12.

43. Ilori A, Adeleye B. Radiation Absorbed Dose Rates from Selected Mobile Phone Base Stations in Ibadan, Oyo State, Nigeria. Journal of Scientific Research and Reports. 2019;22(5):1–10.

44. Nwachukwu AN, Ikeagwuani CF, Nwachukwu NV. Assessment of the Background Radiation of Telecommunication Masts in Ebonyi State, Nigeria. Arab Journal of Nuclear Sciences and Applications. 2021;54(1):134–40.

45. Tran N, Lee MY, Nguyen HH, Jeong WH, Dang NT, Thi LA, et al. Enhanced microwave absorption properties of Y-Co2Z/PANI hexaferrites composites in the

frequency range of 0.1–18 GHz. Journal of the American Ceramic Society. 2021;104(7):3376–86.

46. Tynes T, Hannevik M, Andersen A, Vistnes AI, Haldorsen T. Incidence of breast cancer in Norwegian female radio and telegraph operators. Cancer Causes & Control. 1996;7:197–204.

47. Hossmann K, Hermann D. Effects of electromagnetic radiation of mobile phones on the central nervous system. Bioelectromagnetics: Journal of the Bioelectromagnetics Society, The Society for Physical Regulation in Biology and Medicine, The European Bioelectromagnetics Association. 2003;24(1):49–62.

48. Tseng MCM, Lin YP, Hu FC, Cheng TJ. Risks perception of electromagnetic fields in Taiwan: the influence of psychopathology and the degree of sensitivity to electromagnetic fields. Risk Anal. 2013 Nov;33(11):2002–12.

49. Jeschke P, Alteköster C, Hansson Mild K, Israel M, Ivanova M, Schiessl K, et al. Protection of Workers Exposed to Radiofrequency Electromagnetic Fields: A Perspective on Open Questions in the Context of the New ICNIRP 2020 Guidelines. Front Public Health. 2022;10:875946.