

Effect of Electromagnetic Radiation on Human

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ABSTRACT

Electromagnetic radiation (EMR), spanning a vast spectrum from extremely low-frequency (ELF) waves to highly energetic ionizing forms such as X-rays and gamma rays, has become increasingly pervasive in today's world. The rapid advancement and widespread use of wireless communication systems, electrical appliances, and medical imaging technologies have amplified human exposure to EMR. This review examines how such exposure impacts human biology and health, emphasizing the differences between ionizing and non-ionizing radiation. Non-ionizing radiation—originating from devices like mobile phones, Wi-Fi routers, and microwave transmitters—has been linked to potential thermal and non-thermal biological changes, including oxidative stress, altered cellular function, and neurological symptoms. In contrast, ionizing radiation is well known for its ability to cause DNA damage, mutations, and cancer. Although international safety limits have been established based on existing evidence, emerging research points toward a need for revising these standards, especially concerning prolonged low-level exposure to non-ionizing radiation. This paper summarizes current findings, identifies knowledge gaps, and underscores the necessity of sustained multidisciplinary research to better understand long-term EMR health implications.

Keywords: *Electromagnetic Radiation, Radiofrequency Radiation, Remote Sensing, Non-Ionizing Radiation, Human Health.*

Introduction

Exposure to electromagnetic radiation (EMR) from common technological devices may influence biological systems, potentially disturbing normal cellular functions and overall physiological balance. Limited awareness of these effects among healthcare providers often leads to underdiagnosis and insufficient public health responses [1].

The U.S. National Toxicology Program (NTP) has presented significant findings indicating that long-term exposure to radiofrequency radiation (RFR) from mobile phones can cause tumors and DNA damage. These results question prior assumptions about RFR safety and highlight the urgent need for stricter exposure guidelines and further scientific evaluation to protect sensitive populations from potential chronic health risks [3].

A 2025 study by Ahmet Turgut examined the growing scientific interest in the biological effects of 5G technology, focusing on exposure metrics such as Specific Absorption Rate (SAR) and Absorbed Power Density (Sab). The research integrated anatomical modeling, simulation tools, and engineering analysis to assess exposure risk and emphasized a multidisciplinary approach to ensure safe implementation of emerging communication technologies [6].

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Another area of investigation links heavy metal accumulation in the human body to electromagnetic hypersensitivity (EHS)—a condition characterized by symptoms such as fatigue, headaches, and impaired cognition triggered by electromagnetic field (EMF) exposure. Studies suggest that metals like mercury, cadmium, and lead may enhance tissue sensitivity to EMFs, implying a synergistic relationship between environmental toxicity and radiation sensitivity [2].

Recent evidence also highlights the potential effects of non-ionizing EMR on female reproductive health. Long-term exposure to radiation from digital devices may interfere with ovarian and hormonal functions, potentially affecting fertility. These findings call for further exploration and caution, especially among women planning pregnancy or in their reproductive years [6].

The Effects of Electromagnetic Radiation on Public Health

Genuis (2008) [1] investigated the implications of EMR exposure on public health, focusing on non-ionizing radiation from everyday sources.

- **Sources of Exposure**

Common sources of EMR include household electronics, power transmission lines, and wireless communication systems. Humans are exposed continuously in homes, workplaces, educational institutions, and public areas.

- **Possible Health Implications**

Although conclusive proof remains limited, multiple epidemiological studies suggest that prolonged non-ionizing radiation exposure may be associated with symptoms such as headaches, fatigue, cognitive issues, and sleep disturbances.

- **Insufficient Medical Awareness**

Health professionals receive minimal training regarding EMF-related risks. Consequently, symptoms of EMR exposure are frequently overlooked or misattributed, leading to diagnostic and treatment gaps.

- **Need for Greater Awareness**

Increasing awareness among healthcare practitioners and policymakers is crucial for accurate diagnosis, preventive healthcare, and early interventions related to EMF exposure.

- **Biological Mechanisms and Sensitivity**

Cellular activities depend heavily on electrochemical signaling. EMR exposure can interfere with these processes, potentially resulting in cellular stress, membrane damage, or biochemical imbalance.

- **Environmental Health Gap**

There exists a substantial gap between the growth of digital technology and the corresponding advancement in environmental health practices. Addressing this disparity is vital for managing EMR-related health concerns.

Heavy Metal Exposure and Electromagnetic Hypersensitivity

Ghezel-Ahmadi et al. (2010) [2] explored the relationship between heavy metal exposure and EHS. Although EHS is not yet formally recognized as a clinical condition, individuals frequently report recurring symptoms—such as fatigue, concentration issues, and skin irritation—when exposed to EMFs. The study proposed that accumulated heavy metals (e.g., mercury, lead, cadmium, aluminum) may enhance electrical conductivity in tissues, intensifying EMR sensitivity.

Considering the potential overlap between heavy metal toxicity and EMF hypersensitivity, comprehensive diagnostic approaches should include environmental and occupational assessments, alongside heavy metal screening. Public health initiatives that limit toxic metal exposure and raise EMR awareness are equally essential. While more studies are needed to confirm causation, current findings recommend precautionary actions and multidisciplinary healthcare approaches integrating toxicology and environmental medicine.

Human Health Risks from Cell Phone Radiofrequency Radiation

Melnick (2019) [3] analyzed the NTP's extensive animal studies, which provide robust evidence that long-term RFR exposure may have biological effects even at non-thermal levels. Tests on rodents revealed increased incidences of gliomas and heart schwannomas, along with genetic damage and

cardiomyopathy. These results parallel observations from epidemiological studies on heavy cell phone users, underscoring the human relevance of the findings.

Despite criticism, independent expert reviews have validated the scientific integrity of these studies. Given the ubiquity of wireless devices, such evidence is crucial for revising global exposure standards. A cautious and preventive stance is recommended, especially for children and pregnant women, whose developing tissues may be more vulnerable to radiation effects.

Non-Ionizing Radiation and Male Reproductive Health

Rajamani (2020) [4] examined the potential impacts of non-ionizing EMR—emitted from mobile phones, laptops, transmission lines, and communication towers—on male reproductive function. Studies suggest that prolonged EMR exposure can reduce sperm motility and count, alter hormonal balance, and damage reproductive cells through oxidative stress and DNA fragmentation.

The degree of biological impact depends on factors such as radiation intensity, frequency, and exposure duration. Close-contact devices like laptops or phones carried near the body pose greater risks. Preventive steps, including avoiding direct body contact with EMR-emitting devices and minimizing usage time, are advisable. Although more large-scale human studies are needed, existing evidence supports prudent behavior to protect reproductive health.

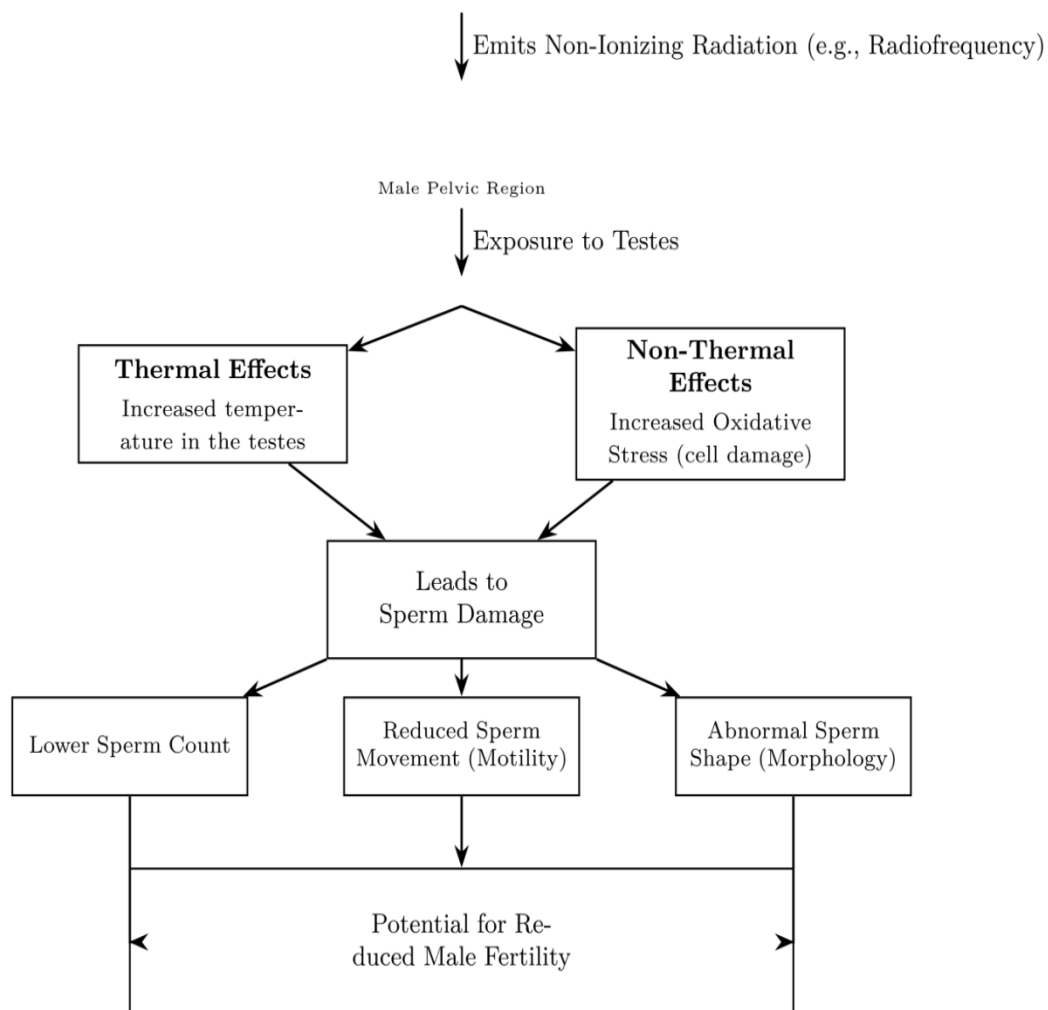


Figure: potential impact of non-ionizing electromagnetic radiation on male's fertility

Non-Ionizing Radiation and Female Reproductive Health

Jangid (2022) [5] explored the influence of EMR exposure on female fertility. The widespread use of wireless technology has raised concerns about how radiation affects ovarian function, endometrial receptivity, and hormonal regulation. Studies have shown that EMR may disrupt follicular development, hinder ovulation, and cause endometrial changes that reduce implantation success.

Additionally, EMR exposure may disturb estrogen, progesterone, LH, and FSH levels, leading to menstrual irregularities and fertility issues. Oxidative stress and inflammation appear to be primary mediators of these effects. Women of reproductive age are encouraged to limit close-range exposure—such as keeping devices away from the abdomen—to reduce possible risks. While further human research is necessary, existing findings advocate cautious device usage and ongoing study to refine safety standards.

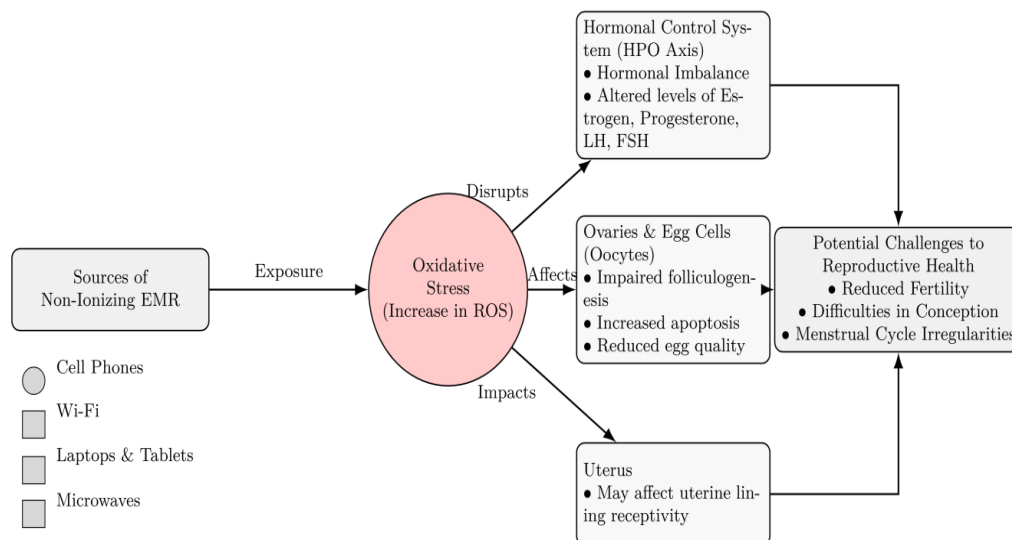


Figure: potential impact of non-ionizing electromagnetic radiation on women's reproductive health

These are potential effects suggested by scientific research. The exact risks and mechanisms are still under investigation.

Health Concerns and 5G Technology

Turgut and Engiz (2025) [6] reviewed current trends in 5G-related health research. Their analysis emphasized SAR and Sab measurements as key metrics for evaluating EMR exposure from advanced antenna systems. The study highlights the necessity of using computational human models—such as the “Duke” model—for accurate simulations of EMR absorption.

Software platforms like CST and HFSS are instrumental in estimating exposure without direct measurement. As 5G networks expand, integrating engineering, biological, and medical insights will be crucial for developing evidence-based safety regulations. Continuous monitoring and simulation-based assessments will help balance technological progress with public health protection.

Conclusion

The influence of electromagnetic radiation on human health remains an active area of study. With increasing exposure from wireless devices, understanding both ionizing and non-ionizing radiation effects is vital. Although current data do not provide absolute proof of harm at low intensities, evidence suggests possible biological disruptions—including oxidative stress, hormonal imbalance, and reproductive damage.

Particularly vulnerable groups, such as children and pregnant women, may face higher risks. Therefore, precautionary measures—like reducing direct device contact and promoting awareness—are essential until more conclusive evidence emerges. Ongoing interdisciplinary research and updated safety guidelines are key to ensuring human well-being in a technology-driven world.

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