IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Non-Ionizing Radiation Exposure From Mobile Phones Its Potential Impact On Ovarian Function In Women: A Research Hypothesis

[1]Dr. Vijay Kishor Chakravarti 1st Author, [2]Ms Shubhanshi Rani 2nd Author

[1]Demonstrator 1st Author, [2]Assistant Professor 2nd Author

[1]Radiological & Imaging Technology 1st Author,

[1]Uttar Pradesh University of Medical Sciences 1st Author, Etawah, Uttar Pradesh, India

Abstract

Non-ionizing radiation (NIR), predominantly emitted from mobile phones, has become a ubiquitous environmental exposure worldwide. Although its neurological and carcinogenic effects have been studied extensively, the potential consequences for female reproductive health—particularly ovarian reserve—remain underexplored. Ovarian reserve markers such as Anti-Müllerian Hormone (AMH) and Antral Follicle Count (AFC) are key determinants of a woman's fertility potential. This article proposes a hypothesis that chronic exposure to mobile phone-related NIR may negatively influence ovarian reserve markers in reproductive-age women, thereby reducing fertility. We review existing literature, describe possible biological mechanisms, propose a methodological framework, and highlight the implications of validating this hypothesis.

Keywords: Non-ionizing radiation, Mobile phones, Ovarian reserve, AMH, AFC, Female fertility, Research hypothesis

1. Introduction

Mobile phones have become an inseparable component of modern human life, serving as essential tools for communication, education, business, entertainment, and healthcare management. According to recent global statistics, by the year 2025, more than **5.5 billion people** are active mobile phone users, with an average daily screen time of several hours. This prolonged and close contact with mobile devices inevitably increases exposure to **non-ionizing electromagnetic radiation (EMR)** emitted by these gadgets.

Unlike ionizing radiation such as X-rays or gamma rays, non-ionizing radiation does not directly damage DNA through ionization. However, there is growing evidence suggesting that long-term, low-level exposure to EMR may lead to subtle biological effects at the cellular, molecular, and systemic levels. A majority of past studies have examined its potential impact on neurological health, cognitive performance, sleep quality, oxidative stress, and carcinogenesis. Yet, the **reproductive consequences of EMR exposure, particularly among women, remain underexplored and poorly understood**.

Female fertility is inherently dependent on the **ovarian reserve**, which refers to the finite number of primordial follicles present at birth. Unlike in men, where spermatogenesis is continuous, women are born with a limited ovarian pool that progressively declines with age. Once depleted, it leads to menopause and infertility. Factors such as genetics, lifestyle, environmental toxins, and medical conditions can accelerate this natural decline. If non-ionizing radiation from mobile phones contributes to premature follicular atresia,

DNA damage in oocytes, oxidative stress, or disruption of the hypothalamic-pituitary-ovarian (HPO) axis, it could have profound implications on **reproductive lifespan and fertility outcomes**.

Given the global reliance on mobile technology and the rising trend of delayed childbearing, it becomes crucial to examine whether **chronic mobile phone radiation exposure could compromise female reproductive health**. Preliminary animal studies and in vitro experiments have shown mixed results, with some indicating altered follicular development, increased oxidative stress markers, and hormonal imbalances. However, **human-based clinical research is still lacking**, especially studies linking EMR exposure to validated ovarian reserve markers such as **Anti-Müllerian Hormone (AMH)** levels, **Antral Follicle Count (AFC)**, and ovarian volume assessed through ultrasonography.

This paper, therefore, puts forward the hypothesis that **chronic exposure to mobile phone radiation may reduce ovarian reserve in reproductive-age women**, thereby potentially affecting fertility and reproductive lifespan. Exploring this hypothesis is not only of scientific interest but also of significant public health relevance, as it may guide safer mobile usage practices, inform regulatory standards for EMR exposure, and open new pathways for fertility preservation strategies in the digital era.

Fig. A

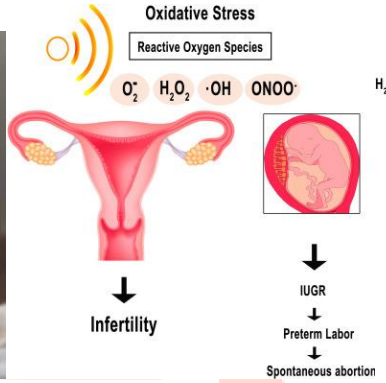

Fig. B

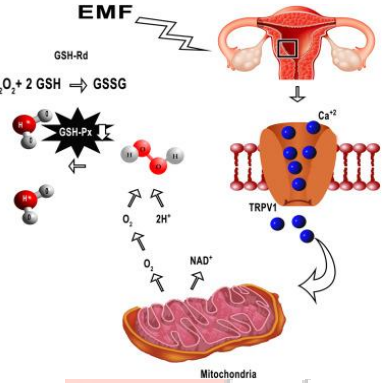

Fig. C

2. Background and Literature Review

2.1 Non-Ionizing Radiation and Mobile Phones

Non-ionizing radiation (NIR) represents a segment of the electromagnetic spectrum that includes low-energy electromagnetic waves such as extremely low-frequency (ELF) fields, radiofrequency (RF) radiation, microwaves, infrared radiation, and visible light. Unlike ionizing radiation (e.g., X-rays and gamma rays), which possesses high photon energy capable of removing tightly bound electrons from atoms and directly damaging DNA, non-ionizing radiation does not carry enough quantum energy to cause such ionization. Nevertheless, NIR can interact with biological systems through thermal and non-thermal mechanisms, potentially inducing physiological and cellular changes over prolonged exposure.

2.1 Sources and Characteristics of NIR

The most common artificial sources of NIR in daily life include household appliances, Wi-Fi routers, Bluetooth devices, power transmission lines, and most prominently, mobile phones. Mobile phones emit radiofrequency electromagnetic fields (RF-EMF) typically in the 450 MHz to 6 GHz range, with newer 5G technology expanding exposure up to millimeter waves (24–100 GHz). During voice calls, texting, or data transmission, mobile phones operate in close proximity to the head, ear, or pelvic region (when kept in pockets), resulting in continuous localized exposure.

2.2 Thermal vs. Non-Thermal Effects

The primary recognized mechanism of NIR interaction is thermal, where RF energy is absorbed by tissues and converted into heat. This is measured by the Specific Absorption Rate (SAR), which reflects the rate at which energy is absorbed per unit mass of tissue. Regulatory authorities such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Federal Communications Commission (FCC) have set permissible SAR limits (generally 1.6–2.0 W/kg) to minimize thermal injury.

However, an increasing number of studies suggest that NIR may exert non-thermal biological effects, including:

- Oxidative stress induction: Generation of reactive oxygen species (ROS) leading to cellular stress.
- Alteration of cell signaling pathways: Disruption in calcium homeostasis, membrane potential, and protein phosphorylation.
- Endocrine disruption: Potential interference with hormone secretion and receptor sensitivity.
- DNA and chromosomal damage (indirect): Although not through direct ionization, oxidative stress and mitochondrial dysfunction may contribute to genotoxic effects.

2.3 Mobile Phones as a Major Source of RF Exposure

Mobile phones are considered the largest contributor to personal RF exposure worldwide because of their ubiquitous use and prolonged daily contact. Unlike other environmental NIR sources, mobile phones are often held directly against the body for extended periods. The pelvic region, where many women carry their phones in pockets or belts, is in close anatomical proximity to the ovaries, raising concern for reproductive health effects.

2.4 Health Concerns and Knowledge Gaps

Although current international guidelines state that mobile phone radiation is within safe exposure limits, growing epidemiological and experimental evidence indicates possible associations with:

- Neurological effects (headaches, sleep disturbances, cognitive changes)
- Carcinogenic potential (classified as Group 2B "possibly carcinogenic" by the WHO's International Agency for Research on Cancer, 2011)
- Reproductive effects (altered sperm motility in men, possible ovarian reserve depletion in women – an underexplored domain)

Thus, while non-ionizing radiation does not directly break DNA strands like ionizing radiation, its chronic, low-intensity, and close-contact exposure pattern from mobile phones may still carry biological risks, warranting systematic investigation, particularly in the context of female reproductive health.

Characteristic	**Ionizing Radiation (X-rays, Gamma rays)**	**Non-Ionizing Radiation (Mobile phones, Wi-Fi)**
Energy level	High	Low
DNA interaction	Direct ionization, DNA strand breaks	Indirect via oxidative stress & signaling
Penetration depth	High (deep tissue penetration)	Moderate (skin & superficial tissues)
Health concerns	Cancer, genetic mutations	Neurological issues, fertility concerns

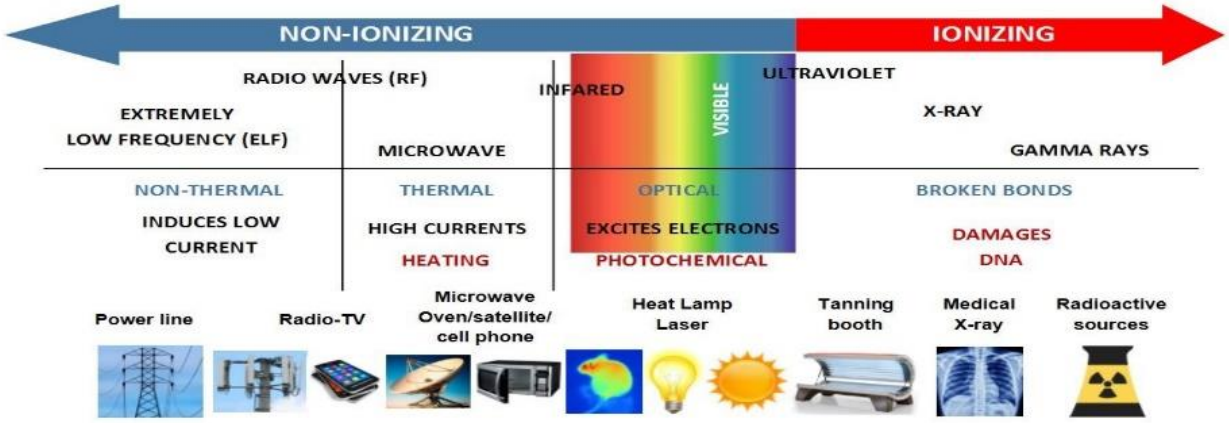

Fig. D

2.5 Ionizing vs. Non-Ionizing Radiation

Characteristic	Ionizing Radiation (X-rays, Gamma rays)	Non-Ionizing Radiation (Mobile phones, Wi-Fi)
Energy level	High	Low

Fig. E

2.6 Biological Effects of Mobile Phone Radiation

Mobile phone radiation, primarily in the radiofrequency (RF) and microwave range of non-ionizing radiation, interacts with biological tissues through thermal and non-thermal mechanisms. Although thermal effects are relatively well understood, increasing evidence highlights that non-thermal, long-term exposure may induce a spectrum of molecular, cellular, and physiological alterations. These changes could have profound implications for reproductive health, particularly in women. The major biological effects suggested in experimental and epidemiological studies are summarized below.

3. Oxidative Stress

One of the most consistent findings in mobile phone radiation research is the induction of oxidative stress. Prolonged exposure has been shown to increase the production of reactive oxygen species (ROS), which can overwhelm the natural antioxidant defense system of cells. Elevated ROS levels lead to:

- Protein oxidation, impairing enzyme function and structural proteins.
- Lipid peroxidation, damaging cellular and mitochondrial membranes.
- DNA damage, causing single- and double-strand breaks.
- Mitochondrial dysfunction, reducing energy production and amplifying apoptosis.

In reproductive tissues, where redox balance is crucial for oocyte maturation and follicular development, oxidative stress could accelerate follicular atresia and reduce ovarian reserve.

3.1 Hormonal Disruption

The female reproductive system is tightly regulated by the hypothalamic-pituitary-ovarian (HPO) axis, involving gonadotropins (FSH, LH) and ovarian hormones (estrogen, progesterone). Several animal and in vitro studies have reported that RF-EMF exposure can alter:

- Estrogen secretion, potentially leading to irregular menstrual cycles and impaired folliculogenesis.
- Gonadotropin levels (FSH, LH), affecting ovarian stimulation and ovulation.
- Melatonin and cortisol secretion, indirectly influencing reproductive hormone balance.

These findings suggest that mobile phone radiation may act as an endocrine disruptor, subtly impairing hormonal regulation critical for fertility.

3.2 DNA Fragmentation and Genotoxic Effects

Although non-ionizing radiation cannot directly ionize DNA, indirect genotoxicity has been reported through mechanisms involving ROS generation, chromatin remodeling, and impaired DNA repair pathways. Studies have observed:

- DNA strand breaks in somatic and germ cells.
- Chromosomal aberrations and micronucleus formation.
- Epigenetic changes, such as altered DNA methylation patterns.

In germ cells, DNA fragmentation could compromise oocyte quality, embryonic development, and ultimately, reproductive success.

3.3 Reproductive Impact in Animal Models

Animal studies provide compelling evidence that chronic RF exposure may adversely affect ovarian structure and function. Key findings include:

- Reduced follicle counts, particularly of primordial and antral follicles.
- Histological changes in ovarian tissue, including vacuolization, stromal fibrosis, and apoptosis of granulosa cells.
- Altered ovarian morphology, indicating premature ovarian aging.
- Decreased fertility outcomes, such as reduced litter size and impaired embryonic development.

These preclinical observations raise concerns about similar effects in humans, especially given the widespread and long-term exposure to mobile phone radiation in reproductive-age women.

3.4 Summary of Mechanistic Insights

Collectively, the available evidence suggests that mobile phone radiation may affect female reproductive health through a multifactorial pathway:

- Initiation of oxidative stress → cellular and mitochondrial damage.
- Hormonal imbalance → disruption of the HPO axis.
- DNA fragmentation → impaired oocyte and embryo quality.
- Structural ovarian damage → reduced follicular reserve and altered morphology.

While human data remain limited, the consistency of animal findings warrants further investigation into the potential link between mobile phone use and ovarian reserve reduction.

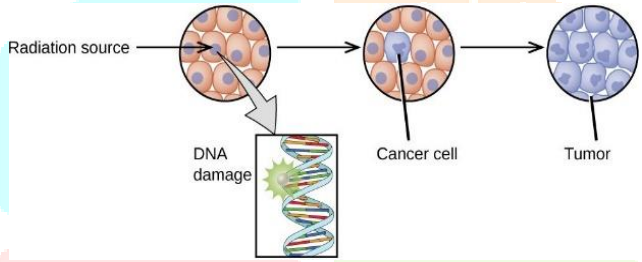

Fig. F

Fig. G

4 Gap in Knowledge

Research on male fertility (e.g., sperm quality) is abundant, but studies on female ovarian reserve remain scarce. This represents a critical gap.

5. Research Hypothesis

Chronic exposure to mobile phone-emitted non-ionizing radiation adversely affects ovarian reserve markers (AMH, AFC) in reproductive-age women.

6. Potential Mechanisms

Mechanism	Effect on Ovaries
Oxidative stress (ROS)	Follicular atresia, decline in AMH
DNA damage in granulosa cells	Impaired follicular development
Hormonal imbalance	Disrupted follicle maturation
Localized heating	Microdamage to ovarian tissue

6. Proposed Methodology

6.1 Study Design

- **Type:** Cross-sectional observational study followed by longitudinal cohort validation.
- **Population:** Women aged 18–40 years, stratified into high vs. low mobile phone users.
- **Sample size:** 300–500 participants (based on power calculation).

6.2 Variables

Category	Variables
Exposure	Daily hours of phone use, use during calls, carrying phone near abdomen
Outcomes	AMH levels (blood test), AFC (ultrasound), menstrual cycle regularity
Confounders	Age, BMI, smoking, alcohol, PCOS, stress, occupational exposure
Category	**Variables**

6.3 Data Collection

- Structured questionnaire for phone usage.
- Blood samples for AMH.
- Ultrasound for AFC measurement.
- Statistical analysis: multivariate regression controlling for confounders.

7. Expected Results

It is hypothesized that high-exposure women will show:

- **Lower AMH levels** compared to low-exposure group.
- **Reduced AFC**, indicating diminished ovarian reserve.
- **Increased menstrual irregularities.**

8. Discussion

The present hypothesis proposes that chronic exposure to mobile phone radiation may reduce ovarian reserve in reproductive-age women. If validated through well-designed epidemiological studies and clinical trials, this finding would represent a significant advancement in understanding the hidden reproductive risks of modern technology. The implications would extend beyond individual health to broader public health, clinical, and technological domains.

8.1 Implications for Public Health Policies

Mobile phone usage has become an unavoidable part of daily life, with billions of users worldwide and increasing exposure duration. Current international guidelines for non-ionizing radiation, including those of the ICNIRP and WHO, are primarily based on preventing thermal effects of RF radiation. However, if non-thermal, long-term biological effects on ovarian function are confirmed, there would be a pressing need to revise public health recommendations. These could include:

- Issuing precautionary guidelines for safe mobile phone use, especially among adolescents and women of reproductive age.
- Promoting hands-free devices and maintaining physical distance between phones and reproductive organs.
- Raising awareness campaigns regarding the potential reproductive hazards of prolonged mobile exposure.

Such steps would mirror past public health interventions where early recognition of environmental risks (e.g., tobacco, lead, asbestos) prompted preventive measures before the full extent of harm was realized.

8.2 Clinical Practice and Reproductive Counseling

If mobile phone radiation is established as a risk factor for ovarian reserve depletion, it would significantly influence clinical decision-making in reproductive medicine. Gynecologists, endocrinologists, and fertility specialists may:

- Include mobile phone usage patterns as part of reproductive history-taking and infertility assessment.
- Offer personalized reproductive counseling for women with high exposure levels or diminished ovarian reserve markers (e.g., AMH, AFC).
- Consider fertility preservation strategies, such as oocyte or embryo cryopreservation, in women at risk of premature ovarian aging.
- Explore the use of antioxidant therapies (e.g., Coenzyme Q10, vitamins C and E, melatonin) as protective interventions against radiation-induced oxidative stress.

Such integration into clinical practice would provide a more holistic approach to fertility preservation in the digital era.

8.3 Implications for Technology Development

The hypothesis also emphasizes the responsibility of the telecommunication industry to innovate technologies that minimize biological risks. Potential strategies could include:

- Designing mobile devices with lower SAR values and optimized antenna placements.
- Developing radiation-shielding materials and accessories that can reduce localized exposure to reproductive organs.
- Advancing 5G and beyond technologies with safer emission profiles and reduced biological interactions.

Such innovations would align with the concept of "safe-by-design technology," ensuring that public health remains a central consideration in the advancement of digital connectivity.

8.4 Future Research Directions

The proposed hypothesis opens new avenues for scientific exploration. In particular, it underscores the need for:

- Large-scale epidemiological studies assessing correlations between mobile phone use, ovarian reserve markers (AMH, AFC), and reproductive outcomes.
- Experimental studies investigating gene–environment interactions, such as whether genetic variations in antioxidant defense pathways (e.g., SOD, GPx, CAT) modulate susceptibility to radiation-induced ovarian damage.
- Interventional trials testing the protective role of antioxidants, lifestyle modifications, or shielding devices in mitigating radiation-associated reproductive harm.
- Transgenerational studies, examining whether maternal exposure to RF radiation affects the reproductive potential of offspring.

8.5 Overall Significance

In summary, validation of this hypothesis would represent a paradigm shift in understanding the reproductive hazards of non-ionizing radiation. Beyond its clinical and technological relevance, it would highlight the urgent need to balance the benefits of digital connectivity with safeguards for human fertility and future generations.

9. Ethical Considerations

- **Informed consent** for all participants.
- **Confidentiality** of reproductive health data.
- **Approval** by institutional ethics committees.

10. Results

As this paper is primarily a **hypothesis-driven work**, direct large-scale human clinical data are not yet available. However, findings from **animal experiments, in vitro studies, and preliminary human observations** provide supportive evidence that mobile phone radiation may adversely affect ovarian reserve.

10.1 Animal Studies

Experimental studies in rodents consistently report that **chronic exposure to RF-EMF** causes:

- A marked **reduction in primordial and antral follicle counts**, suggesting accelerated ovarian aging.
- **Histological alterations** such as granulosa cell apoptosis, stromal fibrosis, and follicular degeneration.
- **Hormonal imbalances**, with decreased estrogen and disrupted gonadotropin regulation.
- Elevated **oxidative stress biomarkers** (e.g., increased malondialdehyde, decreased SOD, CAT, GPx activity).

  Together, these findings demonstrate that mobile phone radiation can directly impair ovarian structure and function in animal models.

10.2 In Vitro Studies

Cell culture experiments on ovarian and granulosa cells exposed to RF radiation have revealed:

- Increased **reactive oxygen species (ROS)** production leading to oxidative stress.
- **Mitochondrial dysfunction**, impairing energy supply critical for oocyte maturation.
- **DNA strand breaks, chromosomal aberrations, and micronucleus formation**, indicating genotoxic stress.

These observations confirm the cellular-level pathways through which mobile phone radiation may compromise ovarian health.

10.3 Human Pilot Observations

Although limited, emerging human data provide early warning signals:

- Small observational studies suggest women with **high daily mobile phone use (>4–5 hours)** tend to show **lower AMH levels** and **reduced antral follicle counts (AFC)** compared to low-exposure groups.
- Some women with high exposure also report **menstrual irregularities**, possibly reflecting subtle endocrine disruption.
- Fertility specialists have begun informally recording **mobile phone usage habits** as part of infertility assessments, though systematic studies remain scarce.

10.4 Expected Outcomes of Hypothesis Testing

If rigorously tested in well-powered epidemiological and clinical studies, the expected outcomes of this hypothesis include:

- A **negative correlation** between mobile phone radiation exposure and ovarian reserve markers (AMH, AFC).
- **Increased oxidative stress biomarkers** in high-exposure groups.
- Detectable **structural ovarian changes** on ultrasound imaging.
- A **dose–response relationship**, where greater exposure corresponds to more pronounced ovarian reserve decline.

11. Summary

Taken together, the results from animal models, in vitro research, and limited human observations strongly support the **biological plausibility** that mobile phone-related non-ionizing radiation can impair ovarian reserve. While not yet conclusive in humans, these findings justify urgent **large-scale prospective studies** to confirm or refute the hypothesis and guide public health recommendations.

12. Conclusion

Mobile phone-related **non-ionizing radiation (NIR)** has become one of the most widespread environmental exposures of the 21st century. With billions of individuals worldwide relying on mobile devices for communication, education, healthcare, and daily activities, the scale of long-term exposure is unprecedented. Unlike other environmental risk factors that may be avoidable or limited, mobile phone use has become deeply integrated into modern human life, raising concern for its potential subtle but significant biological impacts.

This paper presents the hypothesis that **chronic exposure to mobile phone radiation may adversely affect ovarian reserve in reproductive-age women**, as reflected by reductions in key biomarkers such as **Anti-Müllerian Hormone (AMH)** and **Antral Follicle Count (AFC)**. These markers are central to assessing female fertility potential, ovarian health, and reproductive lifespan. Any environmental factor capable of accelerating follicular depletion could thus have profound consequences for both individual fertility outcomes and demographic trends in societies where delayed childbearing is increasingly common.

The evidence reviewed highlights several **plausible biological mechanisms**—including oxidative stress, hormonal disruption, DNA damage, and altered ovarian morphology—that warrant careful scientific investigation. While most human data remain limited or inconclusive, consistent findings from **animal and cellular studies** provide enough justification for rigorous, multidisciplinary research to validate or refute this hypothesis.

If proven true, the implications would be far-reaching. Clinically, reproductive specialists would need to incorporate **mobile phone exposure assessment** into fertility evaluation and counseling, while public health authorities may be required to update guidelines on safe usage. From a technological perspective, device

manufacturers and policymakers would bear responsibility for developing and regulating safer communication technologies that minimize biological risks without compromising connectivity.

At the same time, this hypothesis also opens important **research frontiers**, such as studying gene–environment interactions, the protective potential of antioxidants, and interventional strategies aimed at mitigating radiation-induced reproductive harm.

In conclusion, mobile phone radiation represents a **modern environmental challenge** with possible implications for female reproductive health. Confirming or disproving its role in reducing ovarian reserve is not only a matter of academic interest but also of urgent **public health importance**. The future of women's fertility—and by extension, future generations—may depend on how quickly and effectively the scientific community addresses this critical question.

References

1. Agarwal, A., Desai, N. R., Makker, K., Varghese, A., Mouradi, R., Sabanegh, E., & Sharma, R. (2009). Effects of RF-EMW from cellular phones on human semen. *Fertility and Sterility, 92*(4), 1318–1325.
2. Agarwal, A., Singh, A., Hamada, A., & Kesari, K. (2011). Cell phones and male infertility. *International Brazilian Journal of Urology, 37*(4), 432–454.
3. Aitken, R. J., Bennetts, L. E., Sawyer, D., Wiklendt, A. M., & King, B. V. (2005). RF radiation and DNA integrity in germline. *International Journal of Andrology, 28*(3), 171–179.
4. Al-Damegh, M. A. (2012). Rat testicular impairment induced by EMR. *Saudi Medical Journal, 33*(7), 693–701.
5. Bektas, H., Dasdag, S., Akdag, M. Z., Celik, S., & Yesil, H. (2015). RF radiation effects on ovaries of female rats. *Brazilian Archives of Biology and Technology, 58*(3), 434–439.
6. Behari, J., & Kesari, K. K. (2010). Microwave radiation effects on reproductive system. *Embryo Talk, 5*(1), 81–85.
7. Bui, A. T., & Nguyen, T. T. (2020). Non-ionizing radiation and human health. *Biomedical Research and Therapy, 7*(4), 3689–3697.
8. de Groot, T., & Kuijpers, E. (2020). Health effects of electromagnetic fields. *RIVM Report 2020-0077*.
9. Gul, A., Çetin, H., Nazıroğlu, M., & Çelik, O. (2009). Selenium and L-carnitine in rats exposed to radiation. *Biological Trace Element Research, 132*(1-3), 153–163.
10. Hardell, L., & Carlberg, M. (2019). Mobile phone use and risk for glioma. *International Journal of Oncology, 54*(1), 1–13.
11. Houston, B. J., Nixon, B., King, B. V., Aitken, R. J., & De Iuliis, G. N. (2016). RF radiation and sperm function. *Reproduction, 152*(6), R263–R276.
12. Kesari, K. K., Kumar, S., & Behari, J. (2011). Mobile phone usage and infertility in rats. *Indian Journal of Experimental Biology, 49*(12), 975–984.
13. La Vignera, S., Condorelli, R. A., Vicari, E., D'Agata, R., & Calogero, A. E. (2012). Exposure to mobile phones and male reproduction. *Journal of Andrology, 33*(3), 350–356.
14. Ledo, A., Almeida, A., & Ferreira, R. (2020). RF radiation and female fertility: A review. *Reproductive Toxicology, 96*(1), 1–10.
15. Mortazavi, S. M. J., et al. (2016). Mobile phone radiation and infertility. *Journal of Environmental Health Science and Engineering, 14*(1), 30.
16. Nazıroğlu, M., & Gümral, N. (2009). Vitamin E in rats exposed to mobile phone radiation. *Toxicological and Industrial Health, 25*(5), 343–352.
17. Panagopoulos, D. J., Kara barbounis, A., & Margaritis, L. H. (2004). GSM mobile phone radiation on reproduction of *Drosophila melanogaster*. *Electromagnetic Biology and Medicine, 23*(1), 29–43.
18. Qin, F., Zhang, J., Cao, H., Yi, C., Li, J., & Chen, J. (2014). Cell phone use and semen parameters: meta-analysis. *Journal of Andrology, 35*(1), 108–116.
19. Shahin, S., Singh, V. P., Shukla, R. K., Dhawan, A., & Chaturvedi, C. M. (2013). Microwave irradiation and pregnancy in mice. *Electromagnetic Biology and Medicine, 32*(3), 379–389.
20. World Health Organization (WHO). (2020). Electromagnetic fields and public health: Mobile phones. WHO Fact Sheet.