

## A REVIEW ON THE HEALTH HAZARDS AND FUTURE PERSPECTIVE OF CELL TOWER RADIATION

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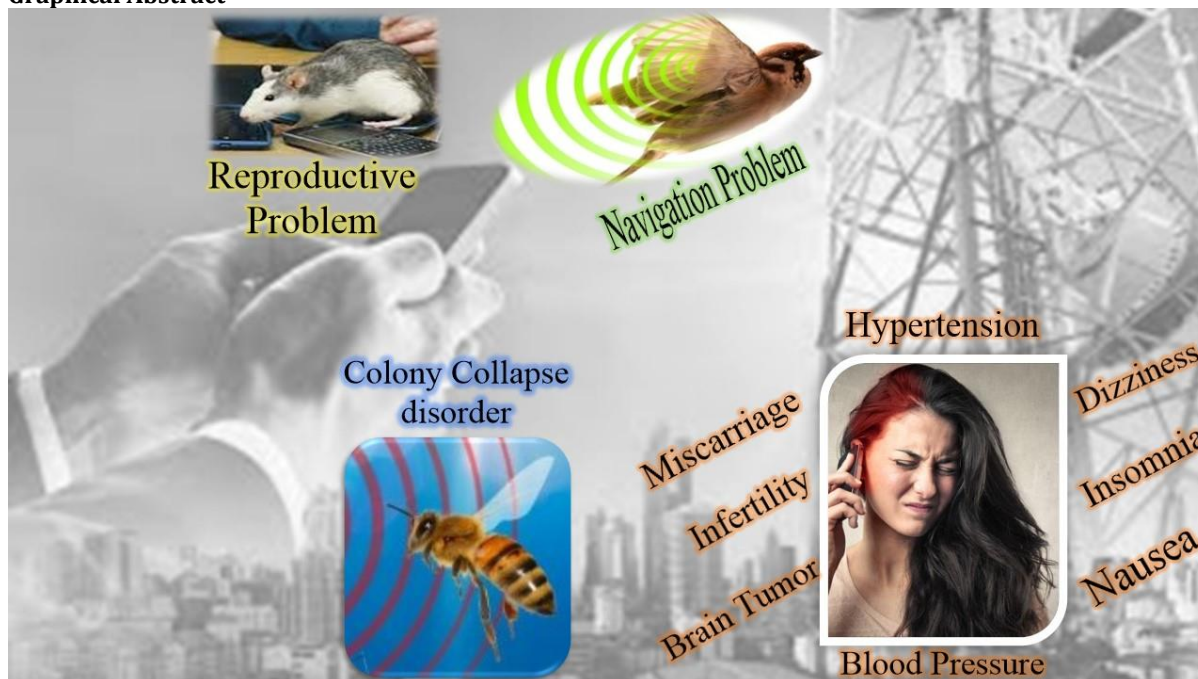
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### Abstract

This review article offers a thorough examination of the impact of mobile phone and base station radiation on human health and the environment. The mobile phone is a momentous breakthrough in human history that has dramatically revolutionized people's lifestyle. The widespread presence of mobile phones has significantly improved the overall standard of living globally. However, concerns regarding the potential effects of radio frequencies on humans, plants, and animals have existed for a long time. The pleasure and convenience derived from using mobile phones are jeopardized by claims that the radiation emitted by these devices has detrimental impacts on human health. The effects of radiation released by cell phones and base stations on wildlife, humans, and the environment have been described through pertinent incidents and studies conducted by different research groups. The rapid expansion of mobile radiation is challenging and creating a danger environment for current and upcoming generation at an unprecedented speed.

**Keywords:** Cell tower radiation; Human health; Animals health; Birds health

### Graphical Abstract



### 1.0. INTRODUCTION

The contemporary epoch heavily relies on technology. Wireless gadgets, such as cell phones, are extensively employed worldwide, for both personal and business reasons. As a result, radiofrequency radiation (RFR) is widely present, even in public areas (Miller et al. 2019). Mobile phones are a modern and widely used method of communication in the present era. Figure 1 depicts a wireless portable electronic communication device that

can work over long distances (Miller et al. 2019). The global telecommunications industry is seeing rapid and substantial expansion, driven by the increasing popularity and indispensability of mobile phones in contemporary culture and society. These technologies facilitate folks to preserve uninterrupted and unimpeded connectivity while also granting them the liberty to roam about freely. Since the introduction of mobile phones in the 1980s, there has been a significant rise in the total number of mobile phone users and installed base stations. The Ericson Mobile Subscribers Outlook Report indicates a worldwide mobile subscription count of around 8.2 billion, with a projected rise to 9.1 billion by the end of 2027 (Ericson Mobile Subscribers Outlook Report, 2021) (Jayaraju et al. 2023).

According to one estimation, the total number of applications in both the Google and Apple app stores is roughly 4.42 million. Mobile applications, particularly those focused on "m-health technologies," are used to actively tackle or control the problem of obesity in children and adolescents (Nadimikeri et al. 2012). These technologies and smartphone apps have proven to be effective in helping individuals during crucial situations. However, our society generally experiences a range of downsides associated with mobile phones.

Mobile phones operate by establishing communication with a fixed facility called a base station or telecommunications infrastructure. The widespread use of mobile phones has probably increased significantly, resulting in a corresponding rise in concerns about the potential health hazards associated with exposure to electromagnetic fields (EMF) emitted by mobile phone base stations. The mobile phone and its base station serve as bidirectional communication equipment that generate radio frequencies (RF) simultaneously. Concerns have arisen over the possible health risks linked to the exposure of radio frequency (RF) and microwave electromagnetic fields (EMF) since the advent of mobile phones (Sunday et al. 2021).

Electrical power lines employ low frequencies between 3 Hz and 300 KHz for transmission, with the United States using a frequency of 60 Hz. Moreover, these frequencies are utilized for maritime and subsea navigation and communications. AM/FM/TV transmissions in North America use medium frequencies between 300 KHz and 900 MHz. Frequencies within the range of 900 MHz to 5 GHz are employed in a wide range of applications such as telecommunications, microwave devices, radio astronomy, mobile phones, and wireless LANs. Radar and microwave Wi-Fi operate at frequencies between 5 and 300 GHz. These frequencies are intended to be utilized for the latest 5G technology. Terahertz frequencies, which span from 300 to 3000 GHz, are extensively employed in medical and security scanning applications as a supplementary imaging technique alongside X-rays (Turner et al. 2016).

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) provides scientific advice and guidance on the effects of non-ionizing radiation (NIR) on human health and the environment. The primary goal is to protect persons and the environment from potentially dangerous exposure to NIR. NIR encompasses the full range of electromagnetic radiation, which includes ultraviolet, visible light, infrared, and radio waves, as well as mechanical waves such as infra- and ultrasound. Common sources of near-infrared (NIR) radiation in daily life include the sun, household electrical devices, mobile phones, Wi-Fi, and microwave ovens. The International Committee on Electromagnetic Safety (ICES) is responsible for creating guidelines to ensure the safe use of electromagnetic radiation between the frequencies of 0 to 300 GHz. These guidelines cover the following aspects:

1. The potential hazards associated with individuals, volatile substances, and explosive devices coming into contact with this energy
2. Regulations for things that purposefully release electromagnetic energy or generate it as a byproduct of their operation, and
3. Regulations governing limitations on the influence of electromagnetic energy on the environment

The International Agency for Research on Cancer (IARC), a specialized cancer agency of the World Health Organization, has classified radio frequency radiation as "possibly carcinogenic to humans" based on insufficient evidence for other types of cancer and limited evidence suggesting a potential increase in the risk of brain tumors among cell phone users. The primary objective of the International Radiological Protection Agency (IRPA) is to foster collaboration in safeguarding individuals and the environment against the harmful effects of both ionizing and non-ionizing radiation. Additionally, the agency aims to facilitate the responsible utilization of radiation and nuclear power for the betterment of mankind, as stated in the IRPA constitution.

## 2.0. THE IMPACT OF ELECTROMAGNETIC RADIATION ON HUMAN HEALTH

There are numerous advantages of mobile devices. The advent of cellular technology has transformed the world into a global village. This compact device enables us to engage in global communication with our friends and families. Video calling has revolutionized the way we communicate, providing a virtual alternative to in-person interactions. However, there are certain obstacles associated with this technology. One of the difficulties lies in the release of electromagnetic radiation. Figure 2 illustrates the harmful effects of these electromagnetic waves on human health. Scientific literature has demonstrated that Electromagnetic radiations can have a spectrum of consequences, ranging from no impact to causing death (Dash et al. 2011). The outcome is contingent upon various parameters such as the frequency range of the electromagnetic radiation, the power density of the radiation, the distance between the radiation source and the body, and the thickness of the beam.

The duration of exposure is also the primary determinant for the analysis of exposure. High-frequency electromagnetic radiation can induce diseases with various detrimental effects due to its frequency range. Exposure to electromagnetic radiation can lead to the development of a range of illnesses. Shorter exposure can lead to elevated temperatures in the head and neck area, while prolonged exposure can have severe consequences such as the development of different types of cancer, including breast, bone, and lung cancer. These potent radiations can heighten the likelihood of dementia (Moradi et al. 2016; Zamanian et al. 2005). Additionally, fertility is also impacted by these electromagnetic radiations. Scientific research has shown that extended exposure to electromagnetic radiation can potentially lead to cardiovascular issues (Sharma et al. 2017).

### **2.1. Hazard to individuals with cardiovascular conditions**

A study was conducted to evaluate the impact of Electromagnetic radiation on cardiovascular disorders. Scientific literature has demonstrated that electromagnetic radiations can lead to many health problems, such as hypertension and high blood pressure. Research has demonstrated that these Electromagnetic radiations elevate both blood pressure and total cholesterol (TC) levels. The researchers conducted an investigation to quantify the effects of electromagnetic radiation on individuals with heart conditions. The researchers conducted the studies using two groups of patients that were exposed to a certain condition, and one group that served as a control. The researchers determined that patients with cardiac problems are significantly affected by Electromagnetic radiation (Vangelova et al. 2006).

### **2.2. Child endangerment**

All persons are susceptible to exposure to electromagnetic radiation. However, youngsters are more vulnerable to these radiations due to the fact that their nervous system is still in the developmental stage. Over the past twenty years, extensive study has been carried out to examine the effects of electromagnetic radiation on children. The researchers have examined the effects of electromagnetic radiation on children. The parameter that influences children is the size of the skull. The researchers emphasize that the cranial thickness is lower in children as compared to adults. Consequently, these radiations can have a negative impact on youngsters (Wiert et al. 2005). The investigation has failed to determine the impact of electromagnetic radiation on human health. Scientific literature has reported that extended exposure to these radiations can lead to juvenile cancer, specifically Leukaemia (Schüz et al. 2011). It is necessary to take specific precautions, such as limiting exposure to radiation (Moon et al. 2020).

### **2.3. Impact on male reproductive capacity**

The proliferation of diverse electronic gadgets such as laptops, WiFi, and desktops has rendered humans susceptible to these electromagnetic radiations. In addition to studying other illnesses that affect children, researchers have conducted investigations to analyze the impact of electromagnetic radiation (EMR) on male infertility. Research has demonstrated that these radiations can lead to male infertility. It has the potential to reduce both the quantity and quality of sperm. That is to say, it can impact the death rate and ability to survive of sperm. The researchers have also examined the effects of electromagnetic radiation on the Testosterone hormone. Research has shown that exposure to electromagnetic radiation leads to a drop in Testosterone levels, as seen by studies conducted (Erogul et al. 2006; Agarwal et al. 2008; Kesari et al. 2018).

### **2.4. Impact on vision**

In addition to impacting children's health and male fertility, electromagnetic radiation also has adverse effects on the eyes. However, there is a scarcity of research and literature that specifically examines the effects of electromagnetic radiation on ocular health. Nevertheless, a limited number of studies have conducted an examination of the effects of electromagnetic radiation on the human eyes. Researchers have demonstrated that Electromagnetic waves can lead to various eye conditions such as cataracts and excessive tearing of the eyes. To examine the impact of electromagnetic radiation on the human eye. A study was conducted on a group of nine healthy male participants who had been using mobile phones for a duration of 3 to 9 years, for one hour every day. According to the studies, Electromagnetic radiation may have an effect on the eye (Schüz et al. 2011; Singh et al. 2016).

### **2.5. Impact on the skin**

The heating effects are caused by electromagnetic radiation. The human skin lacks the ability to effectively disperse the heat generated by these radiations. The elevated temperature leads to various skin-related problems such as severe burns and a sensation of pricking (Bozorgmanesh et al. 2023).

### **2.6. Influence on heart rate variability**

Heart rate variability serves as an indicator of an individual's state of health. This singular metric can yield a plethora of insights into the state of an individual's welfare. It can provide information on both blood pressure and the autonomous nervous system (ANS). In addition, this value also signifies the presence of anxiety and



despair. Due to the proximity of mobile phones to the head, electromagnetic radiation has been demonstrated to affect the cognitive function of the brain. The researchers have demonstrated that these radiations have an impact on the heart rate variability measure (Misek et al. 2018). The impact of electromagnetic radiation is a subject of contention worldwide. Research is necessary to measure the impact of these radiations on human health.

### 3.0. THE IMPACT OF MOBILE RADIATIONS ON INSECTS, BIRDS, AND ANIMALS

Based on our current understanding, continuing research and discussions are examining the potential impacts of mobile phone radiation on insects, birds, and animals (Siddoo-Atwal et al. 2018). Modern cellphone towers emit electromagnetic radiation (EMR) mostly in the form of high-frequency radio waves or microwaves. Observations have shown that insects, birds, and animals (Balmori et al. 2009) experience negative biological consequences as a result of exposure to electromagnetic radiation (EMR) emitted by cellular towers. It is rare to witness pigeons, sparrows, bees, or any other birds lingering or flying near a mobile phone mast. The concurrent decrease in fruit-consuming seed dispersers, such as wild avian species, and insect pollinators, such as bees, may have significant ramifications for human food production.

#### 3.1. Impact of mobile radiation on insects

Scientific research has indicated that specific wavelengths of electromagnetic radiation, such as those emitted by mobile phones, may interfere with the navigation and communication systems of honeybees and other insects (Taye et al. 2017). Honeybees, such as this example, depend on electromagnetic signals to communicate and travel. Studies have shown that bees exposed to specific frequencies of radiation may exhibit changes in their behavior, which could potentially impact their capacity to search for food and pollinate flowers (Sahib et al. 2011).

Albert Einstein is often reported as saying, "If the bee disappears from the surface of the earth, man would have no more than four years to live." In the United States, there was a sudden decrease of bees some years ago, which was linked to the increasing levels of electromagnetic pollution. Colony Collapse Disorder (CCD) refers to a phenomenon in which bees are unable to return to their hive due to continuous electromagnetic background noise, which appears to interfere with communication between individual bees (Kumar et al. 2018). CCD has subsequently expanded to Germany, Switzerland, Spain, Portugal, Italy, Greece, Scotland, Wales, and north-west England. The bee population in England had a decline of 54% between 1985 and 2005, which is significantly higher than the average decline of 20% observed across Europe. Exposing honey bee colonies to radiation resulted in a decrease in honeycomb weight and area, as well as an increase in the time it took for honey bees to return to the colonies, when compared to colonies that were not exposed to radiation.

#### 3.2. The impact of mobile radiation on Birds

Birds have a comparatively bigger surface area compared to their weight, which means they absorb more radiation due to the equation  $\text{power} = \text{power density} \times \text{area}$ . Due to its low weight, fluid content heats up rapidly and is also disrupted by the magnetic field, affecting its navigational abilities. Exposure of birds to low-intensity electromagnetic fields leads to their disorientation and erratic flight patterns, hence compromising the navigational ability of migratory birds. A significant population of avian species, including pigeons, sparrows, and swans, is experiencing displacement as a result of the presence of mobile phone towers, which might be considered a "unseen enemy". Each year, millions of birds from 230 different species perish due to collisions with telecommunications poles in the United States during their migration. In recent decades, there has been a significant decrease in the population of house sparrows. The sparrow population in London has experienced a significant decline, with a decrease of 75% since 1994. There has been a significant decrease, nearly to the brink of extinction, in the populations of certain cities such as Glasgow, Edinburgh, Hamburg, Ghent, Brussels, Dublin, and Belgium. Research indicates a strong temporal correlation between the decline of sparrows and the installation of GSM phone mast towers (Balmori et al. 2007).

Spain effectively fostered 60 nests between May and June 2003 to evaluate the reproductive ability of the White Stork population. A total of 30 nests were found within a 200 m radius of cell phone towers, while the remaining 30 nests were located at distances greater than 300 m from any transmitter (Everaert et al. 2007). 40% of the nests in close proximity to the antennas were empty, compared to only 3.3% of nests located further away at a distance of 27. The avian species in close proximity to the telephone antennas also displayed modifications in their behavior. Unidentified factors led to the death of young bird specimens, and bird pairs had multiple conflicts while building their nests. As a result of the unfinished nests, the storks remained inactive when the 28 antennae were present (Summers-Smith et al. 2003).

There is a scarcity of research on the impacts of mobile phone radiations on birds, and the existing studies do not provide definitive conclusions. Nevertheless, the available information is insufficient to definitively show a clear cause-and-effect relationship between mobile phone radiation and avian behavior (Balmori et al. 2009).

### 3.3. Impact of mobile radiation on animals

The research conducted in Germany revealed that cows that graze in close proximity to cell towers have a higher likelihood of encountering stillbirths, spontaneous abortions, birth abnormalities, behavioral issues, and a general deterioration in their overall well-being (Metta et al. 1956). Relocating livestock herds from these towers has allegedly resulted in immediate enhancements in health. Exposing dairy cows to magnetic fields can lead to a decrease in milk production, alterations in milk composition, and issues with reproduction. Furthermore, it has been noted that sheep experience a compromised immune system, dogs and cats encounter reproductive and developmental issues, rabbits suffer from anxiety and alarm, and domestic animals like hamsters and guinea pigs living near mobile phone towers frequently die. Electromagnetic contamination may contribute to the deformities and decrease observed in certain amphibian populations. The presence of electromagnetic fields has a substantial impact on bat activity, leading to a large reduction in their presence in affected habitats. In a research study conducted on a free-tailed bat colony, it was shown that the population of bats reduced when multiple phone towers were installed at a distance of 80 meters from the colony (King et al. 2022).

Like avian species, there is a dearth of study on the impacts of mobile phone radiation on animals. Several studies have documented modified behaviors in specific animal species that were exposed to electromagnetic fields. Nevertheless, these discoveries are sometimes tentative and lack widespread acceptance among the scientific community (Balmori et al. 2010).

## 4.0. IMPACT ON PLANTS

Aside from honey bees and birds, the electromagnetic radiation (EMR) emitted by mobile phone towers can also affect crops, vegetables, and plants in close proximity. Multiple studies have demonstrated that the electromagnetic fields (EMF) produced by mobile phones can hinder the process of seed germination and hinder the formation of roots. Moreover, the influence on the overall growth and yield of crops is restricted (Sharma et al. 2009). The trees within the main support structure appear dried up, pale, showing stunted tops, limited growth, and increased vulnerability to diseases and pests (Alattar et al. 2017).

## 5.0. POTENTIAL STRATEGIES TO MITIGATE THE DETRIMENTAL IMPACTS OF RADIATION

In India, the current radiation regulations for GSM900 are set at a somewhat permissive level of 4.7 W/m<sup>2</sup>. It is worth mentioning that notable health effects have been seen at far lower levels, notably at 0.0001 W/m<sup>2</sup>, which is comparable to 100 μW/m<sup>2</sup>. One of the first steps to take is to strengthen the radiation rules, making sure they are practical and financially sustainable, without causing excessive inconvenience to the users. It is crucial to recognize that certain countries have set a threshold as low as 0.001 W/m<sup>2</sup>. Thus, our proposed suggestion exceeds the thresholds of these countries in order to ensure cost-effectiveness (Figure 3).

In order to minimize the harmful effects of radiation, it is essential to adopt a comprehensive strategy that encompasses the implementation of preventative measures, the use of protective equipment, and the administration of medical treatments customized to the specific nature and severity of radiation exposure. Here are a few possible methods and strategies. Implementing radiation safety precautions is an effective method to reduce these side-effects. The radiation safety measures involve minimizing exposure, employing shielding, implementing containment systems, and complying with safety regulations.

Personal protective equipment is specifically engineered to provide shielding against radiation. The equipment consists of dosimeters, protective clothing, and respiratory protections.

There are two medical approaches to alleviate the consequences of radiation: radiation sickness treatment and treatment for radiation burns.

- Investigating alternative technologies that utilize less harmful forms of radiation or reduce radiation exposure could be a potential strategy to lessen this impact.
- Environmental remediation is essential for reducing the effects of radiation by establishing techniques to clean and restore polluted areas, hence lowering long-term environmental hazards.

## 6.0 LEGAL MEASURES ADDRESSING THE ADVERSE EFFECTS OF MOBILE RADIATION

In India, the legislative regulations concerning mobile radiation generally concentrate on establishing benchmarks, guaranteeing adherence, and fostering public consciousness. The primary regulatory body for the telecommunications industry in India is the Telecom Regulatory Authority of India (TRAI). Mobile radiation levels are usually regulated according to criteria established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and implemented by national regulatory authorities. The Department of Telecommunications (DoT) in India is tasked with establishing and implementing regulations pertaining to mobile radiation.

These rules establish the acceptable thresholds of electromagnetic radiation discharged by mobile phones and other communications devices. Mobile phone makers and service providers must adhere to these constraints to guarantee the safety of users and the public at large.

In order to tackle issues regarding mobile radiation, TRAI might potentially form partnerships with other pertinent agencies and actively participate in discussions and the formulation of legislation pertaining to the health and safety implications of mobile communication technology. Nevertheless, the primary duty of establishing and implementing precise radiation thresholds typically rests with the regulatory authorities directly supervising the telecommunications and information technology industries in India.

## 7.0. PROSPECTS FOR THE FUTURE AND THE RELATED CHALLENGES

The rapid expansion of different information and communications technologies is fundamentally changing and creating a unique environment for new opportunities at an unprecedented speed. The healthcare sector, like every other industry, has been profoundly impacted by the digital revolution. The progress of telehealth, the deployment of 5G networks, the application of AI techniques such as machine learning and deep learning, the examination of large datasets (Big Data) using supercomputing, and the incorporation of IoT devices, along with the adoption of digital security measures like blockchain, have created substantial prospects for establishing a cohesive ecosystem that can generate novel opportunities in healthcare and other industries (Georgiou et al. 2021).

In 2017, doctors and scientists in the EU launched a petition to stop the deployment of 5G technology due to concerns about its potential carcinogenic effects (Nyberg et al. 2022). One particular concern stems from the newness of 5G technology, which has not allowed for adequate time to conduct comprehensive safety tests. According to specialists, there is a lack of scientific assessments on the potential impacts of densely concentrated 5G networks in metropolitan areas and the prolonged exposure to 5G radiation. Experts suggest that the wider use of 5G technology could result in increased diversity throughout the population, as certain genes are thought to impact an individual's susceptibility to radiation.

A study conducted in 2021 found that the genetic effects of electromagnetic fields (EMF) depend on several factors, such as the frequency and intensity of the EMF, the kind of cells involved, the duration of exposure, and the individual genes that are affected (Karipidis et al. 2021). These findings are consistent with other research suggesting that electromagnetic fields (EMF) can cause genetic harm. Moreover, a substantial amount of the rules sanctioned by the government concerning radio frequency (RF) were enforced throughout the late 1990s and were based on a limited body of research. Scientists today maintain a more nuanced viewpoint on the topic, and a small number are not staying quiet. More than 3,500 specialists specializing in several medical specialties, including preventive and environmental medicine and toxicology, have united to voice their dissent against the implementation of 5G technology. Their worries are grounded in scientifically reviewed studies that emphasize the primary hazards linked to nonionizing radiation (Simkó et al. 2019). The dangers encompassed in this context comprise cancer, cellular stress, genetic harm, alterations in reproductive functions, and neurological diseases.

## 8.0. SUMMARY AND OUTLOOK

This section compiles and discusses research undertaken by many institutions, organizations, and other entities. The effort was motivated by the public's concern regarding the potential risks linked with the use of mobile phones. The incidence of mobile phone usage is consistently increasing; nonetheless, a substantial segment of the public lacks awareness regarding the consequences of mobile phones on human well-being. However, operators are actively competing to attract a larger number of clients and are building mobile towers in every possible site around the country to improve their network coverage, despite their claims that there are no health concerns. Various research suggests a substantial correlation between mobile phone radiation and significant health problems in individuals. However, specific studies suggest that mobile phones and base stations do not have any impact on exposure to non-ionizing radiation. On the other hand, research suggests that prolonged use of cell phones and exposure to mobile and base stations can lead to abnormal mental issues, disturbances in sleep patterns, trouble with focusing, headaches, irritability, dizziness, and high blood pressure, among other things.

Nevertheless, there has been a conspicuous decline in the population of house sparrows (*Passer domesticus*), which can be attributed, among other causes, to the radiation released by base stations. Therefore, it is crucial to conduct interdisciplinary research to uncover the effects of radiation released by mobile phones and cell towers on both individuals and the environment. Policy makers and executive authorities should enforce stringent radiation regulations.



Figure 1. Everyday applications of cell phones

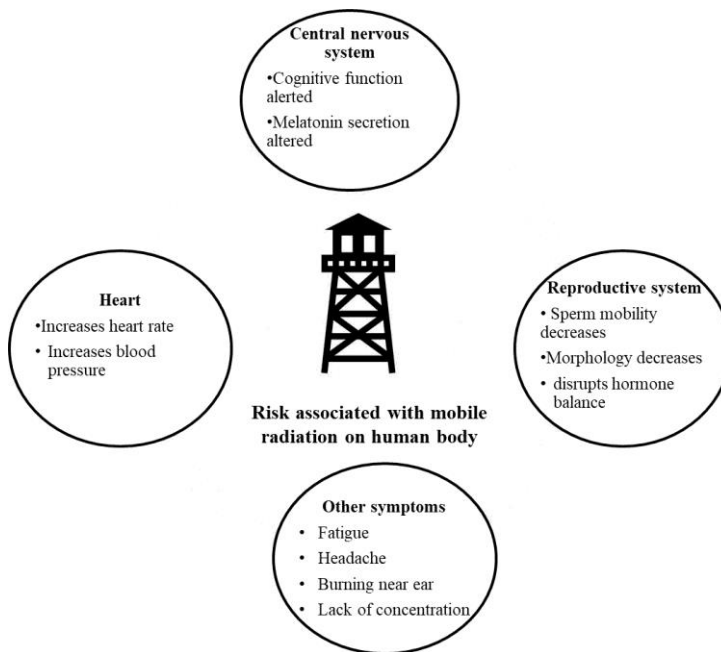


Figure 2. Impact of cellular tower radiation on human health

**To reduce radiation exposure:**

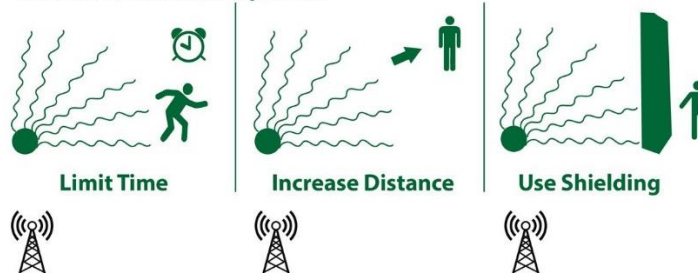


Figure 3. Potential strategies for mitigating the impact of cellular tower radiation

<https://www.gapinterdisciplinaries.org/>



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