A review on the health implications of electromagnetic radiations emitting from cell phone towers

Abstract

The positive aspect of technological innovation makes life easier; it may also involve components that impair the quality of life via certain negative effects. Cell phone towers emit high-frequency radio waves, which are a significant environmental pollutant and a serious problem today. The thermogenic effect is primarily linked to the intensity of electromagnetic fields (EMF), measured by the specific absorption rate (SAR). This review work compiled both field and laboratory studies carried out on various parameters such as growth, behavior, reproduction and development, cancers in human beings, etc. Information on various studies published on the effects of EM radiations and methods employed during EMR studies is enlisted herein. The studies showing the impact on dosimetry, co-exposure, epidemiology, hematology, endocrinology, molecular structure, wildlife, and ecology were considered. Lack of standardization and inconsistent results hindered the ability to generalize the findings.

Keywords: *Radiofrequency, EMF, Electromagnetic field exposure, Mobile telecommunication, Cell tower, Health issues.*

Introduction

The transformation in the telecommunications and communication sector has significantly altered our way of life. Today, we depend extensively on various communication methods in our daily routines. We cannot imagine ourselves without cell phones, televisions, computers, etc. As technology makes business easier, the number of mobile phone users is rapidly increasing, along with the proliferation of cell towers [41,42]. Viewing air as a habitat, Radiofrequency radiation (RFR) emerges as a potential pollutant capable of adversely impacting all species (Manville, 2007). Research examining the effects of RF radiation on individuals residing within 15 meters of a cell tower concluded that they are exposed to a signal 10,000 times stronger than necessary for mobile communication. With continued exposure to RF-EMF, people reported experiencing symptoms such as persistent headaches, head pressure, drowsiness, sleep disturbances, difficulty concentrating, memory lapses, nervousness, irritability, chest tightness, rapid heartbeat, breathlessness, depression, apathy, reduced empathy, skin burning sensation, internal heat sensation, weakened legs, limb pain, organ pain, and weight gain. Researchers have concluded that the current recommendations by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) are insufficient to ensure safe human living conditions. Consequently, some countries have established lower exposure limits than those suggested by ICNIRP. Surprisingly, it has been reported that the National Test Agency discovered that 9 out of 10 phones exceeded the permissible radiation limits. Despite this, the novel 5G technology is being deployed in numerous

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densely populated urban areas without a comprehensive evaluation of potential chronic health and environmental impacts. Additionally, 5G is not operating in isolation; it will coexist and intermingle with other frequencies and modulations including 3G and 4G, facilitating a wide array of devices continually evolving for the internet of things, which could exacerbate the situation further. The frequency range of RF-EMR extends from 10 MHz to 300 GHz. Cell phone technologies predominantly utilize frequencies between 800 MHz and 3 GHz, while cell tower antennas typically operate at frequencies of 900 or 1800 MHz, often pulsed at lower frequencies known as microwaves (ranging from 300 MHz to 300 GHz) (Sivani and Sudarsanam, 2013). In the USA, the SAR limit for cell phones is set at 1.6W/kg for 6 minutes. With a safety margin of 3 to 4, it is recommended that individuals do not exceed 18 to 24 minutes of cell phone usage per day. Specific Absorption Rate (SAR) quantifies the radiation absorbed by the human body, expressed in units of watts per kilogram (W/kg) of tissue (Kumar, 2019).To ensure that RF field emissions from each site remain below public limits and to explore any potential links with health complaints, power density serves as a measurable parameter.

The calculation for the power density (PD) of RF energy is expressed as: $PD = \frac{nPtG}{4\pi D2}$

Here, n represents the number of transmitters, Pt denotes the maximum power output from each transmitter, G signifies the antenna gain (in decibels), and D stands for the distance from the site to the transmitter (Pachuau and Pachuau, 2014).

Effects of Electromagnetic Radiations on Health:

i) Thermal and Non-Thermal Effects- RF-EMR emitted by cell phone towers can impact health through thermal and non-thermal effects. While the thermal effects, which involve a rise in temperature due to RF-EMR absorption, have been thoroughly researched and are widely acknowledged, the matter of non-thermal impacts remains a contentious issue. Despite numerous studies, the evidence supporting non-thermal effects is inconclusive, with only a handful showing compelling indications of their presence (Michaelson, 1988).

Thermal changes are responsible for EMR induced behavioral and cognitive effects. Thermal changes cause tissue heating that induces thermoregulatory alternate behavior (Andrea *et al.*, 2003). According to (Hancock and Vasmatzidis, 1998) some cognitive tasks were quite sensitive to small increases in body temperature. As per report of a thesis tadpole death occur during radiation trails due to temperature fluctuations but during such a study no detrimental effect was seen on catart development in humans due to frequency modulations (Watson, 2013). Considering non-thermal effects of RF-EMR, few studies regarded it as a serious concern. A study investigating the potential health impacts of ground wave emergency networks found that animals are more likely to use auditory cues, such as hearing pulses, to escape danger than the warming caused by continuous electromagnetic fields. Additionally, exposure to modulated RF radiations has been observed to alter EEG activity by stimulating nervous structures through electric and magnetic fields (Committee of NAS Washington, 1993). Furthermore, these studies indicated an increase in

glucose metabolism, suggesting heightened metabolic activity in brain regions closest to cell phone antennas, thus demonstrating the biological non-thermal effects of EMR.

ii) Short-term and Long-term effects- Prolonged exposure to electromagnetic radiation (EMR) can lead to electromagnetic hypersensitivity, characterized by symptoms such as tingling sensations, fatigue, dizziness, decreased mental focus, slower reaction times, reduced memory retention, tachycardia, and phantom pains, among others. Over extended periods, pregnant women have reported an increase in fetal temperature, which has been linked to potential birth defects in children (Guleria et al., 2020). Low-level electromagnetic radiation (LL-EMR) disrupts brain waves and the nervous system's regulation of sleep patterns, leading to disturbances in biological sleep cycles and related abnormalities in sleep quality (Changchitpaisan et al., 2019).

iii) Co-exposure studies-Very few studies are available on co-exposure. During a study on co-exposure of EMR (900MHz) and Noise (High level) in rats hyperphagia and body weight gain were observed whereas only the EMF group showed hypophagia (Pelletier *et al.,* 2019).

iv) Cancer studies- The studies on cancer reveal that exposure to higher levels of power frequency magnetic field is associated with the risk of leukemia in children [Ref?]. EMR or e-smog is toxic damages DNA and inhibits body tissues from repairing them (Rifai and Hakami, 2014). The International Agency for Research on Cancer (IARC) has categorized radiation from mobile phones as potentially carcinogenic, particularly linked to the development of brain tumors (Naeem, 2014).

v) Epidemiological effects - It was found RF-EMF, range(10MHz-3.6GHz) affects the mortality and development of embryos, breeding density, reproduction, and species composition in birds while in insects conflicting results were obtained. One study showed increased reproduction while another showed a decreased effect. In vertebrates, behavioral changes along with alteration in growth and mortality rate were observed. On similar exposures to Land Snail, *C.elegans* and *E. coli* growth and behavior alteration was seen (Cucurachil *et al.,* 2012).

vi) Genetic effects - Although in prior studies on genetic, growth and reproductive effects of EMR -No genetic effect with point mutations was found because of weak energies of photons to ionize genetic materials however Structural and Chromosomal changes were reported while amplifying radiations (Leach, 1979).

vii) Growth and reproductive effects of EMR- Extended mobile phone usage in men has been associated with reduced sperm concentration, motility, viability, and morphology, thereby contributing to male infertility. Additionally, mobile phones have been found to impact heart rate, TP segment, and T wave duration (Nageswari, 2015).

viii) Hematological effects- The studies in the field of hematology are rare and though needs further investigation. In a hematology study conducted under controlled laboratory conditions,

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exposed blood samples exhibited a decrease in platelet count while showing increased levels of hemoglobin, ESR rate, and white blood cell (WBC) counts (Christopher et al., 2020).

ix) Hormonal effects - The hormonal studies indicated tremendous effects of EMR but most studies were confined to brain hormones only. In a research investigation, alterations or suppression of brain hormones like melatonin were observed, which are linked with physiological disruptions such as sleep disorders, depression, stress, and cancers. The 60Hz magnetic field has been documented to decrease the activity of the Pineal gland in women. Furthermore, using cell phones for over 25 minutes per day has been demonstrated to diminish melatonin secretion (Warille et al., 2017).

x) Molecular effects- At the molecular level, exposure to low-dose radiation (LDR) triggers the generation of reactive oxygen species (ROS), inflammatory cytokines, and chemokines. This leads to the down regulation of various neurotrophic factors, resulting in impaired neurogenesis, cerebrovascular diseases, reduced cognitive function, weakened immune response, heightened cellular stress, and altered TGFB1 signaling, potentially causing inappropriate development of developmental genes (Tang et al., 2017).

xi) Effects on wildlife- Radio-telemetry is a method that utilizes radio signals to gather information about animals. This technique involves the use of electromagnetic fields (EMF), and prolonged exposure to it can influence various aspects such as orientation, reproduction, survival, behavior, and sex ratio in wild animals. Consequently, it is imperative to ensure that scientific techniques used for studying animals do not compromise the welfare or alter the behavior of the study subjects, and the scientific integrity of the results should remain unbiased (Steenhof et al., 2006).

The Government of India's Ministry of Environment and Forests established a committee to investigate the effects of radiofrequency electromagnetic radiation (RF-EMR) on wildlife. The committee reviewed a total of 919 research papers focusing on birds, bees, plants, other animals, and humans. Among these, 593 papers indicated impacts, 180 showed no impacts, and 196 were inconclusive (REF?). In response to these findings, the Department of Telecommunications in India implemented new norms for cell phone towers starting from September 2012. These norms involved reducing the exposure standards of RF-EMR to one-tenth of the existing level and lowering the specific absorption rate (SAR) from 2 to 1.6 W/kg (Sivani and Sudarsanam, 2013). Radiation exposures affect wildlife species in diverse ways, leading to either adverse or beneficial effects on fertility, tumorigenesis, and lifespan. These outcomes are influenced by factors such as genetic background, age, sex, and the nature of radiation exposure, which could be acute or chronic.

xii) Dose relationship effect- Individuals residing close to radiation sources are at a heightened risk of adverse health effects. A study revealed significant non-compliance with the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines, as the radiation levels

exceeded the accepted safe thresholds of 0.4 µT for magnetic field and 0.024 W/m2 for power density. This excessive exposure to radiation poses various health hazards to residents (Adekunk et al., 2015). Another study found that individuals living within a 50-meter radius of radiation sources reported more health complaints compared to those residing farther away. Additionally, females tended to report more complaints than males. The measured power density at all sites exceeded the safety recommendations outlined in reports such as the Bioinitiative Report, Salzburg Resolution 2000, and the European Union's (STOA) 2001 guidelines (Pachuau and Pachuau, 2014). According to (Than and Mon, 2020) in the GSM range 900-1800MHzMagnitude of EMF decreases 60% when location is 40-70 meter away from base station. But at 90mt. values get increased as measured location is straight with antenna. Power density is directly proportional to electric field. As we move away Power density also decreases. It was also revealed in a study that children absorb more radiation than adults and that happens due to less thickness of skull. 5years children absorption rate is -75% and in young- 50% and in adults-25%. EMF exposure involves general public as well as occupational group. At low frequency range of 1Hz 100 KHz (mobile communication base station) and High frequency range of 100 KHz- 300 GHz (radio communication) heating of body parts occur due to which Vertigo, Nausea and sensory disorders take place. Up to some extend EMR might be used for treatment of CNS disorders (Nupane, 2019). A study by (Premlal, 2017) on proposed standard of power density -200mW/m^2 Transmission antenna power-8.51W and ERP-425.5, revealed that 25% of sample population got affected by joint pain, Sleep disorder-23.03%, Migraine-23.9%, and digestion related problems-23.34%. Among all, females-53% and males-47% reported problems indicating that females are more prone to exposures than males. Middle aged were more victims to cell power radiation. There is a distinct necessity for accurate dosimetry in experimental protocols, accompanied by comprehensive methodological descriptions. While field situations may pose additional challenges, such as experimentally halting communication stations for maintenance periods, overcoming these obstacles remains feasible. There is a significant demand for further experiments and studies on the effects of RF-EMR, while adhering to existing guidelines (Cucurachil et al., 2012). The major devices used in most of researches comprised of Electro smog meters, Radiofrequency probes, Power and Gauss meters, antennas etc. (Pelletier *et al.*, 2019).

Research Gaps

The studies do not clearly define the duration of exposure, frequency ranges into consideration, intervals (if any) between exposures, and heating amplitude. All variables that have the potential to impact biological responses at a given specific absorption rate (SAR), including factors like sex, age, and the number of subjects, should be documented. In laboratory experiments, it is essential to steer clear of standard laboratory stressors. Additionally, efforts should be made to mitigate the influence of other intervening factors such as temperature, noise, and chemicals. Furthermore, factors affecting the absorption of RF-EMF, such as frequency, polarization, modulation, and field pattern, must be taken into account and reported, alongside other potential confounding elements. According to Michaelson (1991) and Beers (1989), experimental conditions must be precisely

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defined, with careful consideration given to selecting the most appropriate animal species for investigating the effects of RF-EMF, as inherent physical and physiological differences between species could serve as confounding factors. Although the causative effects of mobile phones have been intensively reported but all are based upon epidemiological relationships only and could not reveal any etiopathogenesis (Ozdemir and Kargi, 2019).

Strategies to combat RF-EMR

It has been suggested that the best building material is aluminum, Tin roof shields can also be recommended in buildings to escape from exposure, and we can use heat-reflecting windows and Polarized masks. It is also concluded by a study that top apartments are prone to much exposure than lower ones (Koppel *et al.*, 2019). Maintaining distance and proper shielding can protect us. Human dwelling should be avoided within 50mt. of tower. Regulatory bodies should re-examine the norms and set frequency limits. Moreover, a routine inspection with appropriate penalties should be there for non-adherence or non-compliance of the set limits by the organizations. We can minimize the exposure by reducing our dependence on electronic communication devices and using alternate media channels as much as possible.

Conclusion

Among all reviewed studies on the effects of RF-EMR, it is reported that much emphasis has been laid on the thermal effects while non-thermal effects are equally important but less work has been done considering it. In almost all studies mature/adults were considered to provide very little almost negligible attention to the immature group. Very less works were found on the effects of EMR on hematology and skin. Further studies in these areas are recommended. In some review articles it was also established that the female groups are more prone to risk than males. As the issue is quite relevant and burning further studies are necessitated to exploit the various effects of EMR on health for proper understanding and in the interest of human welfare. Moreover, the authorities/regulatory bodies should reconsider the permissible limits and take necessary steps to redress the vital issue. Furthermore, it is recommended that regulatory bodies and authorities reassess the permissible limits and implement appropriate measures to address this critical issue. A study conducted in 2008 found no consistent association between extremely low frequency (ELF) fields and self-reported symptoms. Additionally, none of the studies conducted to date have included immature groups. Moreover, investigations into neurological and reproductive effects have not identified any health risks associated with exposure levels below the ICNIRP limits established in 1998**.**This review found that very little attention has been paid to co-exposure studies and thus propose further studies exhibiting co-exposure.

Abbreviations**:** RF-EMR-Radio frequency electromagnetic radiation; SAR- specific absorption rate; MW- microwave; PD- power density ; GSM- global system for mobile communications; ICNIRP -International commission on non-ionizing radiation protection ; EMF- Electromagnetic forces.

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