5G Technology Effects on Human Health

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Abstract: **As wireless technologies like Bluetooth devices, Wi-Fi networks, and mobile phones have become integral to daily life, growing evidence suggests potential adverse effects on human health. With the arrival of 5G, utilizing higher-frequency millimeter waves, concerns about biological risks have intensified. This research paper explores the harmful impacts of prolonged exposure to wireless radiation, such as increased risks of cancer, fertility issues, cognitive disorders, and DNA damage. A Swedish case study is presented, where a couple experienced severe microwave syndrome symptoms after the installation of 5G antennas above their residence, with significant health improvements noted after relocating to areas of lower radiation. The findings highlight the urgent need for comprehensive monitoring, stricter exposure regulations, and continued investigation into the long-term health implications of widespread 5G deployment.**

1.ABBREVIATIONS

mmWaves: milli-meter waves

EMF: Electromagnetic Fields

2.EVOLUTION OF 5G

Advancements in wireless telecommunication technologies have revolutionized the manner in which humans interconnect, communicate, and exchange information. Every generation introduced dramatic enhancements in data rates of transmission, mobility, dependability, and services provided. The shift from analog to digital systems as well as from voice- to data-based services have laid the groundwork for today's integrated digital environments.

1G
1G represents the first generation of mobile networks, launched in the early 1980s. It was based on analog technology and provided only voice communication. Major limitations included low capacity, poor voice quality, and lack of security. An example system is AMPS (Advanced Mobile Phone System) used in the US.

2G
2G brought about digital communication, highly enhancing the voice quality as well as capacity in the system. It introduced SMS (Short Message Service) as well as low-level data transfer. CDMA and GSM technologies were notable amongst them. Safety and spectral efficiency also improved upon 1G.

3G
3G was developed for enhanced data rates, such that mobile internet access, video calling, and multimedia messaging became possible. It saw the dawn of mobile broadband and enabled services such as mobile TV and GPS. WCDMA and UMTS became the widely used standards under the umbrella of 3G.

4G
4G networks revolutionized mobile communication through IP-based architecture, providing high-speed internet, HD video streaming, and ubiquitous VoIP calling. LTE (Long Term Evolution) and WiMAX were major standards. 4G provided up to 100 Mbps or higher speeds, accommodating smart devices as well as cloud-based applications.

5G
5G is a paradigm change with the promise of ultra-reliable low-latency communications (URLLC), massive machine-type communications (mMTC), and improved mobile broadband (eMBB). Working in higher frequency bands (millimeter waves), it enables data rates in gigabits per second and serves billions of IoT devices. 5G promises to facilitate futuristic applications like autonomous vehicles, remote surgeries, industrial automation, and smart cities.

3. REGULATORY BODIES

3.1. International Commission on Non-Ionizing Radiation Protection (ICNIRP)
3.2. Federal Communications Commission

4. 5G EFFECTS ON HEALTH AND ENVIRONMENT

4.1 EFFECTS ON EYES

[6] Cataract formation continues to be a leading cause of blindness worldwide. Emerging evidence suggests that exposure to microwave radiation is a contributing factor in the development of cataracts. The ocular tissues, particularly sensitive to electromagnetic fields, are at increased risk during near-field exposures, such as those associated with 5G technology applications. Furthermore, exposure to the 5G spectrum has been linked to the onset of electromagnetic hypersensitivity (EHS), characterized by a range of symptoms including headaches, sleep disturbances, dizziness, cognitive impairments, cardiac palpitations, and persistent fatigue.

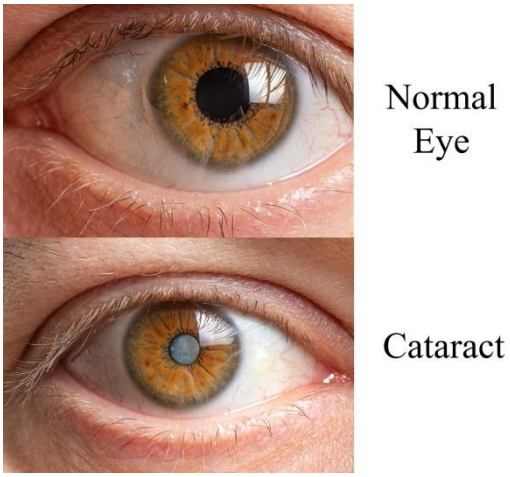

Figure 1: Formation of Cataract

4.2 EFFECTS ON NEUROLOGICAL SYSTEM

[6] The millimeter wave (mmWave) bands are capable of penetrating superficial tissues and are predominantly absorbed by the skin and ocular surfaces. Secondary biological effects are able to penetrate deeper into the body through systemic responses. Exposure to these EMFs has the potential to affect neuronal activity by modifying membrane potentials, neurotransmitter release, and synaptic transmission. Numerous studies have indicated that individuals exposed to such fields experience symptoms, which include headaches, cognitive dysfunction, impaired memory, decreased attention spans, mood disturbances, and elevated anxiety levels. Furthermore, individuals in high-density EMF environments, such as those near 5G base stations or in work environments, have experienced symptoms in line with electromagnetic hypersensitivity (EHS). Symptoms of these include headaches, sleep disruption, dizziness, cognitive impairment, mood swings, anxiety, and palpitations.

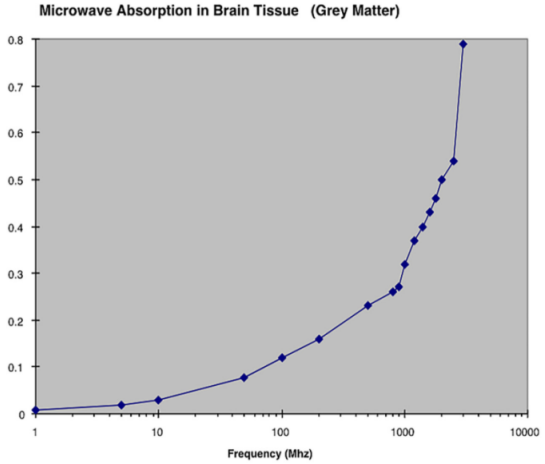

Figure 2 : Effect on Nervous System

4.3 EFFECTS ON SKIN

[6] The skin, as the body's primary barrier and the first point of contact with environmental electromagnetic fields (EMFs), is particularly vulnerable to exposure from 5G technologies, especially millimeter-wave (mmWave) frequencies. This radiation (30–300 GHz) is predominantly absorbed within the superficial layers of the skin, typically within the stratum corneum and upper epidermis. This localized absorption can induce a range of biological effects like cell membrane properties, modifying ion channel activity, and disturbing intercellular communication. Low-grade EMF stimulation could sensitize cutaneous nerve endings, potentially contributing to symptoms such as burning sensations, itching, redness, and unexplained dermatitis, which are often reported in cases of electromagnetic hypersensitivity (EHS).

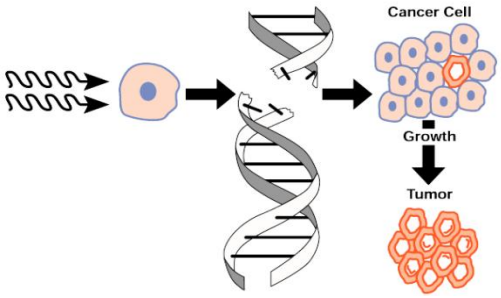

Figure 3: Cancer Formation due to Radiation

4.4 THERMAL EFFECTS

[6] Thermal effects are among the most basic biological concerns with respect to exposure to 5G

electromagnetic fields (EMFs) at millimeter-wave (mmWave) frequencies between 30 and 300 GHz. Due to the shallow mmWave penetration depth—nominally limited to the outer few millimeters of body tissues—the body skin attenuates a significant portion of the incident energy. Local energy absorption can lead to a rise in skin surface temperature; whereas the temperature increase is generally small (in the range 0.1°C to 1°C), cumulative or extended exposures, particularly in urban environments with high population densities, can produce higher thermal loads. Cellular thermal stress can trigger a range of protective and pathological responses. Heat shock proteins (HSPs), namely HSP70 and HSP27, are induced by EMF-induced thermal changes and are markers of cellular stress.

5. SPECIFIC ABSORPTION RATE (SAR)

[6] The Specific Absorption Rate (SAR) is an important measurement used to define the rate of electromagnetic energy absorption by biological tissues exposed to radiofrequency (RF) fields. Expressed in watts per kilogram (W/kg), SAR is a direct measurement of human body energy deposition and is of utmost importance in the evaluation of wireless communication devices like mobile phones, Wi-Fi routers, and new 5G technology. SAR calculation is dependent on tissue electrical conductivity, electric field strength in the tissue, and tissue mass density. Radiation characteristics depend on size, antenna design, and storage and use methods. SAR limits have been established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) to ensure public health protection, typically at 1.6 W/kg averaged over 1 gram of tissue or 2 W/kg averaged over 10 grams of tissue. In the case of 5G technology with increased frequency bands and complex beamforming technology, there have been concerns regarding the possible increases in localized SAR, especially at the skin and ocular surfaces where millimeter waves are mainly absorbed.Measurements of SAR values can be done both computational simulation and physical measurements Computational methods, such as the finite-difference time-domain (FDTD) technique,model how electromagnetic fields interact with anatomical models of the human body. Physical measurements involve using standardized phantoms—models filled with tissue-simulating liquids—along with specialized probes that measure the electric fields within the phantom material.SAR values are also influenced by the operating frequency and modulation scheme of the wireless device. At lower frequencies, RF energy penetrates deeper into the body, while at higher frequencies, such as those used in millimeter wave 5G technology (above 24 GHz), energy is primarily absorbed by the skin and superficial tissues.

5.1 SAR VALUES FOR DIFFERENT PHONES IN INDIA

Brand & Model	Head SAR (W/kg)	Body SAR (W/kg)
Xiaomi Redmi Note 10 5G	0.94	1.06
Realme 8 5G	1.190	1.173
Realme 9 5G	1.053	0.738
Samsung Galaxy A15 5G	0.56	0.65
Apple iPhone 13	1.18	1.17
Apple iPhone 14	1.143	1.108
Apple iPhone 15	1.12	1.09

Table 1: SAR values for different mobiles

6. CASE STUDY

[3] A case study was conducted in Sweden to study the effects of the 5g tower on a Swedish couple, which was installed on the rooftop of their apartment. Man aged 63 years and a woman aged 62 years that had lived in the same apartment in a Swedish city for 10 years. The apartment was located at the top 7th floor of the building. Until the 5G deployment they were both rather healthy.

On November 4, 2021 measurements were made of RF radiation in their apartment, i.e., before the 5G deployment which took place a couple of weeks later. The measurement was initiated by the couple as they were informed that new base station antennas for 5G were to be installed on the roof above their apartment. A base station for previous telecommunication generations (3G and 4G) was operating at the same spot already when they moved into the apartment.

The couple left their apartment for another dwelling, which was the man's office room, a few days after the deployment of the new 5G antennas. A couple of weeks later, on December 15th, 2021 the first measurement of the RF radiation from the new 5G

base station was made in the bedroom of their apartment, located just below the new 5G antenna as well as in the office room where the man and the woman had moved. Additional measurements in the apartment were made on February 2 and March 18, 2022 and in April in the house on the countryside where they moved in March 2022. All measurements were made daytime with the device Safe and Pro II with a true response detection range between 400 MHz and 7.2 GHz. It was calibrated by the manufacturer and has an accuracy of ±6 dB. (https://safelivingtechnologies. com/products/safe-and-sound-pro-ii-rf-meter.html). In Sweden in city environments, the frequencies around 3.5 GHz and below are most commonly used for 5G, i.e., frequencies covered by the exposimeter.

The man and the woman were asked to evaluate prevalence and severity of microwave syndrome symptoms experienced in the different exposure situations.

7. RESULTS

Place	Apartment with 4G/3G before 5G[1]	Apartment after 5G deployment[2]	Apartment after 5G deployment[3]	Apartment after 5G deployment[4]	Office space where the couple moved to[5]	New home countryside[6]
Bedroom	9 000 (NA)	354 000 (NA)	1 690 000 (5 000-20 000)	> 2 500 000 (9 000-50 000)	3 500 (20-105)	33 (2-6)
Living room	2 000 (NA)	51 000 (NA)	222 000 (1 400-3 500)	183 000 (500-5 200)	NA	300 (2-6)
Hall	3 000 (NA)	154 000 (NA)	269 000 (500-3 500)	342 000 (400-10 100)	NA	NA

Table 2: Levels of maximum (peak) microwave radiation in apartment before 5G, with 5G, in office space and present home on countryside. Measured average levels over 2-5 min. in brackets (μW/m²).

NA= Not available.

Symptom	Before 5G November 2021	With 5G November 2021	After 5G (office space) January, 2022	After 5G (house countryside) March 2022
Headache	0	6	0	0
Dysesthesia	0	0	0	0
Myalgia	0	0	0	0
Arthralgia	3	3	3	4
Ear heat/otalgia	0	0	0	0
Tinnitus	2	6	2	3
Hyperacousis	0	0	0	0
Dizziness	0	0	0	0
Balance disorder	0	0	0	0
Concentration/Attention deficiency	0	0	0	0
Loss of immediate memory	0	0	0	0
Confusion	0	0	0	0
Fatigue	0	7	0	0
Insomnia	0	5	0	0
Depression tendency	0	3	0	0
Suicidal ideation	0	0	0	0
Transitory cardiovascular abnormalities, heart rate variability	0	0	0	0
Occular deficiency	0	0	0	0
Anxiety/Panic	0	0	0	0
Emotive	0	3	0	0

Table 3:Clinical symptoms grades 0-10. 0 = no symptoms, 1 = mild symptoms, 10 = unbearable pain and/or discomfort. Previously healthy men and women aged 63 and 62 years respectively.

8. CONCLUSION

[]The rollout of 5G technology has introduced significant biological concerns due to its distinct electromagnetic properties, particularly at millimeter-wave (MMWave) frequencies. While 5G enables higher data rates and extensive IoT connectivity, there is growing evidence that its radiation can adversely affect human health and wildlife. Sensitive tissues such as the eyes and skin appear vulnerable, with potential outcomes including cataract formation, skin inflammation, and

localized thermal effects. Although Specific Absorption Rate (SAR) remains a critical parameter for evaluating human exposure, existing models may need refinement to address the complexities of beamforming and higher-frequency transmissions. Current safety standards focus on limiting acute exposure risks, but the long-term effects of chronic low-level radiation are still not fully understood, making a precautionary approach and further interdisciplinary research essential.

This study reinforces these concerns by documenting symptoms characteristic of microwave syndrome, notably impacting the nervous and cardiovascular systems, following the installation of 5G base stations. Measurements taken before and after deployment showed a strong link between very high radiation exposure and the onset of symptoms, particularly in living spaces located near rooftop antennas with minimal shielding. Health improvements observed after relocation to areas with lower radiation levels further underline this association. These findings align with previous research on mobile base station exposure, though symptoms in this case appeared at much higher intensities. As 5G becomes more widespread, ensuring the safe integration of this technology into daily life must involve stricter regulation, updated exposure standards, and continued research into its biological effects.

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