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The Side-Effects of 5G Between Hypothesis and Theory

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Abstract. Despite the fact that the ongoing world's trends towards competitive improvement, the fifth generation (5G) of broadband wireless telecommunications hypotheses states controversial difficulties and effects negatively the end-users. Without a doubt, this generation will increase the speed of communications, will provide access network to billions of subscribers, and hence a trend to lower cost. But on the other hand, will lead to contradicting voices on the side effects on the end-users. 5G operates in the millimeter-wavelength whose frequency spectrum between 25 to 100GHz. Most of the 5G applications are above 50GHz. Thus, this super high frequency opens points of arguments as far as the end-user's health and safety concerns. In this paper, the authors tried to identify the different sources of EMF that human is exposed to, the UV, the X-ray, the power supply networks. Critically Electro-Motive-Force (EMF), and the telecommunication FR generation including the 5G. The ongoing hypothesis state that 5G sources can generate radiofrequency radiation, which can affect DNA, cell growth, and pre-mature aging. In this paper the side-effects of mm-waves have been presented together with a proposed protection measures to protect end-users. The mm-waves applications and its pre-active means are not limited to telecommunications, it goes beyond that, in e-government, e-business, security, and e-Health, industry, and so forth, that is to say, wide sectors of any society, thus the 5G will be an issue of a smart city. The side-effects of 5G must be considered alongside with requirements for safety and better health for the end-users. The paper found no conclusive evidence based on experimental documented informative data that the 5G can cause harm to health. To testify to any given hypothesis, sufficient empirical investigations are needed to find a well-tested hypothesis. The finding so far is that FR can cause negligible heat energy to the skin of the end-user.

INTRODUCTION

The introduction of the so-called G-dynasty has started in the year 1980, hence 1G First-generation 0started in 1980. The generation started in ten yearly cycles as shown in Table 1. The research on the Fifth-Generation cellular networks started to increase the bit rate significantly, up to 20 GB/s. In general, the points of concern regarding the introduction of the 5G on health has become dominant in media by the year 2020. Table 1 shows the five generations, market introduction years, and their bit rates.

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TABLE 1. Development of Wireless Generations

Generation	Year of opened to market	Bit Rate	Service	Remarks
1G	1980	605 bps	Voice	Communications -calls
2G	1990	9.6 Kbps	Digital Voice	Voice messages
3G	2000	2MPbs	UMTS	The Universal Mobile Telecom System
4G	2010	300Mbps	LTE	"long-term evolution,"
5G	2020	20Gbps	MEC	Multi-access Edge Computing

Worldwide Concerns

European Scientists signed a statement that 5G will substantially increase exposure to radiofrequency electromagnetic fields (RF-EMF) on top of the 2G, 3G, 4G, Wi-Fi, etc. Professor Hardell of Oncology at Örebro University in Sweden states that RF-EMF has been proven to be harmful to humans and the environment [1]. He stated that symptoms related to the side-effect of EMF are a matter of assumption which requires real study for justifications [2]. P. Martin has provided a substantial body of evidence on the existence of each effect. He stated many symptoms such as the attack on the nerve system, hormonal system, on DNA, produce stress on programmed cell death, infertility, excessive calcium signaling, and eventually cause cancer [3]. Also, there is substantial literature showing that EMF cause other effects including life-threatening cardiac effects, early including Alzheimer's, and autism [4].

MATERIALS AND METHOD

In this paper, the authors intended to critically investigate innovations and challenges of 5G and its application such as mm-waves. Presenting the different forms of RF and EMF that might have side-effects on human health, then depth into the update effects and remedial actions being taken to safeguard the %G effects to end-users.

Millimetre Waves

The carrying signals millimeter-waves are electromagnetic (radio) waves of a wavelength whose spectrum between 1 mm and 10 mm called mm-waves. International Telecommunication Union ITU specifically denoted 30 to 300 GHz as spans frequencies for the mm-waves with data transfer rate up to 1Gbps [5]. A bulk data transfer in the communications applications will surely enhance unusual electromagnetic waves that will overlap human internal organs of a low-frequency nature as indicated by Figure 1 [6].

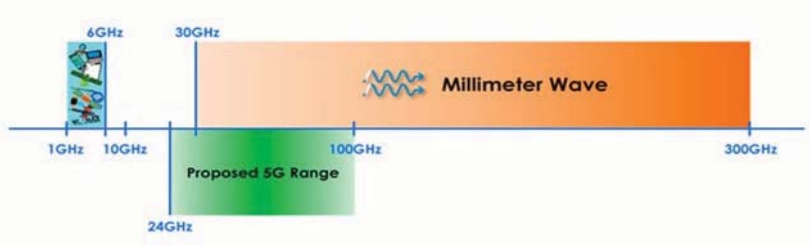

FIGURE 1. Mm-waves frequency spectrum

The specific absorption rate (SAR) is the rate of energy deposited per unit mass per unit time. The (SAR) is proportional to the root-mean-square (RMS) of the induced electrical field strength [E] 2 and the electrical conductivity (σ) of the tissue and inversely proportional to the tissue density (ρ) as shown in equation (1):

$$SAR = [E]^2 . \sigma / \rho \quad (1)$$

The SAR is expressed in W/Kg, SAR also can be calculated using equation (2) where T represents the rise in temperature of the tissue due to RF-energy absorption:

Where Cp is the specific heat of the tissue, δT/δt is the differential rise in temperature per time. Values for the dielectric constant and conductivity may vary substantially over the RF range (30 MHz to 300 GHz). To cause a biological response, the EMF must penetrate the exposed biological system and induce internal EMFs. RF-energy absorption depends on incident field parameters (frequency, intensity, polarization), zone of exposure (near field or far-field), characteristics of the exposed object (size, geometry, dielectric permittivity, and electric conductivity), and absorption or scattering effects of objects near the exposed body [7].

Based on the relationship between wavelength (λ) and frequency where c is the speed of light (3 × 108 m/s), it is obvious that the wavelength (λ) of RF radiation varies substantially between 30 kHz (10 km) and 300 GHz (0.1 cm) as shown in Table 2

$$SAR = C_p . \delta T / \delta t \quad (2)$$

TABLE 2. Shows the calculated wavelength for different frequencies for mobile phones

Frequency f	Wavelength λ	Remarks
30 kHz	10 km	-
1 GHz	30 cm	-
2 GHz	15 cm	-
50 GHz	0.6 cm	Operated 5G
300 GHz	0.1 cm	-

The specific absorption rate of energy absorbed by body tissue, due to mobile usage. SAR maximum calculated value is ≤ 2 W/Kg.

Coverage Issues

To cover every area using 5G is a difficult task due to the high cost in less populated areas. Recent studies have shown that, under a business-as-usual model, in the UK 90% of the population will be covered with 5G, not before 2027, which might mean such coverage cannot be achieved. It can be clearly said that there will be more coverage per base station (macro sites) at lower carrier frequencies, and a restricted coverage area per base station (micro and Pico sites) at higher carrier frequencies. This is one of the major reasons why the 5G New Radio NR needs to exploit frequencies in the mm-wave range, as well as aggregation of multiple wideband carriers [8].

Non-Ionizing Radiation & Ionizing Radiation

Ionizing radiation and x-ray both differ from non-ionizing radiation in the way they react with living tissue. They both can provide enough energy to remove electrons from molecules and atoms from substances. The non-ionizing radiation simply can heat materials an example of which warming food inside the microwave oven.

Ultraviolet Light UV

Invisible light called also black light can release Ultra-violet (UV) radiation, it is a natural part of solar radiation, and The World Health Organization (WHO) recommends 5 to 15 minutes for white-skinned, and double the period for dark-skinned people of sun exposure 2 to 3 times a week to get enough vitamin D. Normal UV exposure can be

helpful to produce vitamin D. An accessible exposure to UV radiation can cause skin burns, skin cancer particularly to white skins individuals, premature aging, and eye problems [9].

High Tension Power Radiation EMF

It has been investigated children living in homes as far as 600 m away from power lines had developed an elevated risk of leukemia. An increased risk of 69% for leukemia was found for children living within 200 m away from power lines while an increased risk of 23% was found for children living within 200 to 600 m away of the power lines [10]. Recent reports confirmed that there is no harm was found due to High tension power transmission lines [11].

5G Technology & mm-waves Health Care Effects

A continuous exposure to radiation of 5G, can be source of concern on health, the ever-continuous source of communication can generate RF radiation which can affect the DNA. It can also lead to uncontrolled cell growth, and premature aging and other diseases [12]. The direct usage of mobile phones can reverberate in frequencies that interfere with heartbeats mode, particularly those individuals who are exposed to unstable conditions of COVID 19 and similar viral diseases [13].

Multipath Reverberation of mm-waves Signals

Figure (2) shows the Millimeters waves reverberation due to buildings surfaces and atmospheric absorption; this will of course lead to energy attenuation before reaching the receiver. The amount of energy received by an individual depends on body surface area and body volume. Since the RF radiation is mainly no-ionizing, it is then causing heat gain to body users. Then again, the end-user is a heat sink which is a function of the duration of phone use, the number of incoming calls, and the distance from the phone. In all research, there is no conclusive evidence that mobile phones can have a direct effect on the health of end-users. This needs close monitoring and data acquisition to volunteers exposed to RF radiation for years. COSMOS is pursuing research on individuals which lasts for 20 to 30 years before one can get solid evidence of mobile usage's effect on health. 290,000 Individual ages 18 years and older are selected for the project [14].

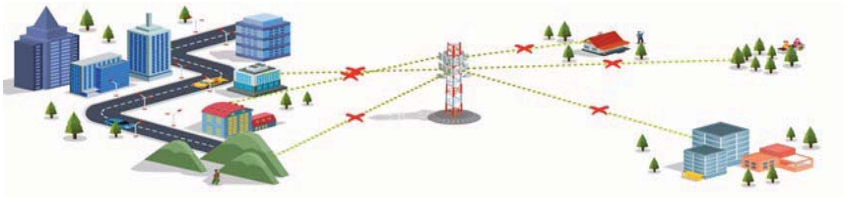

FIGURE 2. Millimeter waves Wave Reverberation due to buildings surfaces and atmospheric absorption

RESULTS AND DISCUSSION

The 1G made users communicate using mobile, the 2G allowed to exchange messages. 3G made it possible to send extended data and internet, the 4G provided high speed of communication and best quality, the 5G is not only made to provide quality and speed hundreds of times more than the 4G, but it is revolutionizing our life. The 5G can reach 1millisecond latency in data transfer, while human latency varies from 200 -300 milliseconds i.e., that the delays are negligible, and the communication is instantaneous. It will enable us to activate instruments without delays, it enables us to operate self-driven cars communicate without accidents, doctors can do operations from remote parts of the world, this applies to agriculture and industry alike. It must be said nothing is coming for free, it provides concern related to side effect on health, at the same time it covers the short distance in comparison with 4G, the 4G can travel 10 km without any disconnection, the 5G cannot reach 300m, it cannot cross walls and very much affected by the environmental changes; this means more sources or stations between houses and factories. Despite the COVID 19 pandemic, the coverage rate is in the rise as shown in Table 3.

TABLE 3. Shows the typical coverage cases of 5G coverage in some countries and the world

Country	Percentage Coverage	Expected Year
UK	90%	After 2027
UAE	80%	2021
Switzerland	90%	2019
Worldwide	60%	2026

Modes for Dealing with Health side Effects

The common practice for dealing with 5G technology exposure aims to boost human immune system. To boost our immune system can be managed simply by following a lifestyle like early sleeping, early walking, excessive water drinking (around minimum 1.5 liters of water a day) and daily walking at early times. This daily routine must be supported with proper natural ventilation in the living space, specific itemized food taking, deep breathtaking many times daily followed by breath-holding for around 60 seconds, mouth wash with salty water four times a day, sun exposure to a minimum of 30 minutes daily, and no mobile usage during the infection period. Along with the above practices, we need physical isolation to the source of 5G radiation as well. It has been noticed that breathing hot air proved to be an effective means to speed up recovery from the COVID 19 [15]. The sown sample of the calculations of energy absorption by human body tissues has no significant effects on human health. The Cohort Study of Mobile Phones Use and Health (COSMOS) study that has been done is the most reliable in the long answers to testify and to find answers to such hypothesis of RF and mm-wave effects on human health. It is possible to say that species are always adapt themselves to environmental resistance for survivals, human can develop such resistance to RF mm-waves in the long run

CONCLUSIONS

Millimeter-wave makes it possible to have a lot of transmitters and receivers installed that will definitely make individuals exposed to their side-effects. The available formula for estimation of specific energy absorption SAR has no significance as far as the mm-wave effects on health since it ignores the penetration of RF into the bodies. The millimeter-waves development is the dominant innovation of 5G technology. The 5G technology is not limited to telecommunication services but it represents the beyond technology in research, automotive, energy, e-business, e-government, e-economy, vertical industry, security, experimentations, e-Health, sport, which improve human being's life and facilitates the challenges of technology services and save money and space and offer faster speeds for uploading and downloading services; this is done on the expense of inevitable side-effects on health. The COSMOS long-term project to study the mm-wave effects on health may be the promising answer to RF effects on health. A protective health measures and followed special living style must be introduced to safeguard individuals of 5G Technology effects, human body can adapt itself in the long run to external changes within the environment.

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