Independent Review on the Sources of Electromagnetic Radiation in Telecommunication: Emphasizing on Cell Phone Communication and Public Awareness Creation

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ABSTRACT

Cell phone usage is increasing rapidly as people's knowledge of its importance in communication and its relevancy in ease of communication is becoming well known to people. Technology growth, improvement, and affordability are perhaps the reasons for this increased number and usage. This study extends the boundary conditions of existing literature by studying the alterations in the terrestrial electromagnetic environment which are believed to have a negative impact on the biological systems of human beings. The microwave frequencies used in cell phones cause both thermal and non-thermal effects. The cell structures of human beings are affected by EMR from mobile antennas and base stations. It is also believed that EMR is a major cause of cancer. EMR is absorbed as it interacts or intermingles with matter and transfers wave energy into the medium. The quantity of RF-EMR radiation energy absorbed by human tissue depends on the duration of exposure, intensity, frequency and polarization. Previous studies show that residents living near mobile phone stations complain of nonspecific symptoms of ill-health such as headache and sleep disturbances. This paper is an independent review of the Sources of Electromagnetic Radiation in Telecommunication with emphasis on Cell Phone Communication and Public Awareness Creation.

KEYWORDS: Electromagnetic spectrum, Communication, Health Communication, Biological effects, electromagnetic radiation

Introduction

The emergence of cell phones in the global information and communication arena has grown rapidly, and their importance to diverse users cannot be overemphasized. The number of cell phone users has increased tremendously due to the reduction in price, availability, and

portability. Most people perceive cell phones as the most convenient means and mode of communication. Due to the overwhelming importance and advantages of the cell phone, which is considered one of the major sources of communication, most people are unaware of or do not consider its disadvantages or negative side effects.

In Nigeria, for instance, as at 2019, there were about 185 million mobile subscribers, which accounts for a penetration rate of 87% of the population. This figure represented a 6.4% growth increase compared to 162 million subscribers in 2017 (Statista 2021). Nigeria also has 24,252 telecommunication towers (www.gsma.com). Due to the need to provide good cell phone coverage to the users, most of these towers are mounted near office buildings and residential areas. In order to provide maximum coverage, the antennas need to be very high. The Federal Communication Commission states, "cellular or PCS cell site towers are typically 50-200 feet high". Cell phone towers can exist as stand-alone structures, or an antenna can be attached to water towers or the roof of the buildings (https://www.reference.com). The combination of antenna towers and associated electronic equipment is referred to as a "cellular or PCS cell site" or "base station". In urban or sub-urban areas, sector antennas for 2G and 3G transmission are used. Broader sector antennas for 4G transmission and parabolic microwave antennas for point-to-point communication are also used. 4G networks consume more bandwidth than 2G or 3G networks. Thus, this study gears towards creating public awareness as its awareness is believed not just in promotion of disease control, but also in its prevention. Hence, in this study, the researchers have discussed extensively the sources and impact of cell phone communication radiation on its users and have also proffered methods to reduce the effects of RF-EMF radiation.

The Concept of Health Communication

Communication is an exchange of information between and among individuals, groups, societies, organizations across various media or channels. It is simply the transference of information from one source to another. The exchange of information could bring about changes in behavior and attitude. It could also lead to cognitive and physical changes. It is paramount to know and understand the process of communication in order to develop messages which can be passed through various channels in order to provide a target audience with relevant health information, which in turn will help them and influence their attitudes, health beliefs, and behavior. Therefore, health information and education, which are all aspects of communication, lead to actions, decisions, beliefs, and behaviors which invariably produce positive health results.

Health is wealth and is needed for life and development. Anyone who is challenged with his or her health can do little or nothing. It is only those that are healthy that can be interested and involved with developmental issues. According to Jonas, Goldsteen and Goldsteen, cited in Parker, Woelfel, Hart, and Brown (2009), health is:

> A state characterized by anatomical, physiological, and psychological integrity, the ability to perform valued family work and community roles, the ability to deal with physical, biological, psychological, and social stress, a feeling of well-being, and freedom from the risk of disease and untimely death. (pg. 4).

The United Nations Development Programs (UNDP) emphasized the importance of good health by developing Millennium Development Goals (MDGs) that have goals that are health-related. Out of the eight (8) MDGs, three are health related and they are: reducing

child mortality, improving maternal health and combating HIV/AIDS, malaria and other diseases. (http://www.un.org/millenniumgoals/).Some diseases are silent killers, like the impact of cell phone radiation on their users. Knowledge is power, and most people are destroyed and perishing for lack of knowledge.

Therefore, positive health outcomes in society might not be sufficiently achieved without the contribution or input of the communication aspect, as has been rightly observed by researchers in behavioral sciences. Health-related fields such as Anatomy, Pharmacy, Physiotherapy, Microbiology, Medicine, Laboratory Sciences, Biochemistry, Nursing, Radiography, and Radiology have, through various researchers, investigated the causes, signs and symptoms, treatment, or management of different health conditions. The use of communication activities in the health sector is vital in addressing the variables that affect health issues, which may not be addressed by the medical sciences (Parrot, 2004). The application of communication to health is known as health communication.

Areas in Health Communication and Awareness Creation

Since coming into existence over four decades ago, the field of health communication research has experienced significant growth and development. This is as a result of the interdisciplinary nature of the field. There are two broad areas of communication in health: health-related information and health-related behavior (Witte et al., 1996). According to these researchers, health-related information means any information that is relevant to an individual's mental, physical, emotional, and spiritual well-being, while health-related behavior refers to an action or non-action that influences an individual's mental, physical, emotional, and spiritual well-being. It is obvious from those two categories that health communication is multidimensional and multidisciplinary in nature. It involves attitude or behavioral change and is not only about awareness creation. The motive of creating awareness is for attitudes or behaviors to change in a positive dimension. There are, however, other areas of health communication which include advocacy for health ethics and health care policies, disease prevention and self-management of health conditions, and health promotions. Creating awareness and putting communication strategies in place that are suitable for human communication, while putting the objective, message, target audience, and cultural environment into consideration.

In communication strategy, the goals of health communication strategies are awareness creation, enlightenment, health education, advocacies, cultural review and evaluation. The target audiences are care givers, health professionals, media practitioners, care seekers, employers of labor, families, friends and policy makers. The best methods and channels of communication should be used and messages addressing what is expected of them should be marshaled out. The mass media can be used as a channel of communication as well. Campaigns, posters, hand fliers, billboards, shows, and face-to-face interaction can be used as well. For message dissemination, multiple channels of communication can be used to ensure information gets to a scattered and heterogeneous audience. Strategies for health communication must include mass communication advocacy, behavior change communication and participatory communication.

Literature review

Since the last couple of decades, the world has become a global village owing to the growth and impact of communication technology. As a result, the global electromagnetic environment has been altered considerably by humans in the quest for sustenance and

advancement of these technologies. The alteration in the terrestrial electromagnetic environment is believed to have some harmful effects on humans and as such, has become a global public health concern.

It is very common nowadays to find telecommunication masts, cell phone towers, and transmitting antennas in major cities, townships, suburbs, and even in remote rural communities. Cell phones have become a very common commodity in the hands of many, and all of these release radiation energy by way of emission into the atmosphere. These rays travel in waves through the air, spreading to the whole immediate environment.

The radiation from communication gadgets is grouped among a group of radiations with similar characteristics called electromagnetic radiation or waves. All these waves are arranged in a spectrum called the electromagnetic spectrum, depending on the magnitude of their frequencies (or wavelengths). Communication equipment, including cell phones, emits radiofrequency (RF) or electromagnetic field (EMF) radiation, which is predominantly low-energy radiation called non-ionizing radiation.

Electromagnetic Spectrum and Types of Electromagnetic Radiation

The electromagnetic spectrum is an array of electromagnetic radiation consisting of waves of electric and magnetic energy moving together (i.e., radiating) through space at the speed of light (Kemal *et al.*, 2013). All forms of electromagnetic radiation (EMR) are propagated as waves and placed on a spectrum of low-to high-energy radiation (Figure 1). The EMR spectrum is widely discussed in physics and is used in different areas of science and technology, and it is broadly divided into two categories (types), namely, ionizing and non-ionizing radiation, with respect to the energy of the radiation, which is a function of the frequency of propagation of the electromagnetic wave.

Ionizing radiation has high energy as compared to non-ionizing radiation. The ionizing radiation has frequencies ranging from 1 PHz (petahertz) to 10 ZHz (zettahertz). They include X-rays, Gamma rays, cosmic rays, etc. In interaction with matter, ionizing radiation has the capacity to cause changes in the structure of atoms or molecules by ionization, thus causing damage to living atoms or molecules. They also have the tendency to cause changes in the structure of DNA in living organisms.

The non-ionizing radiation has frequencies ranging from 1 to 1000 THz (terahertz). They include extremely low-frequency radiation (ELF), very low-frequency radiation (VLF), radiofrequency radiation (RF), microwave (MW), infrared (IR), visible light (VL) and Ultra-Violet light (UV) (Batool *et al.*, 2019; Ju *et al.*, 2019).

Although there has been controversy as to the harmful effects of these non-ionizing radiations, some studies (Diem *et al*., 2005; Erogul *et al*., 2006; Khan, Zaman and Muzafar, 2008; Khan, 2008; Markov, 2015; Ghosh, Paul and Abadin, 2017) have shown that indeed, they could constitute a serious health hazard.

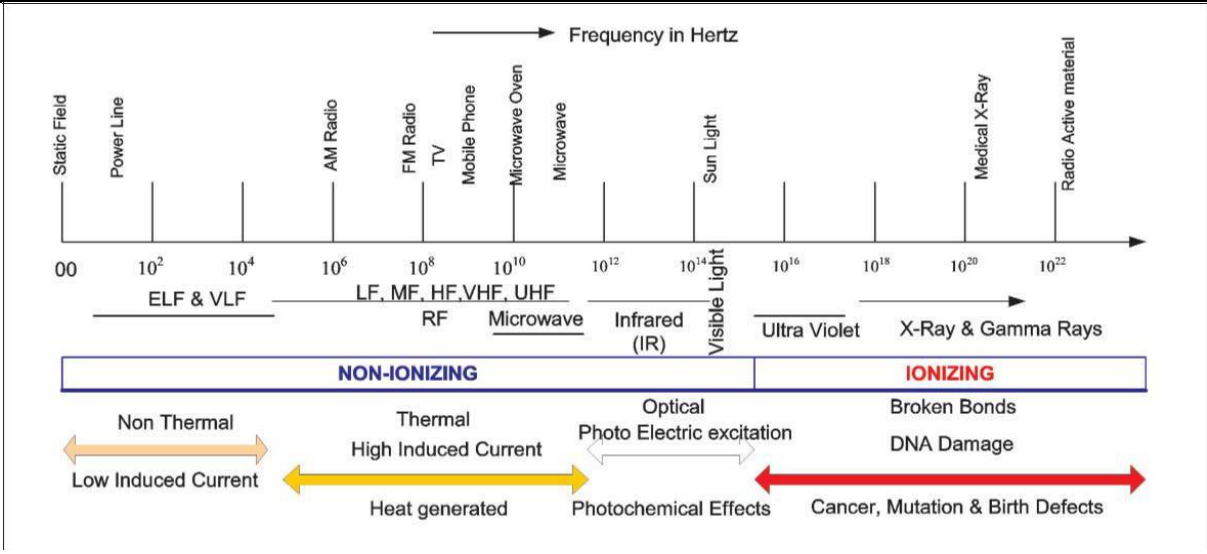

Figure 1: Electromagnetic Spectrum: (www.ncc.gov.ng.>docman-main>policies-reports>file)

RF – EMF Radiation

The term Radiofrequency (RF) or Electromagnetic Field (EMF) is used to indicate the presence of electromagnetic or RF energy. Radio waves and microwaves emitted by transmitting antennas are one form of electromagnetic energy. Cell phones and other communication equipment emit RF or EMF radiation in the Low Frequency (LF), Medium Frequency (MF), High Frequency (HF), Very High Frequency (VHF), Ultra High Frequency (UHF) and Microwave (MW) and Millimeter wave (i.e., 30 kHz to 300 GHz) regions of the electromagnetic spectrum.

An RF or EMF field has both an electric and a magnetic component (electric field and magnetic field). RF waves (radiation) are produced whenever there is a flow of electric current through a wire or cable placed in a magnetic field. That is, the RF wave is a byproduct of the interactions between the electric field and the magnetic field (Sears, Zemansky, and Young, 1980; Littlefield and Thornley, 1980). It is often convenient to express the intensity of the RF environment at a given location in terms of units specific for each component. For example, the unit "volts per meter" (V/m) is used to measure the strength of the electric field and the unit "amperes per meter" (A/m) is used to express the strength of the magnetic field (Kemal *et al.*, 2013).

Sources of Electromagnetic Radiation in Telecommunication

Electromagnetic (EM) radiations encountered in telecommunication are the radiofrequency (RF) and microwave (MW) radiations which have low energies. Like all electromagnetic radiations, RF and MW radiations come from two sources: the natural sources and the man-made sources.

The Natural Sources: Natural sources of RF and MW radiation include outer space and the sun, the sky, including lightning strikes and the earth itself. Most radiation from the earth is infrared, but a tiny fraction is RF (American Cancer Society, 2020). Cosmic rays, visible

light, ultraviolet rays and gamma rays (a byproduct of naturally occurring radioactivity) are other examples of electromagnetic radiation from natural sources.

Man-Made Sources: Man-made sources of RF and MW radiation include radio and TV transmitters, radars, microwave ovens, microwave radio systems, transceivers, handheld radio transceivers, amateur radio transceivers, transmitting signals from cordless telephones, mobile/cell phones and cell phone towers, satellite phones, and 2-way radios, WiFi, Bluetooth devices, and smart meters (Vladimir *et al.*, 2019; American Cancer Society, 2020). Other man-made sources include RF signals from magnetic resonance (MR) scanners, medical procedures involving heating of body tissues to destroy them, Millimeter wave scanners (a type of full body scanner used for security screening) and welding using certain specialized machines (e.g., welding pieces of polyvinyl chloride).

Although RF and MW radiation are classified as non-ionizing in the sense that they have low energy and cannot knock off electrons from an atom (ionization), atoms floating around the fields get excited and become unstable. To become stable again, this energy of excitation acquired by the atom is released by a process called emission. Excitation of atoms in body tissue can result in some harmful effects. This is the reason emissions from telecommunication gadgets have become a global public health concern. Olorunfemi et al. (2016) state that "microwave radiation level depends on the configuration of the antenna on the masts (the types, number, orientation, tilt, operating power, etc.), the height of the mast, the topography of the region, distance to the point of measurement, and intervening medium (houses, vegetation, etc.). "The operating power of the mast depends on the level of use at a particular point in time".

Mobile phones and Wi-Fi devices emit pulsed microwave radiation. It is the pulse, rather than just the power, that appears to be biologically important. When having a conversation, the level of power fluctuates, going up and down again (variation). For several minutes a month and for several hours a week, over a lifetime, one is exposed to these irregularly pulsed signals. Even if the radiation is too weak to cause damage as X-rays, there will be effects from the pulsed nature of the signal and power of the signal too. It is this variation in the signals and the cumulative integrative dose over a lifetime exposure that is of biologic importance. The long-term effect of pursed MW radiation is the cause of the harmful biological effects.

Hazards from RF-EMF Radiation

There is a plethora of health hazards that can arise from the use and misuse of both ionizing and non-ionizing radiation. A large chunk of them have been discussed in this work, but there are still some that have not been covered. For example, risk to the bone, endocrine glands, blood, cardiovascular and lymphatic systems. Suffice it to say that so long as these organs are composed primarily of cells, the building block of all tissues and organs, they are equally susceptible to radiation damage on exposure to EMR. The effects of RF-EMF radiation on bone are discussed in (Kanimozhi et al., 2018), the endocrine gland and lymphatic system in (Wood et al., 1998; Burch et al., 1999; Singh and Kapoor, 2014), and the cardiovascular system in (Savitz et al., 1999; Ghione et al., 2004; Singh and Kapoor, 2014).

Interaction of RF-EMF Radiation with Biological Systems

There will be no biological effect of RF radiation if there is no interaction between the EMR energy and the biological system. The interaction of EMR with matter happens in three ways:

scattering, absorption, and transmission (Meredith and Massey, 1977; Cameron and Skofronick, 1978). Scattering is a process whereby the incident EM waves are reflected back in different directions when they come into contact with an object with energy much less than the energy of the incident radiation energy. A given percentage of this incident radiation passes through the object to emerge from the other side of the object (i.e. transmission). The remaining percentage of the incident energy is retained in the object as absorbed radiation energy (absorption). The absorbed radiation energy is the one that precipitates all the known hazards of EM radiation.

When RF radiation is absorbed, it reacts with the body by exciting the atoms so that electrons within the atom gain enough energy to jump from a lower energy shell to a higher one, but it remains unstable in that state until it returns to the ground state, losing the energy of excitation to the surrounding tissues, heating up the body, and causing other potential hazards.

Methods to Reduce the Effects of RF-EMF Radiation

The health problems associated with the long-term effects of EMR from telecommunication and biomedical devices have been discussed extensively at different international fora and by different world bodies responsible for regulatory and provision of safety guidelines on the use of radiation-producing gadgets. The World Health Organization (WHO), Federal Communication Commission (FCC), and International Commission on Non-Ionization Radiation Protection (ICNIRP) have recommended some safety guidelines for the protection of humans and other living things. Adhering to these safety guidelines does not imply nullification of the harmful effects of the rays; rather, they represent a litany of the do's and don'ts to ensure a reduction in exposure to the radiation and, thus, minimize the effects. Some of the safety measures include:

1. Keep a safe distance from telecommunication masts, antennas, and cell phone towers.
2. Limiting the time spent near appliances, equipment, and other devices that give off RF radiation (such as WiFi routers)
3. Limiting the time spent using a cell (mobile) phone or reducing the time of calls
4. Limiting the time, a cell phone is placed against one's ear or close to any other part of one's body.
5. Limiting EMF exposure
6. Use of EMF protection devices and shielding devices

The ICNIRP has given separate guidelines for occupational exposures and exposures of the general public. Occupational exposure refers to adults exposed to time-varying electromagnetic fields from 1 Hz to 10 MHz at their places of work, generally under known conditions, and as a result of performing their regular or assigned job activities. The general population refers to individuals of all ages and of varying health status who might be exposed to EMF radiation. Often times, members of the public are unaware of their exposure to EMF. These considerations underlie the adoption of more stringent exposure restrictions for the public than for workers while they are occupationally exposed (ICNIRP, 2010).

Conclusion

It is obvious, going by this review, that there is the RF-EMF challenge. The number of mobile phone users is rising on a daily basis, and there is a proliferation of wireless transmitting devices all over the world, but there is little awareness and understanding about the public health and environmental effects of this type of RF-EMF radiation. There are lots of important questions to be asked about mobile phone radiation today, but the reality is that these questions are not being asked by the majority of the people who should know. Except for some researchers who have ventured into this area of inquiry, very little new research is being done in this field, especially in sub-Saharan Africa. Unless serious actions are taken to lower RF-EMF exposure, the achievement of full health for the populace will be a mirage as the harmful effects of RF-EMF radiation are real, and with the introduction of the 5G network, EMF exposures are bound to increase considerably.

Recommendations

1. There is a need for the implementation of health-based precautionary guidelines in the country.

2. The government should provide the necessary information on measurement techniques and procedures for assessing compliance with the general public's electromagnetic field (EMF) exposure limits when a new base station (BS) is put into service, taking into account the effects of the environment and other relevant radio frequency sources present in its surroundings.

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