



## ELECTROMAGNETIC RADIATION (EMR) OF AVANT-GARDE COMMUNICATION DEVICES VIS-A-VIS COMMUNAL HEALTH HAZARD: AN EMPIRICAL STUDY

*Md Rajib\**

\*Department of CSE, Military Institute of Science and Technology (MIST), Dhaka, Bangladesh

### Abstract

Nowadays, cellular devices (Mobile phones, tablets, Smartwatches) have become a bosom companion of our day-to-day life. The supercilious technological advancement has fascinated us in such a way that we tend to forget all probable detrimental impacts of it. Since cell phones and other similar kind of devices Having provided multiple facilities, use of mobile phones have not been limited to adults only. Children are also using mobile phones for education and amusement. Question is, how far safe these phones are. Fact remains that these phones communicate with each other through an interconnected network of Base Transceiver Stations (BTS) by exchanging electromagnetic (EM) waves/ radiation. Although frequencies used by mobile phones and BTS fall under the non-ionizing radiation spectrum, these radiations are not completely harmless as the human body is susceptible to EM radiation. Radiation emitted by mobile phones is measured by Specific Absorption Rate (SAR). The level of SAR determines how much detrimental it is for someone exposed. Too much use of mobile phones interacts with brain cells and may cause damage to health. Living close to a BTS can also be hazardous. Studies have shown that these radiations may even cause cancer. Increased exposure to EM radiation is a global concern now. Adequate measures are to be adopted at various levels to safeguard from overexposure to EM radiation. General awareness in this regard is essential for public safety. Government regulatory bodies may play a vital role in these aspects. More research works may be encouraged to further analyze the effects of non-ionizing radiation and find plausible solutions.

**Keywords:** Electro Magnetic Radiation (EMR), Communal health hazard, Specific Absorption Rate (SAR),

### Acronyms

EMR- Electro-Magnetic Radiation  
 SAR- Specific Absorption Rate  
 BTS- Base Transceiver Station

### 1 Introduction

Mobile or cellular phones are now an inseparable part of modern telecommunications. In some parts of the world, mobile phones are the most reliable or the only phones available. In many countries, over half the population uses mobile phones, and still, the market is expanding rapidly. Currently, there are an estimated 5.135 billion mobile subscriptions globally which are about two-thirds of the world's total population. The total number of mobile phone subscriptions in Bangladesh has reached 150.945 million at the end of June 2018 which is more than 90% of the total population. To connect such a huge number of users to various mobile networks in Bangladesh, the mobile-phone operators have installed a huge number of Base Transceiver Stations (BTS) across the country. According to Bangladesh Telecommunication Regulatory Commission (BTRC), private mobile-phone operators have 96,841 BTS till June 2019. Given the enormous number of mobile phone users and numerous BTS across the country, it is important to understand any potential public health impact from BTSs and mobile phones. The associated health risks of the released Radiofrequency (RF) radiation is an important topic of discussion among scholars and science experts.

Currently smart mobile phones have almost replaced basic mobile phones. Smartphones provide both audio and video call facilities, as well as to send text messages, portability, surf the internet, play games, make purchases through the internet, and many more. Considering these diversified benefits, manufacturing mobile phones and providing cellular communication services have been a great successful business for the last two decades. These

phones communicate by transmitting radio waves through a network of fixed antennas called BTS, also commonly known as mobile towers. Radiofrequency waves are a form of electromagnetic (EM) fields and unlike ionizing radiation such as X-rays or gamma rays, these can neither break chemical bonds nor cause ionization in the human body. However, there is a growing concern regarding the health effect of RF radiation on both BTS and mobile phones.

In this write up an endeavor has been made to talk over the pattern and the characteristics of EMR emitting from varied static communication expedients (BTSs, Short distance Microwave Towers) and portable gadgets (mobile phones, tabs), analyze conceivable communal health hazards due to radiation effect and endorse some plausible measures to lessen such health hazards. Finally, this paper has concluded with few recommendations. This paper has been inscribed based on the hands-on experience of the author in the field of communication and exploring relevant resources available in the relevant books, journals, and open-source materials.

## 2 Electromagnetic Radiation and Its Kinds

**Electromagnetic Radiation** The energy that spreads through space or various types of matter in the form of electromagnetic waves is known as electromagnetic radiation. Radiation is emitted by a radiating source, such as an antenna that transmits energy in various directions.

The energy embodied in electromagnetic radiation depends on the frequency (or wavelength) and/or amplitude (height) of the electromagnetic fields. Frequency is the number of cycles of a wave that pass a reference point per second. Electromagnetic frequencies are described in Hertz (Hz). The International Telecommunication Union (ITU) has divided the frequency spectrum into twelve bands. These different frequencies of electromagnetic radiation are usually represented on a scale known as the Electromagnetic Radiation Spectrum. Details are illustrated in figure-1 below.

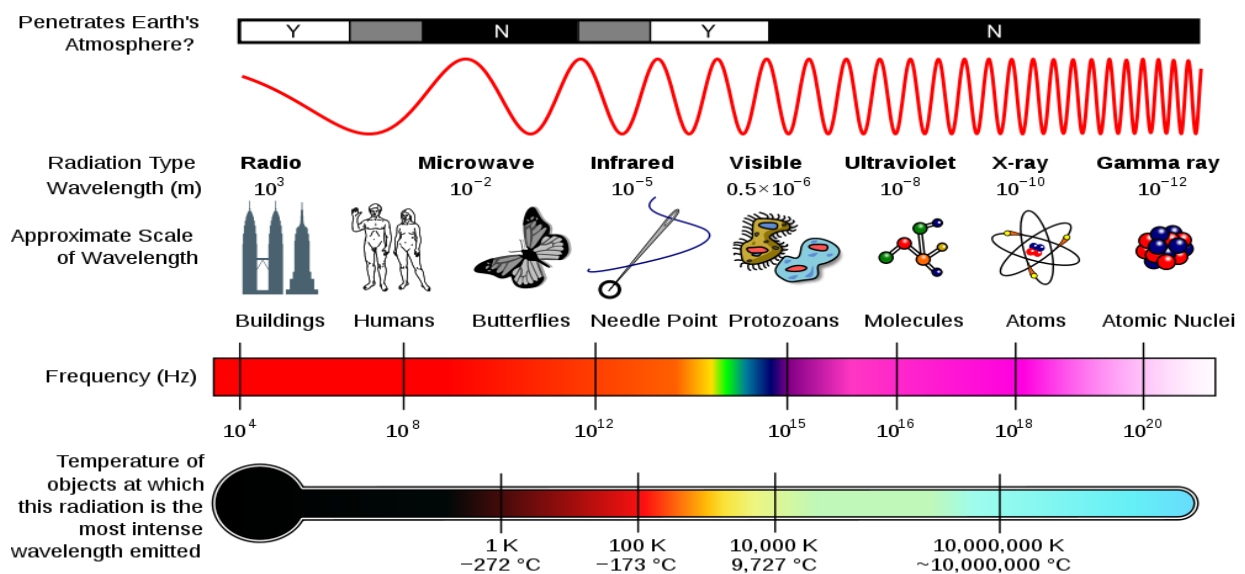


Figure 1: Electromagnetic Radiation

**Kinds of Radiation** The electromagnetic spectrum scale may be divided into two main ranges, according to the amount of energy of the electromagnetic radiation and by frequencies: **ionizing and non-ionizing radiation** (Figure-2). This classification expresses the ability or non-ability of the radiation to cause changes in the physical structure of the atoms or molecules of matter.

1. **Ionizing Radiation.** Ionizing radiation does have enough energy to move around tightly bound electrons from atoms, which in turn, creates ions. This is a much more powerful form of radiation and encompasses ultraviolet (UV) rays, X-rays, and even gamma rays. Higher frequency UV radiation starts to have enough energy to break chemical bonds. This is why so much precaution needs to be taken when being exposed to UV rays or X-rays. X-ray and gamma-ray radiation have a very high frequency, beginning in the range of 100 billion Hertz and very short wavelengths like 1 million millionths of a meter.

2. **Non-Ionizing Radiation.** Radiation that produces enough energy to move around atoms in a molecule, but not enough to remove electrons completely, is known as non-ionizing radiation. Non-ionizing radiation ranges from extremely low-frequency

radiation through microwave, infrared and visible light radiation. The concept of Ionizing and Non-ionizing Radiation are illustrated in figure-2 below

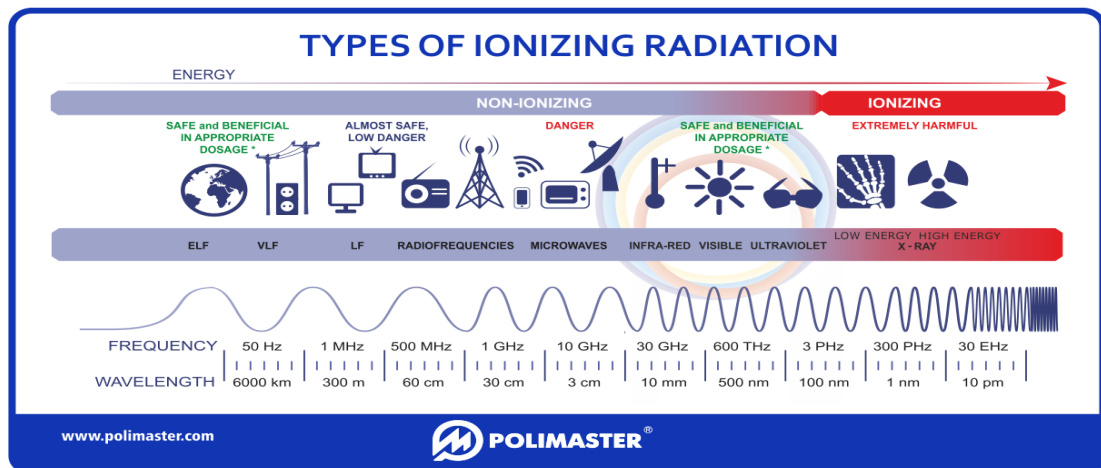


Figure 2: Ionizing and Non-ionizing Radiation

### Frequencies Used by BTSs and Mobile Phones

Band 9 and 10 of ITU Frequency Table i.e. Ultra High Frequency (UHF) and Super High Frequency (SHF) are used for cellular communication networks. Mobile phone generations II, III, III+ and IV including advanced Long-Term Evolution (LTE) operate in the 800-900 MHz, 2100 MHz, 1800-1900 MHz frequency ranges, and at a high frequency around 2.6 GHz or more, respectively. Frequencies utilized by BTSs and mobile phones fall under the non-ionizing radiation spectrum.

### Quantifying Electromagnetic Radiation

**Specific Absorption Rate (SAR).** The human body absorbs energy from devices that emit radiofrequency/ electromagnetic radiation. The dose of the absorbed energy is estimated using a measure called the SAR, which is measured in terms of watts per kilogram (Watt/Kg) of body weight. In other words, SAR is a measure of the electromagnetic field strength and power density for transmitters operating at frequencies from 300 kHz to 100 GHz.

$$SAR = \frac{d}{dt} \left( \frac{dW}{dm} \right) = \frac{d}{dt} \left( \frac{dW}{\rho dV} \right)$$

The time derivative of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (DV) of a given mass density ( $\rho$ ).

International Electro-Technical Commission (IEC) recommends c-SAR3D-A (Figure-3) which is a fully automated SAR testing system. Few other SAR test equipment is also available in the market.



Figure 3: SAR Test Equipment

**Maximum Permissible Exposure.** According to the Institute of Electrical and Electronics Engineers (IEEE) standard, the MPE values are based on limiting the SAR to:

Table 2: IEEE Standard of MPE for Limiting SAR

Radiation Exposure Type	Controlled Environment	Uncontrolled Environment
Whole-Body Average	0.4 W/kg	0.08 W/kg
Spatial Peak Per gram of tissue in the shape of a cube (partial body exposure)	8.0 W/kg	1.6 W/kg

**Controlled Environment.** Controlled environments are locations where there is RF/EM radiation exposure that may be incurred by persons who are aware of the potential for exposure as a concomitant of employment, by other cognizant persons, or as the incidental result of transient passage through areas where analysis shows that the exposure levels may be above the Maximum Permissible Exposure (MPE) for the uncontrolled environment, but do not exceed the MPE for the controlled environment.

**Uncontrolled Environment.** Uncontrolled environments are locations where there is the exposure of individuals who have no knowledge or control of their exposure. The exposures may occur in living quarters or workplaces where there are no expectations that the exposure levels exceed the MPE for the uncontrolled environment.

### 3 Emission From Bts and Mobile Phones and the Safety Limits

**RF Emission from BTS** A BTS provides a wireless communication link between the user and the network. It has several radio transmitters which are combined and fed to the Base station antenna through cables. So, the total radiated power is equal to the sum of the output from each transmitter. The maximum radiation exposure will be at the peak hour when all the channels are used. Gain of antennas and transmission power levels also play a vital role in assessing the exposure of EM radiations from BTS. Figure -4 illustrates the Horizontal Radiation Pattern (HRP) of BTS

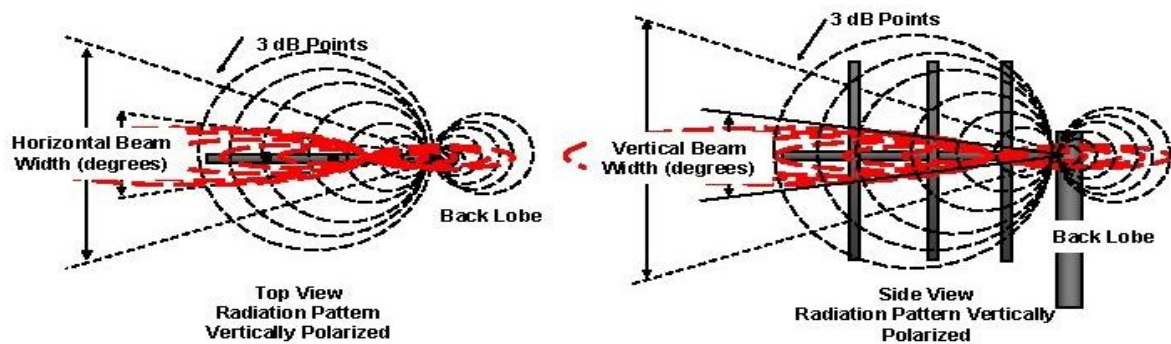


Figure 4: Horizontal Radiation Pattern (HRP)

Omnidirectional antennas have higher gain than sector antennas which provide high efficiency and coverage but the risk of exposure also increases. The primary lobes (Figure-4) exhibit the maximum radiations in the horizontal direction. Radiations from secondary lobes range from medium to low. The level of radiation starts decreasing as an individual moves away from the line of the antenna to its side lobes. Usually, 10-60 watt BTS transmitters are used for GSM (Global System for Mobile Communication) network. However, in Bangladesh, mobile operators tend to use higher power output transmitters to attain more coverage area, especially in densely populated cities.

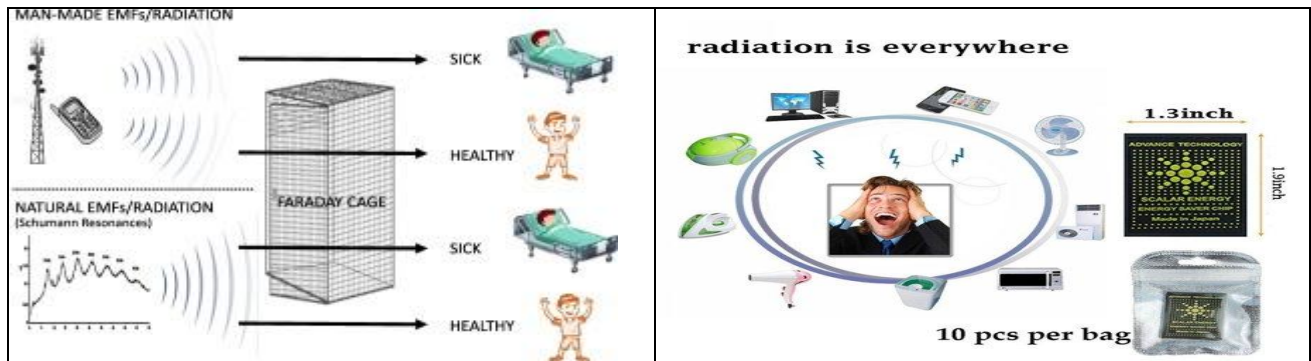
According to "ITU-T Recommendation K.70", different parameters of typical BTS are given in table-3 below

Table 3: Different Parameters of BTS

	GSM 900	GSM 1800/ GSM 190
Transmitter frequency [MHz]	935-960	1805-1880/ 1930 -1990
Per carrier per transmitter rated power [Watt]	10-60	10-40
Rated Power/ Mean Power Coefficient	1.0	1.0
Antenna Height [meter]	25-50	25-50
Antenna Gain [dBi]	7.5-18	8-21

Usually BTS antennas are highly directional, and therefore the RF level behind the antenna is much smaller than in front of it. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines specify an averaging time of 6 (six) minutes for determining RF exposure level. Therefore, an RF level exceeding the reference level for a short period does not necessarily mean that

the RF limit has been exceeded. In practice, this means that even if people walk through a compliance boundary zone, they are unlikely to be subject to overexposure. In Figure-5, the first boundary shows the danger zone which is very near to the BTS. The distance from the first boundary to the second boundary is the occupational distance limit and distance beyond this is the general distance limit which is considered a safe zone for general people. This study has proposed a system model for identifying and limiting radiation from BTS is illustrated in figure 5 below”



**Figure 5: Proposed system model for safety limit identification from BTS radiation**

Mobile phones are low-powered radiofrequency transmitters, operating at frequencies between 450 and 2700 MHz with peak powers in the range of 0.1 to 2 watts. The handset only transmits power when it is turned on. The power, that is, the radiofrequency exposure to a user falls off rapidly with increasing distance from the handset. A person using a mobile phone 30-40 cm away from their body - for example when text messaging, accessing the internet, or using a “hands-free” device - will therefore have much lower exposure to radiofrequency fields than someone holding the handset against their head. To protect the public from the possible harmful effects of radiofrequency radiation emitted by mobile phones, several international organizations involved in this field formulated recommendations for exposure standards. Such organizations include FCC (Federal Communications Commission) - the USA, National Radiological Protection Board (NRPB) - UK, International Commission on Non-Ionizing Radiation Protection (ICNIRP) - EU, North Atlantic Treaty Organization (NATO), and the United States Department of Defence (USDoD).

Any cellphone at or below the SAR levels is a ‘safe’ phone, as measured by these standards while exposure to higher SAR ratings could be dangerous. The German Federal Office for Radiation Protection carried out SAR check on available mobile phones in the market on 08 August 2018. The SAR level for each model is measured under laboratory conditions for maximal output power of the phone. Smartphones that emit the most radiation (while calling with the phone placed on-ear) are shown in figure-6 below:

ZTE Axon Elite	ZTE	0.17
Samsung Galaxy Note8	SAMSUNG	0.17
Samsung Galaxy Note10+	SAMSUNG	0.19
Nokia 6	NOKIA	0.21
Samsung Galaxy Note10	SAMSUNG	0.21
Nokia 8	NOKIA	0.22
Nokia 3.2	NOKIA	0.24
Nokia 2	NOKIA	0.24
LG G7 ThinQ	LG	0.24
Samsung Galaxy A8	SAMSUNG	0.24
Samsung Galaxy M20	SAMSUNG	0.25
Nokia 7.1	NOKIA	0.26
Honor 7A	HUAWEI	0.26
Samsung Galaxy S10	SAMSUNG	0.26
Samsung Galaxy S8+	SAMSUNG	0.26
Samsung Galaxy S7 edge	SAMSUNG	0.26

**Figure-6: Smartphones that emit the most radiation**

#### 4 Possible Health Risks from BTSs and Mobile Phones Radiation

All the radiation reaching matter is partitioned into reflected, absorbed, and transmitted components according to the properties of the matter and the characteristics of the radiation. For example, a mirror reflects almost all of the light radiation reaching it. The amount of energy absorbed by a human body located near a source of radiation depends on the physical properties of the radiation. For instance, most cellular radiation emitted by a mobile phone held near the head, or in the hand, is absorbed by the body. The effects of radiation emitted from cellular devices are illustrated in figure 7 below:



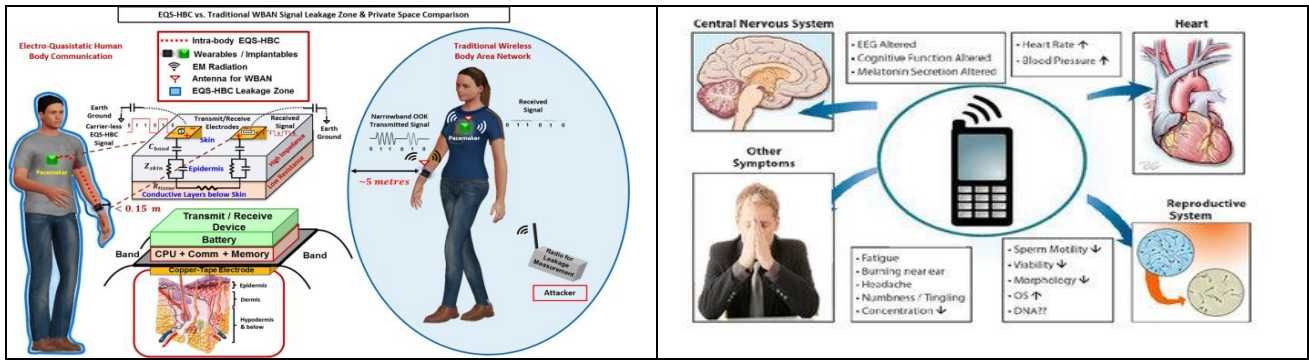
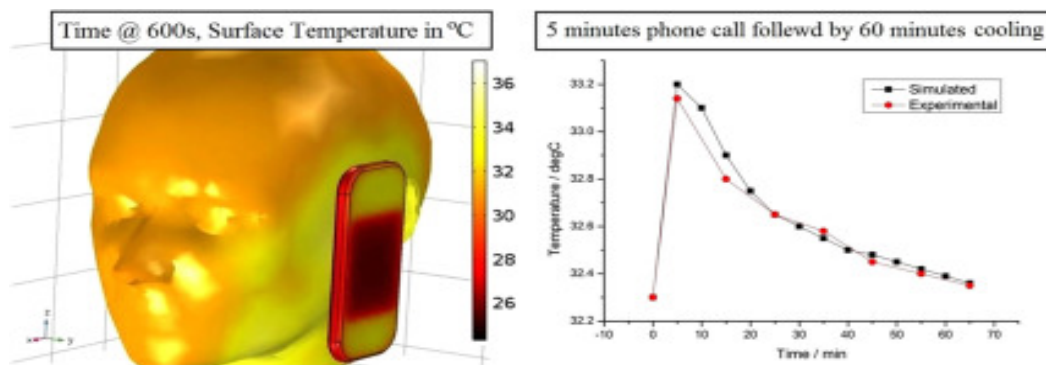


Figure-7: Effects of radiation emitting from cellular devices on Human being

**Short-Term Effects**

**Effects of Living Near to BTS.** There are multiple health risks associated with living near cellphone towers. In 2003, a survey study on “The people living in the vicinity of cellular phone base stations in France” found a variety of self-reported symptoms such as fatigue, headache, sleep disruption, and loss of memory for people who reported that they were living within 300 meters of GSM cell towers in rural areas, or within 100 meters of base stations in urban areas. Similar results have been obtained with GSM cell towers in Spain, Poland, Austria, Egypt, and India.

**Effects of Using Mobile Phones.** Tissue heating is the principal mechanism of interaction between radiofrequency energy and the human body. Most of the energy radiated by a mobile phone is absorbed by the skin and other superficial tissues, resulting in negligible temperature rise in the brain or any other organs of the body. However, extremely long mobile conversations can be harmful to cause cell damage or skin rashes. Figure 8 illustrates the thermal effects resulting from smartphones. Several recent studies have investigated the short-term effects of cellular phone radiofrequency fields on brain electrical activity, cognitive function, sleep, heart rate, and blood pressure in volunteers. To date, research does not suggest any consistent evidence of adverse health effects from exposure to RF fields at levels below those that cause tissue heating. Although those research have not been conclusive of a causal relationship between exposures to RF radiation and self-reported symptoms, or “electromagnetic hypersensitivity”, doctors around the world have cautioned mobile phone users to observe controlled use of mobile phones to safe guard from possible health hazards.



First Principal simulation of heating of human auricle region due to mobile phone use

Figure 6: Thermal effects from mobile phone radiation

**Long-Term Effects**

Epidemiological research examining potential long-term risks from radiofrequency exposure has mostly looked for an association between brain tumors and mobile phone use. However, because many cancers are not detectable until many years after the interactions that led to the tumor, and since mobile phones were not widely used until the early 1990s, epidemiological studies at present can only assess those cancers that become evident within shorter periods.

**1 RF Radiation- a Possible Carcinogen.** The largest case-control study to date on adults, Interphone, coordinated by the International Agency for Research on Cancer (IARC), was designed to determine whether there are links between the use of mobile phones and cancers in adults. Based on data collected from 13 participating countries, IARC and WHO (World Health Organization) has classified RF/EM fields as possibly carcinogenic to humans (Group 2B), a category used when a causal association is considered credible, but when chance, bias or confounding cannot be ruled out with reasonable confidence.

2. The lack of data for mobile phone use over periods longer than 15 years warrant further research of mobile phone use and brain cancer risk. WHO has prompted further research due to the recent popularity of mobile phones among the younger generation, and

therefore a potentially longer lifetime of exposure to BTS and mobile phone radiation.

**3. Effects on Fertility.** Results of studies that examined the effect of non-ionizing radiation on sperm quality parameters are equivocal. In some studies, exposure to radiation emitted by mobile phones did not seem to affect sperm cell quality, while other studies reported an effect on some sperm quality parameters such as motility, vitality, morphology, and DNA fragmentation.

**4 Other Effects.** Hearing impairments and phantom pain in the ear are among other possible long-term health effects of using cell phones.

---

## 5 Suggested Measures to Limit RF/EM Radiation from BTSs and Mobile Phones

5.1 Use of "Hands-free" devices reduces RF radiation exposure, which keeps mobile phones away from the head and body during phone calls. Mobile should not be hung around the neck by a cord. Exposure to RF radiation can also be reduced by limiting the number and length of calls. Mobile phones should not be used for more than 10 minutes continuously. Total use should not be more than one hour per day.

5.2. The SAR level for a specific phone in daily use will vary according to the location of the phone relative to the antennas in its vicinity. Using the phone in areas of good reception decreases exposure to radiation as it allows the phone to transmit at reduced power. Where reception is weak (in areas where antennas are sparse, or reception is disturbed, as in an elevator, train, etc.), the degree of exposure increases, therefore conversing in such situations should be avoided. The SAR level should be indicated on the phone so that users can decide while purchasing a phone.

5.3. Elevators are usually built of metal that does not allow radiofrequency waves from the phone to be transmitted outside the elevator to the antenna/base station that receives them. Consequently, the phone 'strains' to contact the external network while emitting its highest level of radiation. In addition, the user will also experience reception problems. The screening off of radio waves in the elevator exposes the user to the highest level of radiation from the phone. It is important to note that in such a situation persons in the elevator may be passively exposed. It is thus recommended to refrain from using mobile phones while in elevators and to postpone the call until after leaving the elevator.

5.4. Considering studies that demonstrated damage to sperm cells or decreased sperm quality following exposure to RF radiation, and based on the precautionary principle, educated use of mobile phones is recommended, that is, not to place mobile phones in the vicinity of the testes. Mobile phones should be kept away from the bed while sleeping. It may affect sleep physiology. When a mobile phone is installed permanently in the vehicle, it is advisable to attach an antenna outside the vehicle, and to give preference to a wired connection between the phone and the microphone over the use of a Bluetooth system to avoid RF radiation inside the vehicle. Use of mobile phones inside hospitals must be kept to the minimum. Furthermore, Mobile phones should not be given to children. Children are more susceptible to radiation hazards than adults.

5.5. BTS towers should not be installed inside residential areas. If installed nearby, General Distance Limit must be observed from residential buildings considering the radiation safety of the inhabitants. No BTS installation should be allowed in the close neighborhood of kindergarten and hospitals. A safe distance of a minimum of 300 meters from these institutions should be adhered to. Mobile operators must ensure that specific exposure limits are in conformity with ICNIRP, which are recommended by WHO, to protect workers in a controlled environment and the general public in an uncontrolled environment from excessive exposure to RF fields. Signboards and warning signs (Danger - RF Radiation; Restricted Area - Do not enter) must be installed at the BTS site for public protection from radiation.

5.6. No access to the BTS tower should be allowed for the general public by erecting wire fencing and locking of the door to the roof etc.

5.7. Use of commercial devices for reducing RF radiation has not been proved to be effective. So, before using such equipment detailed studies should be carried out.

---

## 6 Conclusions

Interaction or mingling with RF/EM radiation is a daily affair for all of us. We cannot possibly imagine a single day without having mobile phones at our disposal. Mobile phones will not work without BTS. Therefore, we are living in the ocean of unseen waves that help us communicate every day. The advancement of science and technology has made our lives easier and comfortable. However, we also need to be careful regarding associated risks that can lead us to physical ailments. Mobile phones and BTSs keep continuously radiating to maintain a handshake among themselves and maintain the presence of the phones in the network. This radiation coupled

with the added exposure during conversation as the phone comes to close contact with the brain can be a serious concern.

The most critical point is when radiation power from BTS antennas falls, there is a consequent increase in radiation levels from mobile phones. A BTS antenna radiates at 80-160 Watt/Sq.m. However, it has a high distance of separation. Whereas, a mobile phone radiates at <1 Watt/Sq.m. However, it is only a few millimeters away from the headspace or brain cavity. In such a condition, when the phone is radiating at a high, the absorption of radiation by the brain is multiple times higher than that of radiation absorbed from mobile phone tower emission.

A good number of studies have examined the potential health effects of non-ionizing radiation from BTSs and cell phones. Although a causal relationship could not be established in regards to health risks in humans, WHO and IARC declared RF/EM radiation to be a possible carcinogen in May 2011. More research works are needed in this field as exposure to such radiation is increasing day by day. General awareness in respect to using mobile phones and possible radiation hazards is also necessary for the people of Bangladesh. The educated use of mobile phones can reduce exposure to such radiation and help people to lead a better life.