RESEARCH REVIEW FOR POSSIBLE RELATION BETWEEN MOBILE PHONE REDIATION AND BRAIN TUMOR

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ABSTRACT

The aim of this paper is to introduce a research review for the effect of Mobile phone radiation on human health and the possible relation between Mobile phone radiation and brain tumor. Mobile phones become increasingly prevalent throughout our society. In the year 2016, it was estimated that there were 4 billion cellular phone users worldwide; the number is growing by one million every month in the US. The goal of this paper is to give a brief overview and also discuss the biological effects of the exposure to mobile phones radiation. Many effects have been reported with the use of mobile phones on human organisms due to the exposure to electromagnetic radiation. Concerns about the links between using the mobile phones and biological effects, in particular, the brain tumors have been under research. As the other radio signals transmition devices, cellular phone emits radiofrequency energy, which can heat the brain tissues and cause damage to the brain cells. But even mobile phones operates at power level below the level at which such heating effects occur, long term exposure to low level RF from mobile phones could cause other types of health effects, such as brain cancer, due to energy absorption in the brain tissues. Some human biological experiments, such as Aly et al. 2014, Aly, et al. 2008 indicates, the average time for the human cells to respond to the effect of RF radiation was approximately 2.5 min, Hardell et al.2002, and Repacholi et al.1997 indicated increased risk with exposure to mobile phones radiation. The British Association festival of science was told recently that using a mobile telephone more than doubles the risk of developing brain cancer on the side of the head where the phone is held.

KEYWORDS

Mobile phones, brain tumor, RF radiation, EMF, health effects.

1. INTRODUCTION

In recent years, the public concern about the possible health hazards of radio frequency (RF) field exposure from mobile phones has increased and initiated many studies on the possible adverse consequences on human health (*Aly et al,* 2008; *Aly et al,* 2014; and *Barnes et al,* 2005). The possible interaction between the radio frequency (RF) electromagnetic radiation and its biological effects on human tissues particularly on the brain, cancer, and the human immune system have been investigated. Although the important role of the immune system in defending the human body against infections and cancer, only few studies on the possible effects of radiofrequency radiation on the function of human immune cells have been undertaken (*Frohlich et al*, 2006). The strip source diffusion technique which previously used by *Aly et al,* 2008 to study the chemotactic

DOI:10.5121/ijitcs.2016.6401

response of the Leukocytes cells by studying the ability of leukocytes to track cyclic-adenosine monophosphate (C-AMP) concentration gradient.

After the increase in the use of mobile phones in the recent years, concerns have been raised about the biological effect of the exposure to the mobile phones radiofrequency electromagnetic radiation (*Inskip et al,* 2001; *Campion et al*, 1997).

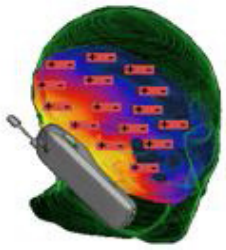

Figure 1. Mobile Phone

The effect translates into a significant public health problem. In recent years, the public concern about the possible health hazards of radio frequency (RF) field exposure from mobile phones has increased and initiated many studies on the possible adverse consequences on human health (*Aly et al,* 2011; *Aly et al,* 2008). The possible interaction between the radio frequency (RF) electromagnetic radiation and its biological effects on human tissues particularly on the brain, cancer, and the human immune system have been investigated. The risk of exposure to electromagnetic field was first highlighted and publicized in the late 1970s by Colorado study *Campion et al.,* (1997) that linked magnetic field exposure from power lines to the possible development of child leukemia.

The importance of some studies, such as; the study by *Satter et al.,*(1999) was done on human patients, where, the rest of the studies used rats as a case control. Some of the advantages of other studies such as *Makar et al. (*2005) is the use of microwave therapy to reduce toxic effects of chemotherapy during the cancer treatment. This is a good addition to chemotherapy treatments even if the mechanism of the radiation effect is unclear. On the other hand, many research studies indicate link between EMF radiation and negative biological effects. The conclusion on the risk, especially for brain tumors associated with the use of cell phone have been mostly with an insufficiently long latency period (*Phillips et al.,* 2006), however, the studies showed a somewhat increase risk for shorter latency periods. Long term (10 years or more) studies showed a statistically significant increase risk on the exposure to EMF radiation (*Christensen et al.,* 2006). The study by *Hardell et al.,* (2006) indicated that significant increase of risk of DNA damage was found with the use of analogue phones and the analysis showed less risk with digital phones. Moreover, many studies indicated another biological effects such as; blood-brain barrier (BBB) permeability function, sleep problems (Hung, 2000), immunity system function (Aly, 2008). The biological effects are uncertain as the biophysical mechanisms behind their occurrence are unknown. Finally, some research studies indicated no clear association was found between the exposure to the EMF radiation and biological effects.

The amount of RF generated by cell phone is usually depends on the number of base stations around the area, the cell phone network traffic, and on how far the cell phone from base stations. The amount of the power which sent from a base station could vary from cell phone to another one even within the same area, depends on the interfering from obstacles such as buildings and

trees. Although, cell phones are designed to operate at power levels below a threshold for known thermal effects, radio frequency radiation could produce other kinds of effects, called biological effects. Due to the radiation effect, are needed to estimate the absorbed energy and its distribution inside the body. A dosimetry quantity that is widely adopted for microwaves is the Specific Absorption Rate (SAR). SAR is defined as the time derivative of the incremental energy, absorbed by or dissipated in an incremental mass contained in a volume element of a given density. SAR is expressed in the unit watt per kilogram (W kg^{-1}). Numerical calculations, based upon coupling from handsets to an anatomically realistic numerical phantom of the head have been performed. Such calculations have shown that, during normal operation, a radiated power of 1 W gives rise to a maximum SAR of 2.1 W kg^{-1} at 900 MHz and 3.0 W kg-1 at 1.8 GHz averaged over any 10 g of tissue. Typical handset powers are 0.6 W.

The satellite network communication systems recently designed to enable communication with sites not easily reachable with ground networks. Small itinerant units and hand-held sets identical to the current mobile telephones will be take part. Higher power classes in these special cases can be visualize.

Digital mobile telephones transmit information in detonation of power. The power of the cellular phone is crooked on and off, and the equipment alienates for a portion of the time only and then is silent for the residual part of the eruption period. The rehearsal frequency is 217 Hz for GSM and DCS 1800 systems and 100 Hz for DECT, the phantom also contains a number of higher symmetrical due to the tight pulse. *Hirata et al.,* (2006) discussed the correlation between peak SAR and maximum temperature increase is blood flow in tissues. Recently, the U.S. Environmental Protection Agency (EPA), established safety guidelines for RF exposure mobile phones in the United States. Specific Absorption Rate, or "SAR, is the gauge of the average of absorption of RF energy in the human head. The Federal Communications Commission has determine the Specific Absorption Rate of handheld mobile phones limit by 1.6 watts per kilogram, rated over one gram of tissue. However, the SAR value may vary from call to call, depending on factors such as proximity to a cell site, the proximity of the phone to the body while in use, and the use of hands-free devices (*Frohlich et al.,* 2006).

The specific absorption rate (SAR) is defined by:

$$\text{SAR} = \sigma \left|E_{ms}\right|^2 / \rho \qquad \text{w/kg} \tag{1}$$

ρ is the mass density (kilogram per meters square)
σ is the conductivity (Siemens per meter)
E_{ms} is the root mean square value of the electrical field (volts per meter)

The threshold level is a Specific Absorption Rate value for the whole body of 4 watts per kilogram (4 W/kg). For hand-held radiotelephones used in occupational situations, ICNIRP recommends that the localized SAR in the head be limited to 10W/kg averaged over any 10g mass of tissue in the head (0. 1 W absorbed in any 10g mass of tissue in the head). SAR is used everywhere as a globally accepted safety measure. Used as guidelines for the maximum energy absorbed by a unit of mass to exposed tissue of a person using a cell phone, over a given time or more simply the power absorbed per unit mass. SAR levels are usually expressed in units of watts per kilogram (W/kg) in 1g of tissue, except in Europe its 10g of tissue.

The exposure to ionizing radiation can cause earnest biological damage. This procedure can produce molecular changes that can lead to damage in biological tissue, including the production of cancer. This procedure requires interaction with high levels of electromagnetic energy. Those kinds of electromagnetic radiation with enough energy to ionize biological material include gamma and X-radiation radiation. The energy levels associated with RF and microwave radiation, on the other hand, are not great enough to cause the ionization of atoms and molecules and RF energy is, therefore, is a type of non-ionizing radiation. However, radiofrequency energy can produce other types of biological effects, such as, thermal effects, which can cause tissue damage due to the heating effect by increasing body temperature.

Mobile phones are designed to operate at power levels below the threshold for known thermal effects. Radio frequency (RF) radiation could produce other effects. Also, other potential biological effects are associated with cell membranes and the movement of currents through the membrane in either direction. However, membranes are far-famed to have strongly nonlinear electric properties (*Montaigne et al.*, 1984). When a voltage is applied across the membrane, the current that flows is not always proportional to the voltage. Part of this no linearity may, in fact, be due to the effect of the electric field on the proteins in the membrane or nearby, which assist the flow of the product currents through the membrane.

A radio can reveal and dilate an exceedingly small signal against a background of very much Larger signals. The resonant circuit basically responds only to electromagnetic waves of frequeqncies within a narrow bandwidth. The power required to enlarge these waves comes from the power supply of the radio.

Region	Reference to SAR measurement	Reference to SAR limit	SAR Limit
United States	Federal Comm. Commission Guidelines (FCC 1997)	American Standard ANSI C95.1 (ANSI1992)	1.6 W/Kg in 1g of tissue
Europe	European Spec. ES 59005 (1998)	ICNIRP Guidelines 1998 (ICNIRP 1998)	2.0 W/Kg in 10g of tissue

Table 1. SAR Guidelines From Around the World

Mobile telephones, sometimes called cellular phones or handies, are now an integral part of modern telecommunications. In some parts of the world, they are the most reliable or only phones available. In others, mobile phones are very popular because they allow people to maintain continuous communication without hampering freedom of movement. In many countries, over half the population already use mobile phones and the market is still growing rapidly.

The industry predicts that there will be as many as 4.7 billion mobile phone subscribers worldwide in the year 2017. Because of this, increasing numbers of mobile base stations have had to be installed. Base stations are low-powered radio antennae that communicate with users' handsets. In early 2000 there were about 20,000 base stations in operation the United Kingdom and about 82,000 cell sites in the United States, with each cell site holding one or more base stations. Several important considerations must be kept in mind when evaluating possible health effects of RF fields. One is the frequency of operation. It is important not to confuse such RF fields with ionizing radiation, such as X-rays or gamma rays. RF fields are called non-ionizing radiation. Mobile phone handsets and base stations present quite different exposure situations.

RF exposure to a user of a mobile phone is far higher than to a person living near a cellular base station. However, apart from infrequent signals used to maintain links with nearby base stations, the handset transmits RF energy only while a call is being made, whereas base stations are continuously transmitting signals. Mobile phone handsets are low-powered RF transmitters, emitting maximum powers in the range of 0.2 to 0.6 watts. Base stations transmit power levels from a few watts to 100 watts or more, depending on the size of the region or "cell" that they are designed to service. Base station antennae are typically about 20-30 cm in width and a meter in length, mounted on buildings or towers at a height of from 15 to 50 meters above ground. These antennas emit RF beams that are typically very narrow in the vertical direction but quite broad in the horizontal direction.

Because of the narrow vertical spread of the beam, the RF field intensity at the ground directly below the antenna is low. The RF field intensity increases slightly as one move away from the base station and then decreases at greater distances from the antenna. Cellular phones operate with radio frequencies, a form of electromagnetic energy located on the electromagnetic spectrum between FM radio waves and the waves used in microwave ovens, radar, and satellite stations.

Cellular phone technology works on a system of geographically separated zones called "cells." Each cell has its own "base station" that both receives and emits radio waves. When a call is placed from a Mobile phone, a signal is sent from the cellular phone antenna to that cell's base station antenna.

The base station responds to the cellular phone signal by assigning the phone an available radio frequency channel. When the RF channel is assigned, modulated radio signals are simultaneously received and transmitted, allowing voice information to be carried between the cellular phone and the base. The base station transfers the call to a switching center, where the call can be transferred to a local telephone carrier or another cellular phone. There are four types of wireless telephones-cordless, transportable, mobile, and portable phones. Cordless telephones, commonly used in homes, have base units that are plugged into telephone jacks and wired to local telephone service; these are not considered "cellular" phones. The question of health risks associated with cordless phones, which operate at 1/600th the power of cellular phones, has not been raised (*Mushtaq et al.,* 2013).

Cellular phones are an important source of RF exposure for those who use them. The amount of RF to which a person is exposed depends on a number of factors. The number of "cells" in a geographical area depends upon the cellular phone traffic in that area. For example, large cities may have many cells per square mile, whereas a less-populated, rural area may have a single cell stretching over several square miles. The farther away a cell phone antenna is from its base station, the higher the power level needed to maintain the connection. Very small cells are therefore associated with much lower exposures.

Each geographical cell has a different number of available channels. Cellular phones operate ideally with the least amount of interference from neighboring channels. To help achieve optimal operation, cellular phones automatically step down to the lowest power level available that still maintains a connection with the base station. On the other hand, any physical obstacle, such as buildings or trees, interfering with the connection between base station and cell phone forces the base station to increase the power sent to that phone. Therefore the amount of power sent from a base station to a particular cellular phone can vary, even within a single call (*Adheed et al.,* 2012).

Manufacturers are required to report the specific absorption rate (SAR) of their product to the FCC. The SAR is the amount of RF energy absorbed from the phone into the local tissues. The upper limit of SAR allowed is 1.6 watts per kilogram in 10 g of tissue. Exposure to RF also depends on the duration and frequency of cellular phone use, with more use implying more exposure. The new models (digital models) of cellular phones are less radiation than the old ones (analog models), (*Hardell et al.,* 2011).

The word radiation is often thought of as referring to the emanations from radioactive material and x-rays. However when scientists use the word radiation they are usually referring to electromagnetic radiation (EMR) which can be emitted from such sources as radio cell phones, TV transmissions, light from the sun as well as x-ray machines.

Electromagnetic radiation has electric and magnetic field components and passes through space at the speed of light – about 186,000 miles per second.

Microwave (MW) and radio frequency (RF) radiation is electromagnetic radiation that is lower in frequency and therefore longer in wavelength than infrared radiation. Radiofrequency (RF) fields are oscillating electric and magnetic fields. Electric and magnetic fields interact with electrically charged particles by exerting forces upon them. If these forces cause charged or polarized particles (e.g. electrons, atoms, molecules, etc.) to move, heat energy is introduced.

This heat energy in the material may or may not be detected as a temperature increase since RF absorption may be small, non-uniform or quickly dissipated. Radiofrequency is the name given to that section of the electromagnetic spectrum from frequencies of 300 kHz to 300 GHz. Mobile phones according to the GSM (Global System for Mobile Communication) standard operates in the 900 MHz and 1800 MHz. The frequency range used for mobile telephony varies according to companies and their technologies, ranging from 850 to 1900 MHz.

The range will be extended to 2200 MHz with the new UMTS technology, and to the 400 MHz waveband with the TETRA system, currently under development. In general the section of the electromagnetic spectrum from frequencies of approximately 300 MHz to 300 GHz and wavelengths of approximately 1 meter (m) to 1 millimeter (mm) are called microwaves.

Although some consider microwaves not to include lower frequencies and to start at 800 MHz with a wavelength of 37.5 centimeters (cm). Analogue telephones rely on frequency modulation (FM) and operate in the range of 370-500 MHz, while digital personal communication devices emit pulsed RF and operate in the range of 800-960 and 1600-2000MHz. The term "microwaves" can be misleading. The wavelengths are not really "micro" in size because they range from 1 meter to the shortest which is 1 millimeter not 1 "micro" meter.

Sources of radio frequency and of microwaves are primarily:

- Radio and television broadcast antenna.
- Communications equipment such as cellular phones, satellite, etc.
- Cooking microwave ovens.
- Civilian, police and military radar.
- A variety of industrial inductive and dielectric heating devices.
- Medical devices such as magnetic resonance imaging (MRI), and diathermy devices.

2. RELATED WORK

Evidence has been reported about the possible health effects such as; brain tumor, blood-brain barrier (BBB) permeability function, sleep problems, cognitive function, DNA damage, immunity system function, stress reaction, and increased incidence rate of traffic accidents due to using mobile phone during driving. Recently, many studies have concerns about the association between exposure to EMF radiation and the risk of cancer. Some studies reported association between cancer and the use of some appliances, such as television sets, hair dryers, radio and television transmitters, TV towers, and electric razors. Other studies has concerns regarding human health effects due to exposure to EMF radiation, such as mobile phones as in (*Hardell et al.,* 1999; *Muscat et al.,* 2000; *Inskip et al.,* 2001; *Johansen et al.,* 2001; and *Rothman et al.,* 1996). Several studies have linked exposure to extremely low frequency electromagnetic fields (ELF-EMF) and increase the risk of childhood leukemia as in (*Ahlbom et al.,* 2000; *Deadman et al.,* 1999; *Foliart et al.,* 2002; and *Foliart et al.,* 2001; *Aly et al.,* 2008).

Recently evidence has been reported about the possible health effects such as; brain tumor, blood brain barrier (BBB) permeability function, sleep problems, cognitive function, DNA damage, immunity system function, stress reaction, and increased incidence rate of traffic accidents due to using mobile phone during driving. Recently, many studies have concerns about the association between exposure to EMF radiation and the risk of cancer. Some studies reported association between cancer and the use of some appliances, such as television sets, hair dryers, radio and television transmitters, TV towers, and electric razors. One of the important reasons for the work presented in this paper is to answer the question of whether the use of cell phone is harmful for users or not. However, the review presented in this paper has not entirely answered the question. More long term studies are needed. What we could conclude is that heavy cell phone could be under high risk of negative effects due to the exposure of EMF radiation. This conclusion indicate that caution is needed when using cell phones and more research is necessary for risk assessment based on higher number of long-term users.

Other studies has concerns regarding human health effects due to exposure to EMF radiation, such as mobile phones as in *Hardell et al.,* 1999; *Muscat et al.,* 2000; *Inskip et al.,* 2001; *Johansen et al.,* 2001; and Rothman et al. 1996. Several studies have linked exposure to extremely low frequency electromagnetic fields (ELF-EMF) and increase the risk of childhood leukemia as in (*Ahlbom et al.,* 2000; *Deadman et al.* 1999; *Foliart et al.,* 2002; and *Foliart et al.,* 2001; *Aly et al.,* 2014).

3. MOBILE PHONE AND BRAIN TUMOR

A diagnosis of cancer can be subversive. And there is good reason for this fear. Cancer is the second leading cause of death in the United States next to heart disease, and will claim more than half a million lives this year. What we think of as "Cancer" is actually a group of more than one hundred separate diseases. These diseases are all characterized by an abnormal and unregulated growth of cells. This growth destroys surrounding body tissues and may spread to other parts of the body in a process that is known as metastasis. We have heard of all kind of different types of cancer, but we focus here on brain cancer (brain tumor).

Cancer can develop anywhere in the body, and at any age. Cancer is usually caused by genetic damage that happens inside an individual cell. When cells divide at an accelerated rate, they often

begin to form a mass of tissue called a tumor. The tumor is fed by nutrients that diffuse through neighboring blood vessels and can also grow by forming a substance called tumor angiogenesis (vessel forming) factor. This factor stimulates the growth of an independent blood supply to the tumor. Tumors can cause destruction in three common ways: Tumors put pressure on nearby tissues and/or organs. Tumors invade tissues and organs directly (direct extension), often damaging or disabling them in the process. Tumors make invaded tissues and/or organs susceptible to infection. Tumors can also release substances that destroy tissues in close proximity to them. What Causes Cancer (brain tumor)?

Reported Symptoms and Diseases Attributed to EMF's	
• Brain cancers and tumors • Eye and ear discomfort and pain • Alzheimer's disease • Anxiety • Asthma • Birth defects • Blood pressure increases • Burning sensations • Calcium Ion changes • Chemical sensitivity • Chronic fatigue • Chronic stress • Crohns disease • Depression • Diabetes • Disorientation • EEG changes • Epilepsy • Facial rashes and swelling • Fybromyalgia • Genetic damage • Gliomas • Hair Loss • Headaches • Heart disease	• Memory Loss • Kidney damage • Leukemia and other blood cancers • Lymphoma • Melatonin reductions • Meningiococcal infections (meningitis) • Meningiomas • Multiple Sclerosis • Neuro-cognitive symptoms • Nerve sheath tumors, including acoustic neuromas • Numbness • Oral cancer • Pacemaker interference • Pain • Parkinson's disease • Parotid gland tumors • Premature aging • Reaction time changes • Sleep disorders • Suicide • Testosterone reductions • Thyroid cancer • Tinnitus

Table 2. *Reported Symptoms and Diseases Attributed to EMF's*

Mutations in tumor suppressor genes are another common cause of cancer. As you might expect, a tumor suppressor gene is supposed to prevent tumors. But when these genes are damaged, they can allow cancer to develop instead of preventing it. One of these genes, p53, normally prevents cells with abnormal DNA from surviving. When p53 is defective, these cells with abnormal DNA survive and can multiply, increasing the probability of developing cancer (brain tumor).

Intracranial tumors comprise approximately 95% of the estimated 17,200 brain and other nervous system malignancies projected to occur in 2001 in the US (*Frohlich et al.*, 2006).

Reported biological Effects Studies by Increasing Power Density.

Citations	Power Density Level	Biological Effects
Dumanski, 1974	5-10 μW/cm^2	Impaired nervous system activity
Belokrinitskiy, 1982	10-25 μW/cm^2	Changes in the hippocampus of the brain
D'Inzeo, 1988	2-4 μW/cm^2	Direct effect of RFR on ion channels in cells/opening of acetycholine channels
Chiang, 1989	4-10 μW/cm^2	Visual reaction time in children is slowed//lower memory function in tests
Veyret, 1991	30μW/cm^2 (0.015 W/Kg SAR)	Immune system effects - elevation of PFC count (antibody producing cells)
Veyret, 1991	30μW/cm^2 (0.015 W/Kg SAR)	Immune system effects - elevation of PFC count (antibody producing cells)
Salford, 1994	120 μW/cm^2	A pathological change in the blood brain barrier (915 MHz)
Navakatikian, 1994	100 μW/cm^2	A 26% drop in insulin
Von Klitzing, 1995	0.1μW/cm^2 (0.001 W/Kg SAR)	EEG brain waves are altered when exposed to cell phone signal
Kolodynski, 1996	0.16 μW/cm^2	Motor function, memory and attention of school children affected (Latvia)
Joyner, 1996	2.4 μW/cm^2	Interference with medical devices at least up to 1000 MHz
Magras & Xenos, 1997	0.168-1.053 μW/cm^2	Irreversible infertility in mice after 5 generations of exposure to cell phone signals from antenna park
Dolk, 1997	1.3-5.7 μW/cm^2	Two-fold increase in leukemia in adults from AM RF exposure

Table 3. Reported biological Effects Studies by Increasing Power Density.

Recent media attention has focused on a possible link between cellular phone use and brain cancer. Network news programs ran their own tests of mobile phones, reporting to the public that some mobile phones exceed the maximum level of emitted radiofrequency (RF) energy allowed by the Federal Communications Commission (*Pokorny et al.,* 1998).

Reported biological Effects Studies	
Szmigielski,S.,et. al.,1982. (Bioelectromagnetics 3: 179-192.)	Accelerated development of spontaneous and benzpyrene-induced skin cancer in mice exposed to 2350 MHz microwave radiation.
Belokrinitskiy, VS., 1982. (U.S.S.R. Report, No. 7, JPRS 81865, pp. 15-20.)	Destructive and reparative processes in hippocampus with long-term exposure to nonionizing radiation.
D'Inzeo, G., et. al., 1988. (Bioelectromagnetics 9; 363-372.)	Microwave effects on acetycholine-induced channels in cultured chick myotubes.
Dutta, SK., et. al., 1989. (Bioelectromagnetics 10: 197-202.)	Radiofrequency radiation-induced calcium ion efflux enhancement from human and other neuroblastoma cells in culture.
Ray, S., & Behari, J., 1990. (Radiat Res 123: 190-202)	Physiological changes in rats after exposure to low levels of microwaves.
Veyret, B., et. al., 1991. (Bioelectromagnetics 12: P 47-56.)	Antibody responses of mice exposed to low-power microwaves under combined, pulse and amplitude modulation.
L. Salford (1993). (Bioelectrochemistry and Bioenergetics, Vol. 30: pg. 313-318.)	Experimental studies of brain tumor development during exposure to continuous and pulsed 915 MHz radio frequency radiation.
Salford, LG., et. al., 1994. (Microsc Res Tech 27(6):535-542)	Permeability of the blood brain barrier induced by 915 MHz electromagnetic radiation; continuous wave and modulated at 8, 16, 50 and 200 Hz.
L. Von Klitzing, 1995. (Physica Medica, Vol. 11, No. 2, pps 77-80.)	Low-Frequency pulsed electromagnetic fields influence EEG of man.
Lai, H., & Singh, NP., 1996. (Int J Radiat Biol 1996;69:513-21.)	Single and double strand DNA breaks in rat brain cells after acute exposure to radiofrequency electromagnetic radiation.
Mann, K., et. al., 1996.(Neuropsychobiology 1996;33:41-47.)	Effects of pulsed high-frequency electromagnetic fields on human sleep.
Magras, IN., & Zenos, TD., 1997.(Bioelectromagnetics 18:455-461.)	RF Radiation-induced changes in the prenatal development of mice.
Repacholi, M., et. al., 1997. (Radiat Res. 1997; 147:31-40.)	Lymphomas in Eμ-Pim1 transgenic mice exposed to pulsed 900 MHz electromagnetic fields.
Salford, 1997. (Bologna, Italy, June 1997.)	Blood brain barrier permeability in rats exposed to electromagnetic fields from a GSM wireless communication transmitter.
Kwee, 1997. (Bologna, Italy, June 1997.)	The biological effects of microwave radiation. Abstract in Proceedings of the Second World Congress for Electricity and Magnetism in Biology and Medicine.
Dolk, H., et. al., 1997. (Am J Epidemiology 145(1) P 1-9 Jan 1997.)	Cancer incidence near radio and television transmitters in Great Britain.

Table 4. Reported biological Effects Studies

Several epidemiological studies published in peer-reviewed scientific journals have been conducted on the health effects of radiofrequency emissions from mobile phones. The investigators reported an association between the side of the head on which the tumor occurred and the side of the head where the mobile phone was used. Laboratory studies on human volunteers have investigated whether radiofrequency exposure has certain noncancer effects, such as neurological changes in blood pressure.

Some of these studies have reported effects, including changes in brain activity, reaction times, and sleep patterns (*Montaigne et al*., 2005). Increased risk for cellular telephone use was found on the same side as the use of a mobile phone (*Hardell et al.,* 2011).

There has been anecdotal evidence for several years associating use of cellular phones, and other sources of electromagnetic radiation in the microwave region of the spectrum, with brain cancers and other cancers. From police officers who used radar guns to heavy users of cellular phones who have contracted cancer, there has been mounting evidence that exposure to this kind of electromagnetic radiation may not be as safe as advertised (*Yee et al.,* 1966).

Taking into consideration recent studies and findings reported in the past two years, it is evident that it remains difficult to identify a direct link between mobile phone RFR and brain tumors [1][2][3][4]. With evidence supporting both sides of the argument, small sample sizes, unreliable data collection, and the inevitable lack of control in human studies; it is apparent that a long term, large sampled, and intensive study is needed. Notably, there are two promising studies currently being conducted with the previous intentions in mind. One of the studies is COSMOS, a large prospective cohort study that launched in Europe in March 2010. COSMOS plans to include approximately 290,000 cell phone users for a duration over 20 to 30 years and focuses on adult users (above 18 years old). The second study is Mobi-Kids which aims “to investigate 2000 young people (10 to 24 years) with newly diagnosed brain tumors and 4000 healthy young people” (*Kim et al.,* 2016). In either case, given the large sample size and duration of the previous two studies, hopefully COSMOS or Mobi-Kids will provide corroborating and in-depth results.

4. CONCLUSION

In this paper, we have introduced a research review for the effect of Mobile phone radiation on human health and the possible relation between Mobile phone radiation and brain tumor. From the above review we can summaries the following:

Cancer can develop anywhere in the body, and at any age. Cancer is usually caused by genetic damage that happens inside an individual cell. When cells divide at an accelerated rate, they often begin to form a mass of tissue called a tumor.

Cellular telephones are a new technology, we do not have long-term follow-up on their possible biological effects. However, the lack of ionizing radiation and the low energy level emitted from cellular phones (Newer digital phones emit less radiation than older analog models) and absorbed by human tissues make it possible that cellular phones cause cancer even if the phone was covered with shields and using the hands-free set will not prevent the risk.

As the other radio signals transmission devices, cellular phone emits radiofrequency energy, which can heat the brain tissues and cause damage to the brain cells. But even mobile phones operate at power level below the level at which such heating effects occur. Long term exposure to

low level RF from mobile phones could cause other types of health effects, such as brain cancer, due to energy absorption in the brain tissues.

Non thermal effects such as calcium ion efflux, blood-brain barrier, melatonin, alterations in EEG, etc., have been observed for low-intensity modulated radio frequency fields. Some studies have reported effects, including changes in brain activity, reaction times, temporal brain tumor, and prevalence of central nervous system (CNS) symptoms, Motor function, memory, and sleep patterns. Other possible biological effects are associated with cell membranes and the movement of currents through the membrane in either direction.

Radiation from mobile phones might cause tumors by preventing cells from dying, if cells that are marked to die do not, tumors can form, this research is particularly important, because the study found that mobile phone radiation can affect cells without heating them. Exposure to radiation from mobile phones can disable a blood-brain-barrier and allow proteins and toxins to leak into the brain. Phone radiation somehow targets proteins in "stress fibers" in endothelial cells, which line blood vessels. This causes the endothelial cells to shrink.

The blood-brain barrier normally prevents unwanted molecules from entering the brain. But mobile phone radiation might allow molecules to pass through small spaces between cells. The blood-brain barrier is a cell layer between the blood that circulates in the blood vessels of the brain and the actual brain tissue. Oxygen and nutrition is let inside by the barrier while carbon dioxide and waste products are transported out through it. The barrier hinders some medicines and several poisonous substances to invade and injure the brain. The microwave radiation from cell phones can open the safety barrier that is supposed to protect the brain from being invaded by poisonous substances contained in blood. This can increase the chances of developing diseases such as brain cancer.

Radio waves can cause biological effects that are not due to heating, nematode worms exposed to radio waves showed an increase in fertility, which is the opposite effect from what would be expected from heating. Non-ionizing radiation can indirectly damage DNA by affecting its repair system. If the DNA repair mechanism does not work as well as it should, mutations in cells could accumulate, with disastrous consequences. Cells with unrepaired DNA damage are likely to be far more aggressively cancerous, that may induce changes in genetic code corrupting DNA that could unleash thousands of birth defects and medical disorders.

Cell phones could cause cancer by forcing the body to produce unusual levels of heat shock proteins. The findings could be the missing link in cell-phone cancer research. The radiation generated by mobile handsets causes ongoing stress to body cells, causing them to give off 'heat shock proteins', which human cells sometimes release in response to injury or infection. Such a chronic activation of the heat shock response affects the normal regulation of cells, which could result in cancer.

Electromagnetic fields can physically move, reorient, or even alter molecules or ions or their distributions in the body. They can affect the rate of chemical reactions and the ability of molecules to pass through a membrane. In addition, if charge acceleration occurs, the tissue itself may reradiate or scatter this energy inside the human body, complicating and intensifying the radiation's effects. Electromagnetic fields of radio and microwaves can also affect cells mechanically, without producing significant amounts of heat.

The risk is higher primarily in the temporal lobe, on the same side as the phone is used. Here the risk is 2.5 times greater. The type of tumor showing the largest increase, a 3.5 times greater risk is tumors of the auditory nerve. The investigators reported an association between the side of the head on which the tumor occurred and the side of the head where the mobile phone was used.

Non ionizing radiation and human health remains one of the most complex and controversial subjects in all of biophysics. There is growing scientific evidence that prolonged exposure to some kinds of radio waves does cause at least low-level changes in the movements, workings, and possibly structure of molecules and cells in living tissue.

From the overview we have, long term exposure to low level RF from mobile phones could cause health effects due to the energy absorption in the brain tissues, mobile phones radiation can affect cells without heating them and can increase the chances of developing diseases such as brain cancer.

Mobile phones radiation can damage DNA by affecting its repair system, might cause tumors by preventing cells from dying, which means tumors can form, disable a blood-brain-barrier and allow proteins and toxins to leak into the brain, force the body to produce unusual levels of heat shock proteins which affects the normal regulation of the brain cells, can affect the rate of chemical reactions and the ability of molecules to pass through a membrane, and can also affect cells mechanically.

So, radiation can cause all of that to the brain cells without producing significant amounts of heat, but by cause ongoing stress to brain cells, and due to energy absorption in the brain tissues, which means brain cancer due to mobile phones radiation can happened without thermal effects. Besides, it has been confirmed by researchers that mobile phones radiation cause brain cancer in rats and also the other diseases. From police officers who used radar guns to heavy users of cellular phones who have contracted cancer, there has been many evidence that exposure to radiation from mobile phones both continuous wave (Analogue) and pulsed microwave (Digital) RF, can cause cancer or increase the chances of developing brain cancer on the side of the head where the mobile phone was used.
Another thing, long term stress on the cells will act the same as the effect for drinking very hot drinks and that is why the Eskimo has much throat cancer. For smoking, long term stress on mouth cells cause cancer. Many studies confirmed that RF radiation from mobile phones cause stress on the brain cells. There is growing scientific evidence that exposure to EMF does cause at least changes in the movements, workings, and possibly structure of molecules and cells.

And I think the reason for confirming the radiation cancer effect on rats but some researchers (beside the mobile phone companies) still skeptical about confirming the effects on human, because Animal studies are easier to control than epidemiology studies, for example it is difficult to keep human under RF radiation for long time, same as rates. But rat's brain has many functions act similar to human brain, especially the blood-brain-barriers function. Another thing, why EMF radiation and smoking, etc. affect some people and does not affect others? One of the reasons; because every human has different DNA.

For children, since their brain still developing, and their skulls are thinner than adults and are not fully developed, which means affecting the brain with higher SAR, we should limit their exposure to the mobile phones radiation.

Cancer is the second leading cause of death in the United States next to heart disease; mobile phone manufacturers could be responsible for generating more than half a billion cancer cases worldwide in the near future.

Finally we should expect Mobile phone manufacturers to deny the researchers' findings about the negative effects of Mobile phones on human health.

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