

# The Potential Effects of Electromagnetic Field: A Review

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## ABSTRACT

Studies about the potential effects of electromagnetic field on human body are increasing day by day. In this study; new investigations on this field were tried to be explained by the help of literature. An exclusive search was conducted in medical databases and these findings were compared with literatures in the world. It is shown, in many studies around the world, that electromagnetic waves as well as the electromagnetic field that is given out by some of the equipment we use, create negative effects on biological systems of humans. Moreover; it had concluded that there are roles of molecular pathways such as oxidative stress on electromagnetic field induced diseases. These effects are the short term effects and long term effects. Decreasing of the area of vision, heavy stress and feeling of tiredness, loosing of concentration and attention, voices in the ears and warming of ears, reversible hearing problems, headache and such can be seen as the short term effects. The long term effects that are commonly encountered are; irreversible hearing problems, damaging of the embryonic development, increasing risk of miscarriage, decrease in the number of sperms, damaging of the brain tissue, heart related problems, weakening of the memory, lymphoma, and damaging of the genetic structure. We cannot stop using electricity. Electromagnetic field related health problems could take many years to present symptoms. Hence, public sensitivity to these issues is a necessity. Preventative measures should be high priority and risks should be minimized.

**Key words:** Cell degeneration, electromagnetic wave, cell phone, harmful effect.

## ABBREVIATIONS

ACTH : Adrenocorticotrop hormone

CAPE : Caffeic acid phenethyl ester

CRT : Chatode ray tube

DNA : Deoxyribonucleic acid

EMF : Electromagnetic field

Hz : Hertz

Kg : Kilogram

LCD : Liquid crystal display

MHz : Megahertz

TSH : Thyroid stimulating hormone

TV : Television

UV : Ultraviolet

WHO : World Health Organization

## INTRODUCTION

Electromagnetic field (EMF) and the potential harmful effects on the human body are two of the current areas which are heavily researched in the medical field as well as in the area of engineering around the world.

Electromagnetic wave is an area that is generated by the source of the radio frequency and distributes in space. All the electronic equipment we use in our daily life, without thinking how much we use or how often we use, create EMF. Electromagnetic sources can be classified into two: Natural electromagnetic sources (sun, some distant stars, atmospheric discharges like thunder, or human body) and unnatural or human-made sources (cables that carry electrical currents, television (TV) and computers, electrical home gadgets, radio and TV base stations, cell phones, mobile phone base stations, and phone equipment). Data that is collected from electrical equipment, which have been playing an important role in our daily lives in the last decade, is not conclusive (Bortkiewicz, 2001; Yasser et al., 2001; Hossmann and Hermann, 2003).

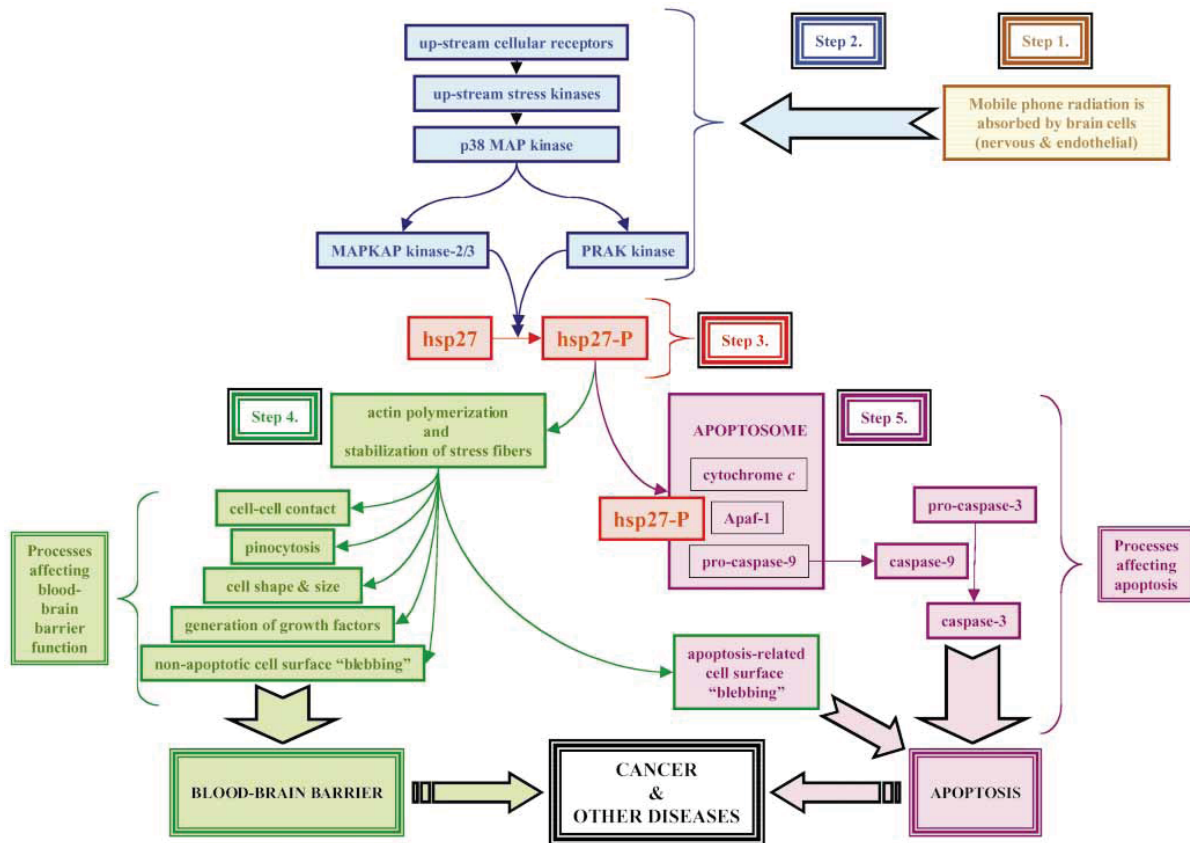
The frequency and the outlet power of this equipment are of crucial importance. Nowadays, the va-

riety of the communication equipment as well as the equipment that uses different frequencies is increasingly emerging. Frequency is number of vibrations of electromagnetic waves in a particular time, at certain points. One cycle of an electromagnetic wave in one second is 1 Hertz (Hz), and one megahertz (MHz) is equal to one million cycles in 1 second. Analog phones work at frequencies between 800 and 900 MHz whereas digital phones work at 1850 to 1990 MHz (Irmak et al., 2002; Ozguner et al., 2005a).

In this study; new investigations on this field are tried to be explained by the help of literature. It had been undertaken a review of biological affects electromagnetic field on tissues in human and experimental animals. Moreover; it had concluded that there are roles of molecular pathways such as oxidative stress on EMF-induced diseases.

### Effects of electromagnetic fields on molecular pathways:

The factors that play a role in the occurrence of the effects in the tissues are very important. It is almost impossible to stay away from all the technological de-



**Fig 1.** Hypothetical flow of events that may occur in brain cells (nervous and endothelial) in response to mobile phone radiation. (Permit of Leszczynski D, et al. 2002)

**Step 1.** Mobile phone radiation is absorbed by brain tissue—nerve cells and endothelial cells lining capillary blood vessels. **Step 2.** Mobile phone radiation, by a yet unidentified biophysical mechanism, activates directly or indirectly cellular stress kinase(s). Activation of stress response is caused either by activation of p38 MAPkinase alone or also some other kinase(s) located upstream/downstream of p38 MAPkinase. **Step 3.** The mobile phone radiation induced kinase(s) activation leads to phosphorylation of hsp27 (hsp27-P). Simultaneously, an increase in the expression of hsp27 occurs which might have an additional, potentiating, effect by providing more hsp27 molecules for the phosphorylation-activation. **Step 4.** The phosphorylated form of hsp27 stabilizes endothelial cell stress fibers and, in conjunction with estrogen, alters generation/secretion of bFGF. This causes the increase in blood-brain barrier permeability, due to the occurrence of one or several of the following processes: changes in endothelial cell shape and formation of gaps between cells; increased (abnormally high?) pinocytosis through the endothelial monolayer; obstruction of capillary blood flow by bleb formation (and shedding?) on the lumen surface of endothelial cells—this event could increase blood pressure locally and help to force large molecules to pass through the endothelial monolayer; in females, possible formation of gaps between endothelial cells caused by induction of de-differentiation and proliferation of endothelial cells, in endocrine fashion, by endothelium-released bFGF. Endothelial cells stimulated to proliferate will round-up and gaps between the cells will be formed. **Step 5.** The phosphorylated form of hsp27 forms a complex with apoptosome, or some of its components, which prevents activation of procaspase-9 and subsequently prevents activation of pro-caspase-3 and inhibition of caspase-3-dependent apoptosis pathway. Thus, mobile phone radiation-induced phosphorylation of hsp27 in cells that are in the process of execution of caspase-9/caspase-3 dependent apoptosis may prevent the destruction of the unwanted damaged/transformed cells.

velopments. However, in order to use this equipment wisely we need to consider technical data, some of the biological effects and the responses to those effects, as well as the factors that bring to surface these responses.

The cell membrane is considered as the primary site for EMF interaction with cellular systems. The mobilization of cellular calcium ion ( $\text{Ca}^{2+}$ ) by electromagnetic radiation is an important biological response in the regulation of cellular activities (CSIRO, 1994).

It is thought that  $\text{Ca}^{2+}$  form cationic bridges with protein/phospholipids moieties on the cell surface. When the  $\text{Ca}^{2+}$  bind to the polar, anionic head groups of phospholipids in the membrane they provide stability to the membrane by raising its structural phase

transition temperature (to 40 °C). Exposure to microwave fields reduces the phase transition temperature to around 37 °C resulting in destabilization of the bridges and release of protein from the cell surface (Liburdy 1992). At the same time membrane permeability is altered. This effect of protein shedding in lymphocytes and erythrocytes has been recently reported after brief exposure of 30 min at 2450 MHz and 60 mW/kg (Liburdy, 1992, 1994).

It is thought that loosely bound proteins play an important role in the transduction of signals to integral proteins that span the bilipid membrane. Exposure of liposome to 2450 MHz at only 0.6 mW/kg for 5 min resulted in a reduction in the main structural phase transition temperature from 39.5 to 38 °C (Liburdy,

1994). Radiofrequency radiation fields have also caused the release of immunoglobulin (Ig) from antibody receptor sites on the surface of B-lymphocytes at non-thermal exposure conditions (Liburdy and Wyant, 1984).

#### **Harmful effects of EMF sources:**

Due to the frequent use of cell phones, they have a unique place in EMF studies. The effects of cell phones on the human body can be categorized as thermal and non-thermal effects (Rothman, 2000). Computer monitors generate EMF between the frequencies of 0 and 1015 Hz. Recent findings indicate that cathode ray tube (CRT) monitors have high risk, while Liquid crystal display (LCD) monitors has less EMF generation. Measurements indicate that with distance from the monitor EMF loses its strength (Cameron et al., 1993). One of the important sources for the EMF generation that raises attention is microwave ovens. They are a very commonly encountered home appliance, since they are very practical. Even though they have internal safety mechanism they still present a risk factor.

Decreasing of the area of vision, heavy stress and feeling of tiredness, loosing of concentration and attention, voices in the ears and warming of ears, reversible hearing problems, headache, electrical burn (Ongel et al., 2007) and such can be seen as the short term effects. The long term effects that are commonly encountered are; irreversible hearing problems, damaging of the embryonic development, increasing risk of miscarriage, decrease in the number of sperms, damaging of the brain tissue, heart related problems, weakening of the memory, lymphoma, and damaging of the genetic structure (Selmaoui et al., 1997; De Seze et al., 1998; Cox, 2003).

#### **EMF and ear:**

The places that are in contact with the equipment most of the time are the head and the neck areas (Hyland, 2000). Therefore, the distance of the cell phone from the eye and the ear has a great importance. One of the major hearing problems that is caused by cell phones is the acoustic neurinoma (Salahaldin and Bener, 2006; Balci et al., 2007).

#### **EMF and testis:**

In the human body there are organs that have low thermoregulation. One of these organs is the testes of men. The preliminary results of the studies conducted so far have shown symptoms of oligospermia in men (Deepinder et al., 2007). In a recent study by Dasdag and his colleagues 1999, showed that the rats that are exposed to cell phones that are in use show histological changes in their testis's and their rectal temperatures are statistically higher compared to regular rats.

#### **EMF and kidney:**

The studies involving the effects of cell phones on kidneys show that cortical renal tubular epithelium is affected more than the medullar tubules (Kang et al., 1997; Pyrpasopoulou et al., 2004; Oktem et al., 2005; Ozguner et al., 2005b).

#### **EMF and skin:**

Human skin, on the other hand, emerges as a protective barrier toward the harmful effects of the cell phones. However, there are studies that report there might be changes even on the skin due to the effects of the cell phones (Ozguner et al., 2004; Sanchez et al., 2006).

#### **EMF and cancer:**

The data involving the tumors show that electromagnetic fields do not directly advance cancer growth but increase the flow of materials into the cell that cause cancer; therefore worsens the stage of the cancer (Schüz et al., 2006; Petrowicz., 2007). Studies conducted in Switzerland 1988 and in Mexico 1992; all showed that there is a relation between living close to base stations and the occurrence of cancer in children specifically leukemia (Hardell et al., 2007; Kan et al., 2007).

#### **EMF and brain:**

Human brain is a structure that functions with electricity, therefore an electromagnetic field can directly affect the function of the brain. It can also be assumed that the electromagnetic field caused by wireless communication such as cell phones might affect many brain functions. Mechanism may be related with the increase of chemical materials, known as the free radicals, in the brain in the presence of electromagnetic field over normal levels.

#### **EMF and neurological diseases:**

DNA damage can cause diseases that affect the nervous system or induce the progress of these diseases. One of the distinctive features of neuron cells that separate them from the other cells is the fact that they cannot divide. DNA damage in cells that perform cell division can cause the occurrence of cancerous cells. However, since the neuron cells cannot divide the damage in the neuron cell DNA mostly affects the function of the cells or causes deaths of the cells. On the other hand, glia cells that are the support tissue of nervous systems can divide. Therefore, DNA damage in these areas can cause cancer (Brain, 2009).

#### **EMF and complicated birth:**

In some studies, it is shown that pregnant women who have stayed in magnetic fields for long periods of time that are higher than the average value experienced complicated births. It is also stated that high magnetic fields increase the chances of miscarriage by three times compared to regular pregnancies (ARPNSA,

1999). Even though the data is not conclusive, it is recommended for pregnancy women to restrict the use of cell phones during pregnancy (Jensh, 1997).

#### EMF and hormones:

Recently, with the major acceptance of the computers in daily life video display units (VDU) have become one of the EMF generating factors that affect humans as well. For example it has been observed that electromagnetic waves propagating from monitors tend to reduce melatonin levels and increase adrenocorticotrophic hormone (ACTH) levels in the human body (Arnetz and Berg, 1996).

#### Role of antioxidants:

As a result of the normal functions of the cells small amounts of these compounds are produced and they are broken up by the antioxidant defense system of the cell. If these compounds cannot be broken up or there is an increase in the amount of free radicals they damage the structures of many compounds that are structurally crucial like deoxyribonucleic acid (DNA) in a cell and such as fats in a cell membrane and the protein molecules in a cell. In addition, free radicals also cause changes that radically affect the functions of a cell such as releasing calcium ions from the cell to the cell liquid. Electromagnetic field reduces the speed of destroying free radical compounds thus allowing them to affect longer periods of time. Therefore, the fact that electromagnetic field increases the amount of free radicals makes us believe that they can also cause cell damage as well as tumors in the brain (Brain, 2009).

Tissue	Effect	Reference
Ear	Acoustic neurinoma	Salahaldin, Bener, 2006 Balci et al., 2007
Testis	Oligospermia	Deepinder, 2007
Kidney	Tubular epithelium damage	Oktem et al., 2005 Kang et al., 1997 Ozguner et al., 2005 Pyrpasopoulou et al., 2004
Skin	Harmful changes	Sanchez et al., 2006; Ozguner et al., 2004
Blood	Leukemia	Hardell et al., 2007 Kan et al., 2007
Neurological system	Cancer	Brain, 2009
Hormones	Melatonin ↓ ACTH ↑	Arnetz, Berg, 1996

**Table 1.** Effects of EMF on different tissues in animal and humans

Besides these antioxidants; L-carnitine and selenium seemed to have protective effects on the 2.45 GHz induced decrease of vitamins A, C and E. L-carnitine seemed to be more protective than the selenium administration (Naziroglu and Gumral, 2009).

Antioxidants	Frequency of EMF, animal and tissue	Effect	Reference
Vitamin E and C (50 mg/kg IM and 20 mg/kg IP)	900 MHz, rat and endometrial tissue	Protective	Oral et al. (2006)
Melatonin (100µg/kg)	900 MHz, rat and kidney	Protective	Oktem et al. (2005)
CAPE (10µMml <sup>-1</sup> kg <sup>-1</sup> day <sup>-1</sup> )	900 MHz, rat and kidney	Protective	Ozguner et al. (2005)

**Table 2.** Effects of antioxidants on electromagnetic field-induced oxidative stress in animal models.

## CONCLUSION

It is certain from literature that; EMF has potential harmful effects on tissues in human and experimental animals. Moreover; it had concluded that there are roles of molecular pathways such as oxidative stress on electromagnetic field-induced diseases. Besides; some antioxidants exhibits a protective effect on EMF induced impairment.

From a public health perspective, manufacturers who sell these products have a lot of responsibilities. As expectedly, each device comes with a manual. While manuals provide instructions on how to operate the product, they also provide preventive information on side effects. Especially kids have to be informed and educated about these kinds of products. We have to be smart buyers when we purchase phones. Especially we should pay attention to cell phone's radiation levels.

We cannot stop using electricity. EMF related health problems could take many years to present symptoms. Hence, public sensitivity to these issues is a must. Preventative measures should be high priority and risks should be minimized. EMF and cell phones are one of the reasons for environmental pollution. Especially, uncertainties in data in these matters cause fear. These psychological effects are one of the main issues that needs be taken into account.

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