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Review paper

## **Association of Electric and Magnetic Fields with Cancer**

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### **Abstract**

The electricity industry and its use is an integral part of life, and due to that, people are exposed to a complex combination of electric and magnetic fields everywhere. A magnetic field results from the flow of current through electrical device. Electric fields are produced whether or not a device is turned on whereas magnetic field are produced only when current is flowing, which usually requires a device to be turned on. Cancer is a complex group of diseases with many possible causes. It is caused by genetic, environmental and dietary factors. Electric and magnetic fields are most important environmental factors that may cause cancer.

Although there are a number of studies indicating that there is no significant connection between exposure to electric and magnetic fields and cancer and there is no known mechanism by which electric and magnetic fields could damage DNA and cause cancer, some studies have reported a significant association between exposure to electric and magnetic fields and cancer. Today, it is a public concern that whether exposure to household electric appliance, Wi-Fi cell phone base station or radio or television transmitters, and ... could increase the risk of cancer in children as well as adults.

Indeed, there are few epidemiological studies concerning the effect of electric and magnetic fields on cancer development in human. Despite a body of knowledge obtained from experimental studies on cells, tissues and animals, they could not reveal clearly the association between electric and magnetic fields and cancer.

**Keywords:** *Electric fields, Magnetic fields, cancer*

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## Introduction

Electricity produces Electric and Magnetic fields. The location, speed and direction of an electric charge determine the force acting on it. This force is defined by two vector fields:

- 1- The electric field that expresses the force on a stationary charge and gives the component of force that is independent of movement.
- 2- The magnetic field which expresses the component of force on the moving charge and gives the force component that is proportional to the speed and direction of the charged particles [1].

*Electric field:* Electric field is the property that every electric charge creates around itself. Now, if another charged particle placed inside the electric field caused by the first charge, a force is applied to it from the electric field, which can be attractive or repulsive. Time-varying electric currents and electric charges cause the creation of electric fields. As we get closer to the electric charge or as the voltage increases, the amount of electric field increases. Volts per meter (V/m) is the SI unit of measurement of electric fields which is equal to the newton per coulomb (N/C). If the electrical device is turned off or on, there are always electric fields. Walls and other objects can easily prevent or weaken the passage of electric fields [1], [2].

*Magnetic field:* When an electric charge moves, a magnetic field is created. In other words, the effect of two electric fields on each other creates a magnetic field. The magnetic field created by single charges, current-carrying wires, orientation of magnetic dipoles (permanent magnets), conductive fluid flow (Earth's magnetic field) [2], [3].

In this way, it is the result of the current flowing in wires and electrical devices. The magnetic field is directly proportional to the amount of electric current and inversely proportional to the distance, that is, as the current increases, the value of the magnetic field increases, and on the other hand, the further away we are from the source of the magnetic field production its value decreases. The magnetic field measurement unit is microtesla ( $\mu\text{T}$  or millionth of a tesla).

magnetic fields require a device to be turned on. which means flowing of current. Because current is always flowing through Power lines so magnetic fields continuously produced in them. magnetic fields can pass through buildings, living things, and most other materials [4].

*Electromagnetic fields:* In fact, the interaction of two perpendicular magnetic and electric fields creates an electromagnetic field or EMFs. This field affects the electric charges that are inside it and changes their behavior. The amount (intensity) of the electromagnetic field can be infinite. The types of electromagnetic radiation are broadly classified into the following classes (regions, bands or types):

1. Gamma radiation
2. X-ray radiation
3. Ultraviolet radiation
4. Visible light
5. Infrared radiation
6. Microwave radiation
7. Radio waves

This classification goes in the increasing order of wavelength and decreasing the order of frequency, which is characteristic of the type of radiation [5]. In this way, there are two main categories of EMFs:

*Higher-frequency EMFs:* which include Gamma radiation and X-ray radiation and can damage DNA or cells directly.

*Low- to mid-frequency EMFs,* which include magnetic fields from electric power lines and

appliances, radio waves, microwaves, infrared radiation, and visible light. These EMFs are not known to damage DNA or cells directly [6].

The waves that we deal with in our daily life and are studied in this article are low and medium frequency EMF waves, which we call non-ionizing EMFs. Low- to mid-frequency EMFs are produced by natural and artificial sources. The Earth's magnetic field, which causes the needle on a compass to point north, is an example of natural EMF [1], [2], [6].

Man-made EMFs can be produced from various sources as follows:

power lines, electrical wiring, and electrical appliances such as shavers, hair dryers, and electric blankets, wireless telecommunication devices and equipment, including cell phones, smart meters, and portable wireless devices, such as tablets and laptop computers [2], [6], [7].

Household appliances and other electrical devices used at home, the intensity of the magnetic field is greatest near the source of the field, and the farther the user is from the source, the faster it decreases. Magnetic fields fall off quickly at a distance of about 30 cm from most devices. For example, for a computer screen, at a distance of 30 to 50 cm from the screen where most people using a computer sit, the magnetic fields are significantly less [6], [7].

#### *The Relationship between Low Frequency EMFs (ELF-EMFs) and Cancer*

With the ever-increasing consumption of electricity, wireless technologies, and changes in work systems and social behavior, public concern about electromagnetic fields (EMF) from power systems is increasing [8], [9], [10], [11]. Modern exposure to very low frequency electric and magnetic fields (ELF) is very common. In 2002, the International Agency for Research on Cancer (IARC) classified ELF (including power frequencies of 50 and 60 Hz) EMFs as "probably carcinogenic to humans." classified [12]. Many epidemiologic studies and comprehensive reviews of the scientific literature have evaluated possible associations between exposure to ELF-EMFs and risk of cancer in adult and children [13], [14], [15]. Although these types of waves cannot directly damage DNA or cells, some scientists thought that ELF-EMF can cause cancer through other mechanisms, such as reducing the level of the hormone melatonin which according to some evidence, melatonin may suppress the development of certain tumors, so in this case exposure to these waves and the very small changes in cells in the body are of great clinical importance [16], [17].

Leukemia and brain tumors are the most common cancers among children. Many studies and Several meta-analyses around the world have investigated the possible relationship between exposure to low-frequency EMFs and the risk of cancer in children [13], [14], [15], [18], [19], [20], [21], [22]. These studies have examined living near power lines, magnetic fields generated by household appliances, and parental exposure to high levels of magnetic fields at work [23], [24], [25]. No consistent evidence was found for a link between any source of low frequency EMFs (ELF-EMFs) and cancer [26].

Breast cancer is the most common cancer and also second highest mortality rate of all cancers among women [27]. The excessive exposure to EMFs increases the risk of female breast cancer, as demonstrated in several pooled or meta-analyses as well as some peer-reviewed studies [28]. It is questionable whether chronic human exposure to EMFs might affect melatonin secretion, its circadian rhythm, or both [29], [30], [31], [32]. In general, no cumulative effects on melatonin secretion in humans have been found in response to MFs and this rebuts the "melatonin hypothesis" in which a decrease in plasma melatonin concentration (or a disruption in its secretion) would be correlated with the occurrence of breast cancers as a consequence of exposure to MFs [33], [34], [35], [36], [37], [38], [39], [40]. Studies have been conducted regarding the possibility of parents being exposed to high levels of magnetic fields before conception and/or during

pregnancy and the risk of cancer in future children. The results obtained have been contradictory and more research is needed in this matter [41], [42].

In 2002, an expert working group was appointed by the International Agency for Research on Cancer (IARC), a component of the World Health Organization, to review all available evidence on static and very low frequency electric and magnetic fields [43]. The Working Group, considering the little and limited information recorded in connection with childhood leukemia, classified ELF-EMFs as "probably carcinogenic to humans" and static electric and magnetic fields and very low frequency electric fields as "in terms of Carcinogenicity for humans cannot be classified" [43]. In 2015, the European Commission's Scientific Committee on Emerging and Newly Identified Health Risks examined EMFs in general, as well as mobile phones in particular. The results of this epidemiological research in many areas Low-frequency studies have shown that children exposed to daily averages above 0.3 to 0.4  $\mu\text{T}$  of electromagnetic waves have an increased risk of developing leukemia, although no mechanism has been identified and there is no support to explain these experimental studies. It also found that epidemiological studies of radiofrequency exposure did not show an increased risk of brain tumors or other head and neck cancers, although the possibility of an association with acoustic neuroma remains open [44]. In some findings, EMF has been considered as a mutagenic and involvement in chemical reactions that produce free radicals, but EMF does not seem to exert mutagenic effects and the generation of free-radicals that might be linked to several other factors, beside the variability of EMF exposure [45].

## **Conclusion**

Despite the evidence of a high risk of various types of cancer from excessive exposure to magnetic fields, there has not been a general acceptance that exposure to these waves is dangerous to human health. The concept of "prudent avoidance" popularized by Granger Morgan (1988) from Carnegie Mellon University about 30 years ago is still valuable. We do not reduce our electricity consumption, but there are many simple ways to reduce excessive exposure to magnetic fields that do not interfere with quality of life but reduce the risk of developing cancer.

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## **Conflict of interests**

The authors declare that there are no competing interests.

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