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Effect of exposure to non-ionizing radiation (electromagnetic fields) on the human system: A literature review

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ABSTRACT

The indiscriminate presence of radio base stations, which emit non-ionizing radiation (NIR), as well as the frequent use of mobile phones, can cause increased susceptibility of populations to the emergence of diseases such as cancers of the head and neck, biochemical, hematopoietic and hepatic changes, among others. Exposure to physical contamination, including NIR, has been implicated in numerous diseases, raising concerns about the widespread sources of exposure to this type of radiation. This paper reviews studies that have assessed associations between likely exposure to electromagnetic fields, such as radiofrequency transmissions, and many kinds of human diseases including cancer, as well as alerts to the current knowledge on the association between environmental exposure to NIR and the risk of development of adverse human health effects. This way, there appears to be an urgent need to reconsider exposure limits for low frequency and static magnetic fields, based on combined experimental and epidemiological research.

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INTRODUCTION

Non-ionizing radiation (NIR) is the low-frequency radiation generated by electric, magnetic and electromagnetic fields, time-varying (up to 300 GHz) created by electrical and electronic equipment in general (cordless phones, cellular, microwave ovens, computers, video games, televisions, and others) [1]. NIR can cause headaches, insomnia, fatigue, nausea, stress, eczema, dermatitis, cataracts, glaucoma, Parkinson's disease, impotence, miscarriage and cancer, among others, depending on the time of exposure to this radiation [2,3]. The increased use of mobile cell phones by the public is associated with contradictory reports about the possible effects on health to users by a repetitive exposure to electromagnetic NIR [4-6].

It is very strange that although no exist conclusive studies on the effects of NIR in man, manufacturers of products that emit this type of radiation, make a series of recommendations for their use. There is considerable public concern about possible adverse health effects due to the use of mobile phones for a long time. While there is scientific controversy about the health effects due to prolonged use of high frequency electromagnetic fields in the last 50 years, the growth and success of mobile telecommunications makes it necessary to investigate these problem more comprehensively, and carefully highlight the possible risks, because never before in history, a substantial proportion of the population had been exposed to microwaves

in nearby fields and in relatively high levels [7]. Due to the main target to exposure is located in the head, most epidemiological researches focuses on brain tumors. There are some cancers from salivary gland [8,9]; and other cancers from lymphoid and hematopoietic tissues [10,11]. However, all studies have methodological shortcomings: (1) Very short duration of the use of mobile phones to assist in risk assessment, (2) exposure was not rigorously determined and (3) there is the possibility of re-call and response error in some studies. In these studies, there is evidence of an increased risk of cancer with increased latency and duration of use of mobile phones [12].

The power level used by mobile phones is one of the most important factors determining the intensity of radio frequency (RF) exposure during a call. Calls from mobile phones made in areas where base stations are densely located (usually urban areas) should, in principle, use average power levels with lower output than calls made from mobile phones in areas with greater distances between base stations (rural areas) [13]. The most important exposure parameters such as: Signal, distribution field and minimum requirements for assembly and dosimetry were described in a guide to facilitate the development of display systems to be used in studies with healthy human volunteers [14,15].

According French *et al.* [16], repeated exposure to radiation from mobile phone acts as a continuous repetitive stress leading to overexpression of heat shock proteins. These proteins

are a normal defense response to cellular stress, but chronic expression induces or promotes oncogenesis, metastasis and/or resistance to cancer chemotherapeutic agents.

In thermosensitive mutant eukaryotic cells, which undergo apoptosis when subjected to elevated temperatures, there was a potentiation of apoptosis when they are exposed to amplitude modulated of RF fields simultaneously with harmful agents known. This effect was observed at low values of specific absorption rate when compared with the peak values found inside the head of a mobile phone user [4].

Furthermore, Chinese hamster ovary-K1 cells exposed to electromagnetic fields of 2.45 GHz and to different temperature ranges showed an increase in the formation of micronuclei (MN). MN formation is induced by breaking of the chromosome or by inhibiting spindle during cell division, which leads to cell injury [17].

For years, scientists have debated why cancer rates are increasing in the central nervous system, and if increased these rates are artificial, or they reflect real increases in occurrence. An area of the current consensus is the potential risk of exposure to non-ionizing electromagnetic fields [8]. The hypothesis that the human brain cancer can be caused by exposure to extremely low frequency magnetic fields (ELF-MF), such as those emitted from power frequency equipment of 60 Hz, and distribution systems of electric power, has been exploited by over 25 years.

The biological and epidemiological evidences are failure to support a causal relationship between ELF-MF and brain cancer [18-21]. The rapid and extensive proliferation of wireless RF devices, such as analog and digital mobile phones, have stimulated studies to investigate the stories of occurrence of brain tumor associated with the use of these phones [22-24].

On the other hand, according Morgan *et al.* [25], no association was found between exposure to RF and mortality caused by brain tumor, in a study conducted among workers of a phone company. Furthermore, results of another case-control study found no association between mobile phone use and brain tumor occurrence [26].

All are exposed to a complex environment of electric and MFs of low intensity. The exposure of the general population is range from 5 to 50 V/m electric field and 0.01-0.02 micro-tesla (μT) to MFs. The fields in question are those associated with the use of electric currents (ELF: 50-60 Hz) and those related to the use of mobile phones (RF 900 and 1800 MHz).

The question about the possible health risk from exposure to electric and/or MFs has become a subject of interest to scientists and is now a major public debate. A great number of expertise led to a careful inspection of the scientific publications of numerous countries, and conclude that current data do not allow us to assert the existence of health effects, however, knowledge about the biological effects of electromagnetic fields still contains certain gaps that could be filled [27,28].

According Roses *et al.* [29], no histological changes were observed in rats that were subjected to microwave radiation at a frequency of 850 MHz and power of 1.6 mW/cm². In another line of research, rats subjected to electromagnetic radiation (850 MHz frequency) have higher levels of stress and higher anxiety [30], which would lead to some behavioral changes in these animals [31].

Numerous epidemiological studies on the occurrence of cancer by exposure to electromagnetic fields are very conflicting yet. For example, in the few studies that assume that there is an increased risk of cancer, such increase is always low [32]. The measure of relative risk is 2-3. Until date, there is a few data about the risk of childhood leukemia by exposure to ELF generated at home. These can exist when children are chronically exposed to more than 0.4 μT (relative risk is in the order of 2) [28].

In general, MF sources in homes fall into two categories: Sources that produce fields extending beyond the immediate area surrounding the source (e.g., currents on pipes, power and distribution lines). Such sources are called "area sources;" and sources where the field is essentially confined to an area within a small distance of the source (e.g., appliances, electrical panels). Such sources are called "local sources." There are two power fields: Electric field and an MF. The difference between electric field and MF is that an electric field is produced by voltage while MF results from the flow of current through wires or electrical devices. Electric field is present everywhere in the environment, but is invisible to the human eye. This is because all charged objects create an electric field that travels into the space that surrounds it. Electric field increase in strength as voltage is raised, and it can be detected even if the equipment is switched off, but not unplugged from the main power socket. The following sources producing MFs in homes were identified: Electrical appliances; grounding system of the residence; overhead power distribution lines; underground power distribution lines; overhead power transmission lines; ground connections at electrical subpanels; electrical wires used for ceiling or floor cooling and heating systems; electrical wiring associated with some multiple-way switches; and knob and tube wiring (old wiring where the wires are separated by a few inches) [32-36].

In the recent years, some pathological processes such as gene mutations, induced oncogenesis, different cellular and metabolic effects, pseudo-iron deficiency, allergic conditions, cataracts, breast cancer, osteoblast cellular response, and other processes associated with lesions in the main functional and structural systems have been reported as potential biological effects from radiation produced by mobile telephones [37-50]. However, the existence of many contradictory data available in the literature hinders a true assessment of the unfavorable effects of NIR in relation to distinct organism as well as for the population as a whole.

A link with breast cancer and others cancers has been postulated via modified melatonin activity [51,52]. Other illnesses have been linked to electricity distribution, by association or

mechanistic considerations. MF exposures above $0.1 \mu\text{T}$ are postulated to result in many cases of depression and suicide in adults [53].

According Calvente *et al.* [54], there is a consistent pattern of increased leukemia incidence in children exposed to low electromagnetic fields. This increase is pronounced in children exposed to fields greater than $0.30 \mu\text{T}$, but can also be observed in weaker fields, and they suggest possible future actions such as to investigate adverse effects to a lower level of exposure than is classically used for risk estimations ($\geq 0.30 \mu\text{T}$), comparing between groups with low and high exposure to NIR among others.

A positive association was found between high-level exposure – above $0.4 \mu\text{T}$ – and the risk of brain tumors in Japanese children under 15 years of age. This association could not be explained solely by confounding factors of selection bias. Surveys indicated that about 5-7% of children under age of 7 in Taiwan are exposed to residential ELF-MF above $0.3\text{-}0.4 \mu\text{T}$ [55,56].

Everyone is exposed to ELF-MF whenever electric current flows in household appliances, office equipment, power lines, medical devices, personal electric appliances. A key point World Health Organization makes, based on their detailed study, is that “even the exposure of people living in the vicinity of high voltage transmission lines differs very little from the average exposure in the population” [57].

CONCLUSION

The fact that ELF-MF is a possible carcinogen and may cause childhood leukemia remains valid [58-60]. Moreover, the constant exposure of modern society to ELF-MF has raised considerable concerns about the potential risks to male reproduction [61,62]. Research on electromagnetic fields and possible health effects has been conducted for over 44 years, and a large number of researches have been conducted only relate to cancer study. Although uncertainties remain as they do with almost all exposure and are being researched, a wide variety of possible health effects have been studied, and so there is now a huge amount of scientific knowledge about electromagnetic fields and possible health effects, particularly cancers [63,64].

These studies provide scientific information to society and their respective authorities they need for selecting and deciding on the better security measures to protect the general population against exposure to electromagnetic fields.

AUTHOR CONTRIBUTIONS

Paula RS Câmara designed the research study, wrote a paper and reviewed it.

DEDICATION

This work is dedicated to all victims from World Trade Center in the September 11 attacks of 2001.

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