A Survey of Health Effects of Electromagnetic Fields

M.A. Mohamed,M.M. Abdelrazek andM.S. Zewita

Faculty of Engineering-Mansoura University-Mansoura-Egypt

Abstract

The potential health effects of the very low frequency of electromagnetic fields surrounding power lines and electrical devices are the subject of ongoing research and a significant amount of public debate. While electrical and electromagnetic fields in certain frequency bands have fully beneficial effects which are applied in medicine, other non-ionizing frequencies, be they sourced from extremely low frequencies, power lines or certain high frequency waves used in the fields of radar, telecommunications and mobile telephony, appear to have more or less potentially harmful, non-thermal, biological effects on plants, insects and animals, as well as the human body when exposed to levels that are below the official threshold values.

One must respect the precautionary principle and revise the current threshold values; waiting for high levels of scientific and clinical proof can lead to very high health and economic costs, as was the case in the past with asbestos, leaded petrol and tobacco.

Keywords: *Electromagnetic fields (EMF), Radio Frequency (RF), and Extremely Low Frequency (ELF), Hyper Frequency (HF), Personal Communication Services (PCS).*

1. Introduction

It should be noted that with satisfaction that a major contribution was made by the technological innovations resulting from electrification and new radio-telecommunication techniques to economic growth and the material well-being of the populations of industrialized countries. Domestic appliances, for example, have greatly helped to lighten the load from everyday chores in millions of households and played an inconsiderable role in the women's liberation movement.

Nevertheless, it must be said that, since some of these new technologies were first introduced, environmental or health problems have emerged and become a topic of discussion in certain countries, both in scientific circles and in the field of health and occupational medicine.

Microwaves are a specific category of radio waves that can be defined as radio frequency radiation where frequencies range upward from several hundred megahertz (MHz) to several gigahertz (GHz). One of the most familiar and widespread uses of microwave energy is found in household microwave ovens, which operate at a frequency of 2450 MHz (2.45 G Hz).

Microwaves are also widely used for telecommunications purposes such as for cellular radio, personal communications services (PCS), microwave point-to-point communication, transmission links between ground stations and orbiting satellites, and in certain broadcasting operations such as studio-to-transmitter (STL) and electronic news gathering (ENG) radio links. Microwave radar systems provide information on air traffic and weather and are extensively used in military and police applications. In the medical field, microwave devices are used for a variety of therapeutic purposes including the selective heating of tumors as an adjunct to chemotherapy treatment (microwave hyperthermia).

Radiofrequency radiation, especially at microwave frequencies, efficiently transfers energy to water molecules. At high microwave intensities, the resulting energetic water molecules can generate heat in water-rich materials such as most foods. The operation of microwave ovens is based on this principle.

2. Electromagnetic Wave Overview

An electromagnetic wave in a vacuum consists of mutually perpendicular and oscillating electric and magnetic fields. The wave is a transverse wave, since the fields are perpendicular to the direction in which the wave travels. All electromagnetic waves, regardless of their frequency, travel through a vacuum at the same speed, the speed of light c (c = 3.00 x 108m/s). The frequency f and wavelength λ (lambda) of an electromagnetic wave in a vacuum are related to its speed through the relation $C = f \lambda$

3. Human Health Studies

Concerns have expressed about the possible interactions of RF with several human organ systems, such as the nervous, circulatory, reproductive and endocrine systems, particularly those emitted by wireless communication handsets, such as mobile phones. One way of investigating causal effect relationships in this area is to perform experiments with voluntary human beings in controlled circumstances (so-called provocation studies).

3.1 Cognition, Memory and Attention

It was suggested by the reviewers that although in some studies shorter response times were obtained, this should not be interpreted as a beneficial effect of cell phones, since in more complex situations, they might be detrimental. In addition, since no long-term experiments were carried out, there is limited relevance of such studies for the question of whether mobile phone use is detrimental to health.
Studies in children are also lacking [1]

3.2 Epidemiological Surveys – cell/Mobile phones

A researcher group noticed that many patients with perceived hypersensitivity to electricity reported aggravation of symptoms (which included headache) from cell-phone use [2] On the basis of a questionnaire survey, they noted that people living in the vicinity of cell-phone base stations reported "various complaints mostly of the circulatory system but also of sleep disturbances, irritability, depression, blurred vision, concentration difficulties, nausea and lack of appetite, headache and vertigo."[3] From another questionnaire others concluded, "The use of mobile phones is a risk factor for health hazards [4]

3.3 Headaches

In a study, persons with self-reported sensitivity to mobile phone signals did not react to such exposures with any increased severity of headache symptoms [5]

3.4 Hormones

After shutdown of a short wave broadcast transmitter, a slight increase in melatonin excretion in study volunteers. The authors noted, however, lack of exposure blinding might have affected the results [6]

3.5 Fasciitis and Dermatitis

In a comparison of blood samples from radio-field engineers versus controls, a study found no significant differences in sister chromatid exchanges or chromosomal aberrations [7]
There was, in fact, a trend toward less genetic damage in RFE-exposed subjects. Others found a negative correlation between natural RFE emission (as measured by 2800-MHz solar radio flux) and the incidence of Down syndrome (a year after the RFE measurements) [8]

3.6 Electrophysiology and Sleep

A researchers group investigated the effect of exposure during six nights not only on sleep parameters evaluated by polysomnography, but also on an array of neuropsychological tests [9]
Data analysis was done by comparing the baseline night with the first and last exposure night and the first two sleep cycles of the respective nights. They did not find “significant effects, on conventional sleep parameters or on EEG power spectra and correlation dimension, as well as on cognitive functions.” Their opinion was that “previously realized sleep studies yielded inconsistent results regarding short-term exposure. Moreover, data are lacking on the effect that short- and long term exposure might have on sleep as well as on cognitive functions.”

3.7 Vision, Hearing and Vestibular Systems

There are few experimental studies published in these areas. Two Brazilian physicians reviewed the literature on cell phones, hearing and vestibular system. They argue that, since cell phones are very close to the user’s ear, the skin, inner ear, cochlear nerve and the temporal lobe surface might absorb a part of its radiofrequency energy, so that effects could be expected[10]
In addition, an increase in the temperature of the inner fluids of the vestibular apparatus theoretically could induce neural responses in the receptor cells, such as vertigo and nystagmus. Vertigo is one of the complaints frequently made by people who are allegedly hypersensitive to RF radiation emitted by cell phones.
The proximity of a mobile phone to the human eye also raises the question as to whether RF could affect the visual functions.

3.8 Electrical EMF Radiation Exposure Elevates Risks of Depression

A research focused exclusively on the electrical EMFs generated by power lines and its effects on humans, The study concluded that electrical EMFs of above 1mG within a distance of 150 meters from power lines resulted in an excess of 9,000 cases of depression and about 60 cases of suicides in adults. The study also showed that the electrical EMFs of power lines within 400 meters enhanced exposures to air pollutions, leading to around higher cases of 200 to 400 lung cancers, 2 to 6 childhood leukemia cases, 17 non-melanoma skin cancer cases, and between 2000 and 3000 cases of air pollution related other diseases, ailments, and illnesses[11]

3.9 Endocrine System

A researcher group investigated the effect of exposure to 900 MHz GSM RF on steroid (cortisol and testosterone) and pituitary (thyroid-stimulating hormone, growth hormone, prolactin and adrenocorticotropin) hormone levels in healthy males. Exposure was daily, for one month and hormones were measured by blood samples every hour before the beginning, at the middle, and at the end of the exposure period. The study reported that all hormone concentrations remained within normal physiological ranges, and that the circadian profiles were not disrupted. For growth hormone and cortisol, there were significant decreases of about 28% and 12%, respectively, 2 and 4 weeks after exposure, but no difference persisted in the post-exposure period, but factors other than RF could be responsible for this (no control group was set up)[12]

4. Effect of EMF on Human Brain

Effects of microwave radiation on human brain bioelectrical activity have become of major interest with increasing applications of telecommunication devices.
The difficulties in independent replication of the experimental results cause doubts in these effects and mechanisms behind the effects are still unclear.
There are different reasons for difficulties in identification and doubts in microwave effects on electroencephalogram (EEG) and cognitive processes.

4.1 Reasons for Doubts in MW Effects on Brain

Microwave exposure as a weak physical stressor causes only small changes in the EEG and the effect is hidden in natural variability of the EEG signal. Effect of microwave exposure differs for individuals, some of the subjects under investigation may be significantly affected and the others not affected. Ability of the brain to adapt physiologically to an external stressor decreases or even compensates the effect. Variations in microwave power density inside the brain tissues can cause differences in the effects. Instability of the physiological state of the brain.

4.2 Discussion Individual Sensitivity

Sensitivity of some subjects to exposure is most likely related not to hypersensitivity of these individuals but to variability of the physiological state of the brain. Human brain is highly complicated chaotic system and affected simultaneously by hundreds of physical, chemical, psychological etc. stressors. Microwave exposure is one of these stressors. Effect of microwave exposure as a weak stressor depends on combination of the other stressors and state of the brain. The effect of exposure varies in different days and conditions. Similar situation takes place in the case of the effects caused by alcohol. Reliability of the effect becomes complicated due to variability of many coexisting factors. The rate of subjects affected during one experimental session depends on the physiological states of their brains at this time.

5. Effect of EMF on Human Heart and Blood Pressure

Magnetic Resonance Imaging (MRI) has been listed as the single most important medical innovation, on par with CT scanning [13]. In current clinical MRI ECG is being using for three major purposes. Firstly, heart motion, blood flow and blood pulsation are commonly dealt with using electrocardiogram (ECG) for synchronization of MR data acquisition with the cardiac cycle to address or compensate for cardiac activity related motion artifacts which is of paramount importance for an ever growing portfolio of cardiovascular MR (CMR) and neurovascular MR (NVMR) applications Secondly, ECG is widely used to simultaneously register cardiac activity with MRI; for example to eliminate physiological fluctuations from brain, activation maps derived from functional MRI studies. Thirdly, there are an increasing number of clinical applications that require ECG monitoring prior to/after the MR examination while the patient is still in the MR environment but outside of the MR scanners bore using ECG devices as a patient emergency indicator [14]

5.1 Practical Considerations

For ECG monitoring on MRI environment Careful skin preparation includes (i) removal of chest hair by shaving, if applicable, (ii) cleaning of the skin with special abrasive skin prepping gel and (iii) the use of a clean gauze pad to thoroughly dry the skin area where the surface electrodes will be positioned. Typical placement of ECG surface electrodes in an MRI environment are placed relatively close to each other on the left hand side of the upper and for safety to avoid skin burn ,there advice for use of extra padding for keeping RF coils in a safe distance from ECG electrodes being mounted to the chest.

5.2 Interference of ECG with Magnetic Fields

Artifacts in the ECG trace and severe T-wave elevation might be uninterrupted as R-waves resulting in misdetection of cardiac activity or erroneous cardiac gating together with motion corrupted image quality. These artifacts render magneto-hydrodynamic MHD effects detrimental for a reliable synchronization of MRI or registration of MRI data with the cardiac cycle and constitute a practical impediment.

5.3 Blood Pressure and Blood Flow

As regard to effect of MRI Concerning occupational studies data, show a significant increase in arterial pressure [15]

5.4 Reproductive System Birth Defects or Fetal Loss

In a case-control study, after controlling for potential confounders low birth weight was associated with presumed exposure among female physiotherapists to short waves (typically 27.12 MHz) (odds ratio 2.75; 95% confidence interval (CI) 1.07–7.04) [16]
In contrast, another group found lower incidences of congenital malformations and miscarriage in physiotherapists than those in the general community [17]

6. Result and Discussions

A group of researcher studied the effects of static magnetic stray fields emitted by a 7 T magnetic resonance imaging scanner on both postural body sway .In this study subjects were exposed to sham, low intensity (0.24 T static and 0.49 T s -1 time varying field) and high intensity (0.37 T static and 0.70 T s -1 time varying) magnetic fields. Body sway was measured in eyes closed and feet in parallel (normal) and tandem (one in front of the other) position. The results showed a significant

($p < 0.05$) increase in body sway in feet parallel condition as a function of increasing the intensity of both static and time-varying magnetic fields, but only an almost significant increase in feet tandem condition in the group of 30 healthy volunteers (average age 28.8 years, 21 female). The authors concluded that a spatially heterogeneous static magnetic field affects postural body sway either by affecting cognitive functions (proprioceptive, visual, vestibular) or vestibular system, or both, which in turn affect the postural stability[18].

6.1 Childhood Leukaemia

The relationship between residential magnetic field exposure, contact currents and childhood leukaemia group was assessed in a case-control study in California. 30-minute measurements of contact currents as well as of magnetic fields were taken in homes of 245 leukaemia cases and 269 controls. No association was found for either contact currents or magnetic field exposures and childhood leukaemia. ORs for magnetic field exposures above 0.2 or 0.3 μT compared to ≤0.1 μT were around unity or below one. In the analysis by Does et al., the correlation between the two exposures measures was low (Spearman < 0.3), meaning that effects could be assessed independently. However, Kavet highlights that the correlation was high enough to be a problem in other analyses if not accounted for. Contact currents depend on the electricity system configuration and might therefore be particular to the system applied in the US. Contact currents have not been evaluated elsewhere [19][20].

6.2 Electrical Injury

Only little new information regarding parental exposure and risk of childhood cancer has become available, which does not materially change the conclusions from the previous report: "There appears to be little support for the hypothesis relating parental exposure to cancer in the offspring." New evidence regarding adult brain tumours and leukaemia and exposure to high voltage power lines were compatible with an earlier meta-analysis that showed very small increased risks (around 10%) in those exposed [21].

7. Conclusions

Considering the very low exposure levels and research results collected to date, there is no convincing scientific evidence that the weak RF signals from base stations and wireless networks cause adverse health effects. We have only limited knowledge about the long-term effects of EMF. Many will use this uncertainty as a reason for asking regulators to adopt a precautionary approach and, by reducing exposure guidelines below the present levels, provide a greater measure of safety. The existing guidelines for public exposure are set at safety of 50 times below the established threshold for harm. It should be noted however, that mobile phone exposure is short term at high levels while base stations give long-term low-level exposures. People generally worry more about the long-term effects that are unknown than short-term acute effects.

Nevertheless, anxieties and fears remain in wide sectors of the population over the health hazards posed by the waves, and of the demands voiced by high-level scientists, by groupings of doctors and by the associations of concerned citizens, which abound in many Council of Europe member states.

REFERENCES

[1] Z. Sienkiewicz, N. Jones and A. Bottomley, "Neurobehavioural effects of electromagnetic fields", Bioelectromagnetics, Suppl 7:S116-26. 2005.

[2] B.Stenberg, J. Bergdahl, B. Edvardsson,N. Eriksson, G. Linde´n and L. Widman, "Medical and social prognosis for patients with perceived hypersensitivity to electricity and skin symptoms related to the use of visual display terminals. Scand. J. Work Environ", Health 28, 349–357. 2002.

[3] A. Bortkiewicz,B. Pilacik,E. Gadzicka and W. Szymczak , "The excretion of 6-hydroxymelatonin sulfate in healthy young men exposed to electromagnetic fields emitted by cellular phone -- an experimental study", Neuro Endocrinol Lett. Suppl 1:88-91. Apr. 2002.

[4] T.Al-Khlaiwi and S.A.Meo, "Association of mobile phone radiation with fatigue, headache, dizziness, tension and sleep disturbance in Saudi population" Saudi Med. J. 25, 732–736. 2004.

[5] G.J.Rubin, G.Hahn, B.S.Everitt, A.J.Cleare and S.Wessely. "Are some people sensitive to mobile phone signals? Within participants double blind randomised provocation study" BMJ 332, 886–891. 2006.

[6] E.S.Altpeter, M.Roosli, M.Battaglia, D.Pfluger, C.E.Minder and T.Abelin. "Effect of short-wave (6–22 MHz) magnetic fields on sleep quality and melatonin cycle in humans: the Schwarzenburg Shut-Down Study" Bioelectromagnetics 27, 142–150. 2006.

[7] A.Maes, U.Van Gorp and L.Verschaeve. "Cytogenetic investigation of subjects professionally exposed to radiofrequency radiation" Mutagenesis 21, 139–142. 2006.

[8] E.Stoupel, R.Kalediene, J.Petrauskiene, S.Starkuviene, E.Abramson, , P.Israelevich and J.Sulkes, "Suicide– homicide temporal interrelationship, links with other fatalities. and environmental physical activity" Crisis 26, 85–89. 2005b.

[9] G.Fritzer, R.Goder , L.Friege, J.Wachter , V.Hansen , D.Hinze-Selch and JB.Aldenhoff . "Effects of short- and long-term pulsed radiofrequency electromagnetic fields on night sleep and cognitive functions in healthy subjects Bioelectromagnetics. (4):316-25. May 2007.

[10] AP.Balbani and JC.Montovani. "Mobile phones: influence on auditory and vestibular systems" Braz J Otorhinolaryngol.74(1):125-31. 2008 Jan-Feb. Review. Erratum in: Rev Bras Otorrinolaringol (Engl Ed). 74(2):319. Mar-Apr 2008.

[11] DL.Henshaw, "Does our electricity distribution system pose a serious risk to public health?" Med Hypotheses 59(1):39-51. 2002.

[12] Y.Djeridane , Y.Touitou and R.de Seze. "Influence of electromagnetic fields emitted by GSM-900 cellular telephones on the circadian patterns of gonadal, adrenal and pituitary hormones in men" Radiat Res.169(3):337-43. Mar 2008.

[13] VR.Fuchs and HC.Sox "Jr. Physicians' views of the relative importance of thirty medical innovations." Health Aff (Millwood); 20:30-42. 2001.

[14] T.Niendorf, DK.Sodickson and GA.Krombach. "Toward cardiovascular MRI at 7 T: clinical needs, technical solutions and research promises." Eur Radio l; 20:2806-2816. 2010
[15] K.Vangelova , C.Deyanov, M.Israel. "Cardiovascular risk in operators under radiofrequency electromagnetic radiation." Int J Hyg Environ Health, 209(2):133-8. 2006.
[16] Y.Lerman, R.Jacubovich and M.S.Green. "Pregnancy outcome following exposure to shortwaves among female physiotherapists in Israel." Am. J. Ind. Med. 39, 499–504. 2001.
[17] J.E.Cromie, V.J.Robertson and M.O.Best. "Occupational health in physiotherapy: general health and reproductive outcomes" Aust. J. Physiother. 48, 287–294. 2002.
[18] L.E. van Nierop , P. Slottje , H. Kingma, and H. Kromhout . MRI-related static magnetic stray fields and postural body sway: A double-blind randomized crossover study. Magn Reson Med, 2012a.
[19] R. Kavet, C. Hoope, P. Buffler and M. Does. The relationship between residential magnetic fields and contact voltage: a pooled analysis. Radiat Res, 176, 807-15, 2011.
[20] M. Does, G. Scelo, C. Metayer, S. Selvin, R. Kavet and P. Buffler. Exposure to electrical contact currents and the risk of childhood leukemia. Radiat Res, 175, 390-6, 2011.
[21] K. Grell, A. Meersohn, J. Schuz and C. Johansen. Risk of neurological diseases among survivors of electric shocks a nationwide cohort study, Denmark, 1968-2008. Bioelectromagnetics, 33,459-65, 2012.

Mohamed Abd-El-Azim received the PhD degree in Electronics and Communications Engineering from the Faculty of Engineering-Mansoura University-Egypt by 2006. After that, he worked as an assistant professor at the electronics & communications engineering department until now. He has 40 publications in various international journals and conferences. His current research interests are in multimedia processing, wireless communication systems, and field programmable gate array (FPGA) applications.

Mohamed zewita received the B.S of engineering degree from department of communication and electronics- faculty of engineering-Mansoura University, Egypt, in 2002; He served as a communication engineer in Egyptian radio and television union from 2004 until now. His current research interests include Health effects of Electromagnetic fields.