

Electromagnetic Fields and Human Beings: A Person-Centered Approach to Human Technology

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Abstract

In this paper, we first briefly review the work from the World Health Organization (WHO; 1996), which recognized the need for research addressing the EMFs' influence on human health. The WHO has given guidelines focused mainly on three directives: Challenges, Competencies, and Context. In addition, we also briefly review the projects conducted by the European Union (EU) that have investigated the influence of EMFs on human beings. As the third part of this article, we briefly explain the work of a unit of the International Telecom Union (ITU), the Telecommunication Standardization Sector (ITU-T), which assembles experts from around the world to develop international standards for communication systems. At the end of this article we make some suggestions for further research based on the nature of human beings, person-centered research, and the Science of Well-being.

Keywords: Electromagnetic fields; European Union; International Telecom Union; Person-centered methods; Science of well-being; World Health Organization

Introduction

In our daily life we are exposed to Electromagnetic fields (EMFs) from different sources, natural and man-made. Some of them are visible; such as the sunlight, and other are invisible; such as, infrared and ultraviolet waves. Another example from nature is electric fields during thunderstorms that cause lightning to leap across the sky. EMFs are indeed well known to us; the Earth's magnetic field causes compasses' needles to point North and helps birds and fishes to navigate. Electric and magnetic fields are linked because whenever an electric current flows in an electric field, then a magnetic field is generated and together they form an EMF [1]. An example of man-made EMFs can be found in hi-fi systems in our homes, where an electric field, or voltage, drives a varying electric current that produces a varying magnetic field that causes the speaker cone to vibrate and reproduce sounds. EMFs also arise from microwave ovens, hairdryers, the electric wiring in houses, and remote control devices, computer screens, and electric motors, among others. Additionally, humans are also exposed to EMFs from electric train and tram cables, power lines, radio-frequency communication antennas for emergency services, and now, with the growth of wireless networks, from Wi-Fi and 'Bluetooth' type technologies. One of the main sources of EMFs are mobile phones and wireless networks, which usage have grown rapidly during the last decades. Mobile phones generate EMFs in two ways, one from the antenna mast that covers the specific area in which a person with a mobile phone is and the other from the phone to the antenna mast when we are in a mobile phone call [1]. Importantly, although there are many sources, these EMFs are most of the time relatively weak.

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The World Health Organization (WHO): Guideline

The WHO is the directing and coordinating authority for health within the United Nations and has the responsibility for:

1. Providing leadership on global health matters,
2. Shaping the health research agenda,
3. Setting norms and standards,
4. Articulating evidence based policy options,
5. Providing technical support to countries, and
6. Monitoring and assessing health trends.

In 1996 the WHO recognized EMFs as a rapid growing factor on public anxiety, so the WHO focused on Challenges, Competencies, and Context in order to create guidelines on EMFs and the health of the human population. The WHO mapped EMFs' risk issues for each country and for regions, like EU, and globally as well (i.e., Challenges).

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With regard to Competencies, the WHO suggested that scientific expertise, communication skills, and corporate, and regulatory judgment should be used to mitigate EMFs' risks and challenges through risk management, risk perception, and risk assessment. So at the end, the WHO came up with one guideline to establish a dialogue on risks from EMFs, to research, identify, analyze, and mitigate the effects of EMFs on health (WHO, 2002). The WHO has assessed the scientific evidence of possible health effects of EMFs in the frequency range from 0 to 300 GHz. Extensive research has been conducted into the potential health hazards of exposure to many parts of the frequency spectrum, including the radio frequency EMFs (RF-EMF) used by mobile phones, base stations and other wireless systems and services. Expert review groups mandated by national or international authorities have analyzed the data emerging from this research in more than 150 reports. Weighing the whole body of evidence, there is no evidence to convince experts that exposure below the guidelines set by the International Commission on Non-Ionizing Radiation Protection carries any health risks, for adults, pregnant women or children. Further information about the WHO's EMFs Project can be found at: <http://www.who.int/emf>.

The European Union (EU): Research

The EU acknowledges that technologies that use and generate EMFs bring lots of benefits to our life and also the fact that nowadays we seem not to be able to live and do anything without them. However, the EU also acknowledges that we need to understand and have health standards to avoid any consequence of EMFs (EU EMF Report 2005). EU funded eight major projects aiming to increasing our understanding about the influence of EMFs on human beings under the Framework Programs between 1998 and 2002. This funding continued between 2002 and 2006. The majority of these research projects focused on EMFs from mobile phones and their relationship to the development of cancer. A smaller number of projects investigated possible effects on hearing, memory, and behavior. Researchers conducted the studies in two different ways: (1) *in vitro* research was based on laboratory experiments using biological materials, for example, cell cultures; and (2) *in vivo* research was performed on living organisms, such as rats or

humans. A summary of some of projects is listed in Table 1. All in all, The EU stated that there is no evidence that mobile technology used between 1998-2002 influences health in a harmful way. Nevertheless, one of the rapports was confidential (i.e., The Perform-A). In addition, the EU recommended that more research is needed on the next generation of mobile technology (i.e., The Guard Project).

International Telecom Union (ITU): Standards

The ITU's unit Telecommunication Standardization Sector (ITU-T) assembled experts from around the world to develop international standards that act as defining elements in the global infrastructure of information and communication technologies (ICTs). Standards are critical to the interoperability of ICTs when users exchange voice, video or data messages in another country, because standards enable global communications by ensuring that countries' ICT networks and devices are speaking the same language.

Within ITU's organization there are lots of units with different visions and assignments. The 5's units' (SG5) mission is to do research on methodologies for evaluation of ICT's effects on climate change and publishing guidelines for using ICTs in an eco-friendly way. In recent years one of the SG5's focuses has been studies about technical frameworks for responsible management of the ICT systems that underpin wireless communications. The aim of these studies is to give operators, manufacturers and government agencies the tools required to assess EMFs' levels and to verify compliance with the recommended human-exposure guidelines set out by the WHO, the International Commission on Non-Ionizing Radiation Protection, and the IEEE International Committee Electromagnetic Safety (ICES). The SG5 activities are mentioned in more detail below.

EMF report

A new report from Latin America measuring EMFs provides an overview on how compliance with national and international standards can assist the management and mitigation of public concerns pertaining to EMFs, making it easier to garner social acceptance for the installation of new wireless technologies. It also presents case studies

Projects Name	Purpose	Methodology	Results and Conclusions
The Cemfec Project	To Investigate whether EMFs transmission from Mobile Phone could act as a co-carcinogen.	<i>in vitro – in vivo</i>	Typical RF-EMF exposure of mobile phones did not enhance the cancer-causing activity of the MX chemical carcinogen widely present in our drinking water, animals or cell cultures. .
The Guard Project	To investigate the potential effects of digital mobile phones on hearing.	<i>in vitro – in vivo</i>	No adverse effects on the hearing of the animals (<i>N</i> = 490) or humans (<i>N</i> = 550). Researchers suggested the need of investigating the effects of 3G systems, which have not yet been studied.
The Interphone Project	To extend our limited knowledge of possible link between cancer and RF-EMF.	<i>in vitro – in vivo</i>	The project published analysis of data on acoustic neuromas from five Nordic countries. For example, data from Denmark suggested no increase linked to use mobile phones, data from Sweden suggested an increase, but below the risk area, and the rest showed no risk.
The Perform-A Project	To clarify whether RF-EMFs cause or increases cancer in animals.t	<i>in vivo</i>	The results and conclusions are confidential between the EU, WHO, and the sponsors.
The Ramp 2001 Project	Does current safety limits of RF-EMF can anyhow cause cellular or molecular changes in the brain.	<i>in vitro – in vivo</i>	There was no particular effect of RF-EMF exposure.
The Reflex Project	To investigate whether ELF-EMF and RF.EMF influence human health.	<i>in vitro</i>	ELF-EMFs and RF-EMFs caused, in human and animal cells cultured in the laboratory, several genotoxic effects as well as effects on gene expression However, before any conclusions can be drawn regarding the risks to human health, the results will have to be complemented by whole animal studies.
The THz Bridge Project	In this project TeraHertz (THz) radiation was used to study the potential damage of EMF's radiation on biological systems.	<i>in vitro – in vivo</i>	No biological effects, but in some cases they discovered a change in the ability of certain chemical compounds to flow through artificially created membranes.
The Advice Pulsed Fields Project	To investigate the effects of security systems that operate by generating pulsed EMFs.	<i>in vitro – in vivo</i>	No signs on that exposure guidelines were exceeded. Two recommendations: (1) to increasing efforts for the measurement of exposure levels and (2) that technical information should be provided to customers..

Table 1: Summary of selected projects funded by the EU during the years 1998 to 2002.

on the continuous monitoring systems installed in some countries in Latin America, as well as the policies adopted at governmental level for the implementation of Recommendation ITU-T K.83 in Latin America.

The EMFs application

The EMFs Application, designed for smart phones, tablets, or desktops, provides information and education resources on EMFs suitability for all communities, stakeholders and governments and is available online in six different languages (<http://emfguide.itu.int> or at iOS, Blackberry World and Google Play app store). The mobile application does real site measurements and modeling of the multiple sources operating on different frequencies and transmitting antennas. The application determines the validity of EMFs that are being measured; process and guides using numerical modeling of EMFs in the areas around telecommunication transmitting antennas and other various systems. The application works on existing Specific Absorption Rate measuring and calculating procedures, techniques and protocols for evaluating EMFs.

EMFs considerations in smart sustainable cities

Wireless and wired networks provide the underlying connections that underpin smart sustainable cities. According to the SG5, the design and deployment of wireless networks should aim to ensure compliance with the required quality of service as well as with the standards and regulations on human exposure to RF-EMFs. The technical report details the considerations that need to be taken with respect to EMFs in smart sustainable cities to ensure that the networks and connected devices operate safely and efficiently. Efficient deployment of wireless infrastructure will reduce the transmitted radio frequency power in providing services and improve the efficiency of ICTs. The key audience of this technical report includes city officials, town planners, urban developers, infrastructure providers, network operators and the public. The three sub-activities are briefly described next:

The first activity called ICTs and EMFs provides information about how ICTs get support from wireless network in the community and service providing that includes smart metering, remote healthcare, medical monitoring, smart home, and education. The second activity called EMFs and Health gives huge and deep knowledge about EMFs health effect based on WHO directives. Another sub-activity is EMF exposure limits that provides and collect valuable information from various resources regarding EMF exposure limits from the International Commission on Non-Ionizing Radiation Protection with more information about limitation for workers and information about general public safety to give more awareness about linkage between EMFs exposure, health, and safety. In addition, also informing communities to increase public and policymaker awareness and help citizens to get engaged better into this issue. On the other hand ITU provides different technical information regarding ICT network infrastructure and different wireless technologies like WiMAX, 3G, 4G. The ICT also helps to increase awareness about how different technology usage have an effect on the environment and the approval process for planning on good policy making of ICT networks. This information is available for all countries and communities to decrease the level of EMFs exposure in their society.

Summary

We have briefly reviewed the work done by the WHO, EU, and ITU. We consider that in order to understand the influence and effect of EMFs on human health, these organizations have given guidance (e.g., WHO's Challenge, Competence, and Context), knowledge (e.g., EU's

EMFs research), and technical standards and advice (e et al., .g., ITU's technical reports) (see Figure 1). At this point, the reports about EMFs' influence on health suggest that as long as the short range frequencies of VHF (between 62 MHz to 90 MHz) are used, there should be no health impairments. At the present, however, in order to keep the quality of mobile services (e.g., voice, text, and high speed data), the public is exposed to higher frequency ranges (e.g., 900 MHz, 1800 MHz, and 2100 MHz) on a daily basis. Although, to the best of our knowledge, no study shows that such high ranges are bad for human health, no studies seem to entirely dismiss it. One possible explanation could be that high-frequency voltage transients, which are superimposed on 50/60-Hz fields but are generally not measured, are the real causal agent. This is, however, not based on scientific data of acceptable standard for such claims [4]. Additionally, individuals presenting idiopathic environmental intolerance attributed to EMFs display a higher than random detection performance (d index of signal detection theory) whereas no difference in their bias (β index) toward the presence of the magnetic field was observed [5]. Hence, people with high sensitivity to EMFs might be able to detect the presence of the EMFs to a small extent; however, their symptom reports are connected to perceived exposure. That being said, we certainly agree that to scrutinize the effects if EMFs on human health should indeed be an imperative for the coming years.

Conclusion and Recommendations

In recent years, public health care has been addressed using person-centered approaches [6,7]. The use of a person-centered approach in health care, in contrast to a patient-centered one, focuses in individual interrelationships over time, views diseases as interrelated phenomena, views body systems as interrelated, allows for the person's own health concerns in their own treatment, and follows the development of people's health problems as well as the diseases (see [8] for a clear differentiation between patient-centered and person-centered care). In this context, high risk perception of EMFs waves associated with cellular phones usage was observed when the affected subjects contemplated that they had more personal knowledge [9]. Furthermore, negative inductions produced by EMFs may be the source of hippocampus dysregulation, thus affecting the regulation of emotions, everyday behavior, motivation, and cognitive functions [10]. In this line of thought we propose a person-center approach to innovate human technology that might or might not be endangering our health [11]. For instance, the human body works at 62-68 MHz and the human brain works at 72-90

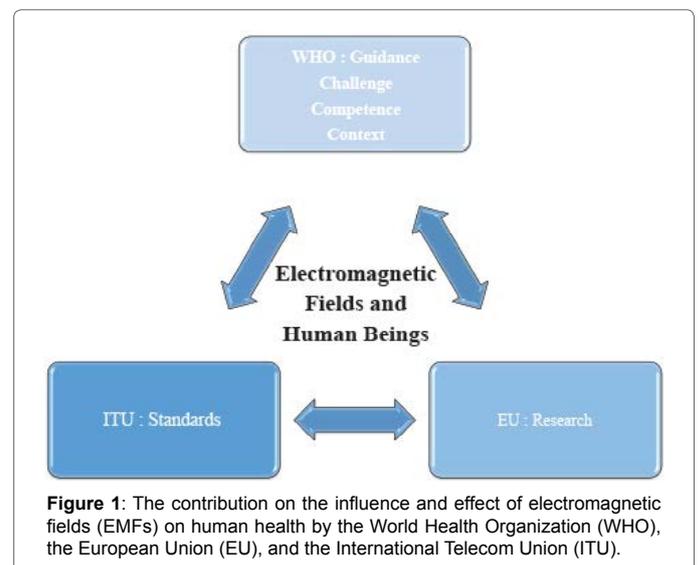


Figure 1: The contribution on the influence and effect of electromagnetic fields (EMFs) on human health by the World Health Organization (WHO), the European Union (EU), and the International Telecom Union (ITU).

MHz like open circuits, thus, exposure could be balanced or limited to this range [12].

On this basis, we suggest a quest for the development of new technical paradigms that take into account the human being and nature as the model. At this moment, critics will say that it is impossible to keep the same quality of services with short-range frequency waves. We agree on that it will be difficult, but not impossible, especially as long as we have nature as our guide.

"I follow Nature, the best of guides, as I would a god, and am loyal to her commands."

Cicero.

Competing Interests

Dr. Dr. Danilo Garcia is the Director of the Blekinge Center of Competence, which is the Blekinge County Council's research and development unit. Bahram Ghandchi is a research project manager at the Blekinge Center of Competence. The Center works on innovations in public health and practice through interdisciplinary scientific research, person-centered methods, community projects, and the dissemination of knowledge in order to increase the quality of life of the inhabitants of the county of Blekinge, Sweden. Dr. Danilo Garcia is also an Associate Professor at the University of Gothenburg and together with Professor Trevor Archer and Associate Professor Max Rapp Ricciardi, the leading researcher of the Network for Empowerment and Well-Being.

Author Contributions

Bahram Ghandchi and Danilo Garcia conceived and designed and wrote the paper, prepared figures and/or tables, reviewed drafts of the paper. Trevor Archer reviewed drafts of the paper.

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