Facts and opinions in studying electromagnetic fields bioeffects

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Research on the bioeffects of electromagnetic fields has been ongoing for 70 years, but the controversy continues regarding safety. Two international groups, ICNIRP and IEEE ICES, have been addressing this issue for decades. While the goal of both groups is to provide limits that protect against established or known adverse health effects, there are groups that advocate more stringent exposure limits based on possible biological effects, at limits that are impossible to implement without serious consequence. The two different approaches, i.e., protection against established adverse effects versus protection against possible effects, polarize the debate. This presentation focuses on facts and opinions when dealing with EMF bioeffect studies.

Introduction

Health concerns started when electricity and radio waves were introduced in the late 19th century. Following the end of World War II, research initiated by the US military (e.g., the Tri-Service Program) focused on the effects of exposure to RF energy in the microwave region. The concern at the time was exposure to the fields produced by radar, the power of which continued to increase during and after the war [Osepchuk and Petersen, 2003]. Results of the Tri-Service Program led to the first US RF safety standard C95.1 "Safety Level of Electromagnetic Radiation with respect to Personnel," which was published in 1966 by the United States of America Standards Institute (now the American National Standards Institute – ANSI). The current ANSI standard, ANSI/IEEE C95.1 was published in 2006. Independently, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) published exposure guidelines since 1998.

Both the IEEE standard and ICNIRP guidelines are living documents. Based on available scientific evidence, IEEE and ICNIRP develop and revise their standards and guidelines over the years. For example, revisions of the ANSI standards were published in 1974, 1982, 1992 and 2006. Included in the scope of the latest ANSI/ IEEE C95.1-2006 is the statement: "The purpose of this standard is to provide exposure limits to protect against established adverse effects to human health induced by exposure to RF electric, magnetic and electromagnetic fields over the frequency range of 3 kHz to 300 GHz." Similarly, the ICNIRP 1998 guidelines contain the statement: "this publication is to establish guidelines for limiting EMF exposure that will provide protection against known adverse health effects." Thus the goal of both groups is to provide science-based exposure limits that protect against established or known adverse health effects.

Validity of EMF Bioeffect Studies

Currently there are tens of thousands of papers or articles relating to effects associated with exposure to electric, magnetic and electromagnetic fields the quality and validity of which varies extensively, from confirmed or established science to junk science published in non-peer-reviewed literature [Osepchuk 2004]. Currently there are more than 6500 relevant references in the IEEE ICES EMF database. In EMF research, dosimetry and exposure systems are critical in conducting high quality research. There are many pitfalls and artifacts in many studies that can lead to erroneous conclusions. Only reporting an effect is not sufficient, one must strive to explain the effect [Chou 2015]. Unique finding is not a glory in science, unlike in art. Verification and repeatability are must in scientific process. It is well known that one's believe can influence the results. That is the reason that a good study should be double blinded to minimize personal bias. Knowing the treatment condition can influence an evaluator's judgment. Therefore, double blind evaluation of pathological samples is a standard practice. However, very few studies implement this double blind procedure. In certain cultures and technical journals, there are biases to publish only positive effects. Lack of essential information in these papers also makes it difficult to evaluate their significance.

Weight of evidence is typically used by committees or government agencies to evaluate the relevant scientific literature. For example, the difference between established adverse health effects and possible biological effects are clearly defined in ANSI/IEEE C95.1-2006; an established adverse effect is defined as "A biological effect characterized by a harmful change in health that is supported by consistent findings of that effect in studies published in the peer-reviewed scientific literature, with evidence of the effect being demonstrated by independent laboratories, and where there is consensus in the scientific community that the effect occurs for the specified exposure conditions." Biological effects, on the other hand, are defined as "alterations of the structure, metabolism, or functions of a whole organism, its organs, tissues, and cells. Biological effects can occur without harming health and can be beneficial. Biological effects also can include sensation phenomena and adaptive responses." Only established adverse health effects are considered by both the IEEE committee and ICNIRP from which threshold levels are identified. Safety factors are applied to set exposure limits. Expert groups and health authorities around the world have published numerous reviews [http://www.ices-emfsafety.org/expert-reviews/]. In general, the reviews agree that no adverse health effects have been confirmed below the current international RF safety guidelines or exposure standards (ICNIRP, IEEE).

In contrast to IEEE and ICNIRP approach, Repacholi et al. [2012] indicated that the general approach to public health protection and setting exposure limits by previous Soviet and current Russian committees is that people should not have to compensate for any effects produced by RF exposure, even though they are not shown to be adverse to health (pathological), and exposure limits are then set that do not cause any possible biological consequence among the population (regardless of age or gender) that could be detected by modern methods during the RF exposure period or long after it has finished. This is an important difference from the approach used by the IEEE committee and ICNIRP, where safety factors are applied to the lowest RF exposure levels that cause any established adverse health effect.

International Agency for Research on Cancer (IARC) is part of the World Health Organization. IARC coordinates and conducts both epidemiological and laboratory research into the causes of human cancer. They have classified 998 environmental factors or agents into 119 carcinogenic (1), 81 probably carcinogenic (2A), 292 possible carcinogenic (2B), and the rest 505 not classifiable and only one probably not carcinogenic. IARC in its monographs classified ELF magnetic field and RF exposures as possible carcinogenic in 2002 and 2013, respectively.

Some activist groups invoke the precautionary principle to promote much lower exposure limits to protect against "possible biological effects." By definition, "possible biological effects" are not proven effects. Excessively low exposure limits such as $0.3nW/cm^2$ recommended in the BioInitiative 2012 report as a precautionary limit are impossible to implement without totally shutting down all wireless applications including broadcasting, communication, defense, and public safety networks. Examples of the implementation of low exposure limits are those of Russia and China; here military operations have to be exempted from the regulations because they are impossible to implement in military settings, such as on a battleship. To protect military personnel, IEEE C95.1-2345-2014 was developed at the request of NATO for use in military workplaces. The NATO standard includes relaxed (elevated) induced current limits for trained personnel who must enter Zone 2 restricted areas, i.e., experts highly trained in electromagnetic environmental effects who are also experienced with the specific equipment or systems.

Definitions

Fact: Fact is a thing that is indisputably the case, and something that actually exits, a reality and truth. To be qualified as a fact, it can be proven, and must be always true.

Opinion: An opinion is a view or judgment formed about something, not necessarily based on fact or knowledge, and a belief or judgment that rests on grounds insufficient to produce complete certainty.

By definition, established effects are proven effects and always true therefore are facts. Possible biological effects are not proven and not always true, because lack of reproducibility. Using possible effects for discussion is therefore an opinion. When developing standards, the basis is built on facts. Safety factors are judgement which are opinions.

Quality research should be robust, and repeatable. It is important to conduct studies correctly with proper exposure methods and dosimetry so the studies are understandable and not just "I found an effect". Science must be repeatable, consistent and make sense. The incorporation of sufficient information to verify the validity of EMF studies needs improvement. As scientists, we should contribute to resolving problems by providing facts and not to create more problems by reporting possible effects that generate wide range opinions.

Conclusion

While science continues to verify and confirm the biological and health effects from exposure to non-ionizing electromagnetic fields, standard development groups have, and should, continue to use only established adverse health effects as the basis for human safety limits, i.e., development

of standards and guidelines should be based on facts and not reliance on opinions. If scientists would discuss EMF safety issues based on validated scientific facts and not on low quality non-reproducible possible effect studies and opinions, the controversy would be minimized or resolved.

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