

Electromagnetic Fields and Cancer: The Cost of Doing Nothing

President's Cancer Panel January 27, 2009

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Abstract. Everyone is exposed to electromagnetic fields (EMFs) from electricity (extremely low frequency, ELF), communication frequencies, and wireless devices (radiofrequency, RF). Concern of health hazards from EMFs has increased as the use of cell phones and other wireless devices has grown in all segments of society, especially among children. While there has been strong evidence for an association between leukemia and residential or occupational exposure to ELF EMFs for many years, the standards in existence are not sufficiently stringent to protect from an increased risk of cancer. For RF EMFs, standards are set at levels designed to avoid tissue heating, in spite of convincing evidence of adverse biological effects at intensities too low to cause significant heating. Recent studies demonstrate elevations in rates of brain cancer and acoustic neuroma only on the side of the head where individuals used their cell phone. Individuals who begin exposure at younger ages are more vulnerable. These data indicate that the existing standards for radiofrequency exposure are not adequate. While there are many unanswered questions, the cost of doing nothing will result in an increasing number of people, many of them young, developing cancer.

INTRODUCTION

It has been known for many years that high frequency EMFs (X-rays, gamma rays, cosmic rays) have sufficient energy to directly break chemical bonds, causing damage to molecules ranging from water to DNA, leading to increased risk of cancer and birth defects /1/. Thus these forms of EMF are "ionizing". There is less consensus as to whether lower energy forms of EMFs, such as radiofrequency and ELF, can cause disease. In spite of strong documentation that exposure to non-ionizing EMFs is associated with an elevated risk of cancer, most national and international bodies have discounted this evidence, based on the belief that lower energy EMFs cannot possibly have adverse biological effects. This particular point of view is held by many in the physics and engineering communities, individuals not known for their

knowledge of biology or medicine /2/. There are legitimate concerns as to what mechanisms might explain the association between exposure and cancer. The purpose of this presentation is to provide an overview of the issues, explore both the associations between exposure and disease and the mechanisms that might explain them, and to propose biologically-based standards of exposure which, although difficult to achieve, would be more protective of human health. While there are a variety of diseases of possible concern, this review will focus on only cancer.

HEALTH EFFECTS OF ELF EMFS

There has been evidence that residential exposure to elevated magnetic fields results in an increased risk for childhood leukemia since the pioneering 1979 studies of Wertheimer and Leeper

/3/. Most subsequent studies have confirmed elevated risks of leukemia /4/, and several meta-analyses have shown significantly elevated odds ratios (ORs) whether exposure was determined through use of wire codes or measured magnetic fields /5/. In addition there is evidence that leukemia is elevated in adults employed in occupations that involve elevated exposure to EMFs from electricity /6/. Meta-analyses of occupational exposure have also reported elevated risks for leukemia, with less strong evidence for associations with other kinds of cancer /7/. A meta-analysis has also reported a significant elevation in rates of brain cancer among adults working in "electrical" occupations /8/. Thus the association between ELF exposure and cancer, especially leukemia, is very well documented in both children and adults and has been replicated in multiple investigations.

HUMAN DISEASE FROM EXPOSURE TO RF EMFS

Until recently there has been relatively little attention to RF exposures and human health. Older studies have reported elevations in both leukemia and brain tumors among individuals with occupational exposures to RF (see www.bioinitiative.org for references), but the results were not very consistent across studies. Recent reports have found elevated rates of leukemia among children who live near AM radio transmitter sites /12/. This is the same cancer elevated with exposure to power-line frequency EMFs, suggesting that leukemia is the cancer most likely to show elevated risk with whole body exposure to EMFs of any frequency. With the advent of enormous increases in the use of cell phones, we now have a situation in which a very large segment of society is regularly exposed to high levels of RF. In addition, the whole population has increased exposure through the placement of cell phone towers,

wireless buildings and even wireless cities. The strongest evidence for hazards has come from Europe, especially Scandinavia, where cell phones were initially manufactured and have been in wide use for a longer period of time than in other parts of the world. Long-term use of a cell phone is associated with an elevated risk of ipsilateral brain tumors and acoustic neuromas. A meta-analysis by Hardell et al. /13/, based on four studies, reported an OR of 2.0 (95% CL = 1.2-3.4) for glioma among adults who have used a cell phone for ten years or more, but only on the side of the head where the phone was used. There was also an OR of 2.4 (95% CL = 1.1-5.3) for acoustic neuroma among long-term users. Risks for meningioma were elevated, but not significantly so. Kundi /14/ has reported on 33 epidemiological studies, and finds that the combined ORs from these studies show an OR of 1.5 (95% CL = 1.2-1.8) for glioma. There was also a non-significant elevation in ORs for acoustic neuroma but no relationship with meningioma. Hopefully, additional information will come from the pooled results of the INTERPHONE study, a 13-nation investigation coordinated by the World Health Organization (WHO), which should be available in the near future. The Israeli component of this study has also found an elevated risk of ipsilateral parotid gland cancer with long-term cell phone use /15/. There is reason for particular concern about risks to children exposed to RF. Hardell et al. /16/ studied relative risk based on the age when a person began to use a cell phone. For use of either analog or cordless phones when assessed at >1 or >5 year latency, he found that individuals whose use began while they were in their 20s has higher ORs for brain cancer than those whose use began use at an older age. Later Hardell reported at a meeting in London last September that children who began use of a cell phone prior to the age of 20 had an OR of developing glioma of 5.2 (95% CL = 2.2-12) after only one+ year of cell phone use, while for all ages the OR was 1.4 (95% CL = 1.1-1.7).

The same relative relationship was seen with use of a cordless phone, where use before the age of 20 years gave an OR of 4.4 (95% CL = 1.9-10), whereas for all ages the OR was 1.4 (95% CL = 1.1-1.8). These studies support the conclusion that use of cordless phones also increases risk, and that children are more vulnerable to risk of brain cancer than adults. The elevated risk to children poses a major concern given the current extensive use of cell phones by even young children.

WHY HAVE THESE RESULTS NOT BEEN REFLECTED IN NEW STANDARDS OF EXPOSURE?

In spite of this consistency in observations relating to ELF EMFs and leukemia, and the developing evidence for a relationship between cell phone use and elevated risk of brain cancer and acoustic neuroma, there has been a general failure of governments and international advisory bodies to accept the reported relationships as being cause and effect, and to follow through with standards designed to reduce exposure. This is a consequence of two major scientific problems, public support of wireless technologies and the political power of the industry. No single mechanism has been identified to be the basis for the development of cancer following exposure to EMFs. In addition, animal studies have not consistently demonstrated cancer as a result of exposure to ELF EMFs. This dilemma is captured well by a statement from the 2007 WHO report /17/: *“Resolving the conflict between epidemiological data (which show an association between ELF magnetic field exposure and an increased risk of childhood leukemia) and experimental and mechanistic data (which do not support this association) is the highest research priority in this field.”* The central question in this issue is whether the statement that the experimental and mechanistic data “do not support this association” is correct. There is the widespread

but mistaken belief that all carcinogens act by causing direct DNA damage, as is the case with ionizing radiation. However, many proven human carcinogens do not cause direct DNA damage. These agents are identified as “non-mutagenic carcinogens” by the US Environmental Protection Agency and include such well-documented carcinogens as arsenic /18/ and dioxin /19/. Exact mechanisms are not known to explain the carcinogenicity of either. Thus the fact that ELF and RF EMFs are “non-ionizing” does not mean they are not carcinogens. Both ELF and RF EMFs are known to induce genes /20/, generate reactive oxygen species /21/, trigger formation of heat shock proteins /20,22/ and cause indirect DNA damage /21,23/, any one of which might lead to cancer (see www.bioinitiative.org for additional references and detailed discussion). Thus the argument that mechanistic data does not support a relationship between EMF exposure and cancer is simply wrong. The other argument for discounting the human health information is that animal models have not consistently demonstrated cancer as an outcome. While this is the case for most rodent laboratory studies, Reif et al. /24/ have demonstrated that dogs living in homes with very high wire codes (comparable to those associated with elevated risk of childhood cancer) showed a significant 6.8-fold elevated risk of developing lymphoma. EMFs differ significantly from chemical carcinogens, and it is not clear exactly what field parameters would be comparable to those levels resulting in cancer in humans. It is important to note that the US Supreme Court in the case of *Daubert vs. Merrell Dow Pharmaceuticals* /25/ effectively ruled that animal studies were not relevant to human health, and that the only admissible evidence must be from human studies. While this is certainly not a justifiable conclusion, in the case of EMFs we have strong evidence for a relationship between exposure and cancer in humans, but much weaker evidence from animal studies. For all of the above reasons lack of strong

evidence for cancer in animals is not a sufficient reason to disregard that strong evidence for a relationship between both ELF and RF exposure and cancer in humans.

**PROPOSED EMF STANDARDS THAT ARE
BASED ON STUDIES OF HUMAN HEALTH
AFTER EXPOSURE**

The Bioinitiative Report (www.bioinitiative.org) presents recommendations for standards of EMF exposure that are based on the epidemiological evidence in human populations. For ELF EMFs the proposed standard is 1 mG (0.1 μ T), to be compared with the current International Commission on Non-ionizing Radiation Protection standard of 1,000 mG (100 μ T). For RF radiation the proposed standard is 0.1 μ W/cm², to be compared with the US Federal Communications Commission standard of 583 μ W/cm² for 875 MHz cell phone frequency, and 1,000 μ W/cm² in the frequency range of 1,800-1,950 MHz. The differences between these numbers show the magnitude of the problem. There is no question that a sudden imposition of standards so drastically different from those existing would impose hardship. However, there is also no question that the human studies clearly indicate that the existing standards are not protective of human health. The benefits to society derived from electricity and wireless communications are significant, and certainly none of us is willing to return to the pre-electric age. However it is imperative that society at least acknowledge the disparities between current standards and current evidence of risk of cancer. Rigid and sudden imposition of the standards we propose is unrealistic, but these levels are appropriate goals that could at least be approached by a combination of development of new technology and changes in behaviors.

THE COSTS OF BEING WRONG

At present we do not know precisely to what degree the risk of cancer is increased by exposure to EMFs. Human studies are difficult under any circumstances, but those difficulties are even greater when studying the effects of EMFs. Levels of exposure for each of us vary over the course of every day as we move through our environment and use appliances, cell phones and other wireless devices. This makes exposure assessment extremely difficult. Given the long latency for development of cancer, one would expect that the actual risk of EMF-induced cancer is significantly greater than that indicated by studies with inadequate exposure assessment. There is considerable evidence that children are more vulnerable to many environmental insults than are adults /26/. The reality is that children are using cell phones at increasing rates and for long durations. Therefore, if the risks are real, and especially if children are more susceptible, we may be facing an epidemic of brain and other cancers. The concern is increased because to date, there has been little warning advising restrictions on use of cell phones, especially by children. While questions regarding mechanisms are not all answered, the evidence for a relationship between EMF exposure and cancer is sufficiently strong so as to demand action. The alternative may be significant increases in certain cancers, especially leukemia and brain cancer. It is not clear whether there is increased risk of other kinds of cancer following exposure because there has not been a study of, for example, the health hazards of wearing a cell phone on your belt and pelvic cancers. Fortunately, the rates of leukemia and brain cancer are not high, at least not at present.

There have recently been significant improvements in treatment of leukemia, especially among children. Kundi /14/ has hypothesized that use of cell phones may increase the rates of brain cancer by as much as 50%. Even if this is true, this

certainly does not mean that every exposed person will develop brain cancer. However an increase in brain cancer of 50% would still have a significant impact, not only on the individuals affected but also on society, especially given that much of this increase is likely to occur among young people. It is not appropriate to deny the well-documented relationship between EMF exposure and cancer only because the mechanistic details are uncertain. The evidence that we have at present is too convincing to be ignored. Our national and international standards are obsolete, and ignore evidence reported by many different investigators. The lack of certainty with regard to mechanisms and animal models is no reason to ignore studies of human health.

We need the electric and communications industries to be proactive in developing products that can be used with reduced exposures. We need governments and international organizations to set standards that are based on the evidence of hazard, not on a hypothesis that is not credible based on the evidence from animal, cellular and human studies. Most importantly, we need individuals to understand that personal decisions will significantly impact the level to which they are exposed to both ELF and RF EMFs.

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