Conference of Radiation Control Program Directors, Inc.

Fact Sheet

Biological Research in EMF

Background

A number of epidemiologic studies have suggested there may be a link between disease and 60 hertz electric and magnetic fields (EMF) exposure in humans. However, without the support of biological evidence to explain what is happening, the epidemiologic studies can only show correlations and cannot prove a health effect.

Concerns

With most environmental agents, from radon to gasoline fumes, there is usually a single parameter that can describe the exposure—parts per billion in the air inhaled, for example. EMF are much more complicated. The electric and magnetic fields can be measured in terms of intensities and frequencies, as well as relative phases and angles between them. Even the angle between the fields and the earth's natural magnetic field may be a factor. Biological research is needed to determine which of these or what combination is important to human health.

Research

Scientists agree that in experiments done under carefully controlled laboratory conditions there are indeed biological effects due to EMF exposure. These effects include changes in the way individual cells behave, subtle changes in the heart rate, and hormone production. The effects usually represent quite small changes from the normal functioning of an organism and it is not clear whether these biological effects will lead to direct health effects. Usually the body is able to cope with small changes and recover without disease or malfunction. EMF health concerns focus on abnormal cell growth, reproductive issues and neurophysiology.

The biological research is concentrating on understanding how cells and animals function in the presence of fields. Biological effects of EMF tend to be quite small. They also tend to be much more complicated than the effects of other environmental agents. A few examples of recent research will show this.

Human studies

When humans are exposed to fields of 200 mG for several hours, the heart rate slows from a normal rate of about 70 beats per minute to 65 beats per minute (a decrease of three to five beats per minute). However, exposure to magnetic fields of 100 mG or 300 mG does not cause any reduction. There seems to be a "window" of field strengths where an effect is found. At other intensities there are no effects.

When intermittent fields are used (the fields are turned on or off every 45 minutes) a distinct speeding up of the heart rate is caused. So, not only do the fields themselves have an effect, but switching them on and off may be just as significant. In both cases, the change is small compared to other factors which effect heart rate, such as standing up. The health implications, if any, are unknown.

Animal studies

Rodent experiments focus on a hormone called melatonin. The body produces very little of this hormone during the daytime. Most of it is produced at night. This hormone is important because it signals the daily rhythms of the body and because it affects all the other major hormone systems (like the adrenal glands and the reproductive organs). Experiments, unrelated to EMF exposure, have shown that a lack of melatonin production increases the risk of breast tumors in female rats. It has been found in a number of experiments with rodents that magnetic field exposure can lead to a reduction of the amount of melatonin produced during the night. Experiments are now underway to determine if magnetic field exposure can affect melatonin in humans.

Cell studies

When cells are exposed to magnetic fields the main effect seems to be at the membrane surrounding the cells. The membrane regulates the flow of biologically active ions, such as calcium, in and out of cells. These ions serve as messengers and are essential for keeping the cells healthy and functioning. The field-induced changes in calcium flux in turn lead to changes in the production of intracellular hormones. Here, too, "windows" have been observed.

DNA studies

It has been shown quite convincingly that EMF do not have any direct effects on DNA. The strands of genetic material are not broken, as they are from x-rays or nuclear radiation. Therefore, tumors cannot be induced directly by EMF exposure. But recently it has been shown that there may be some effects on gene transcription which can effect the rates at which proteins are made from the DNA templates. This possible avenue to health effects remains to be pursued further.

Summary/Conclusion

Biological research has not yet determined what constitutes dose in EMF exposure. This makes it difficult to interpret the existing epidemiology or to plan future studies. Really good studies will become possible only when we can determine what attribute of EMF exposure, if any, constitutes dose. This will only be accomplished when, and if, a specific measure or measures of exposure can be correlated with increased risk of disease.

We also know very little about the dose-effect relationship. With many agents the effect on the body is more or less proportional to the amount of toxic material to which the body is exposed. The dose-effect is linear: twice the exposure, twice the effect. Existing research suggests that EMF effects may not be linear: there are windows in field strengths and certain frequencies at which effects seem to occur while there is no response at others. Not knowing what the dose-effect relationship is and which field attributes are important makes scientific experiments very difficult.

The lack of meaningful measure of dose and absence of a well defined dose-effect relationship makes it extremely difficult to develop reasonable guidelines for regulation, suggest ways to modify fields, or change our usage of electricity. We do not yet know what defines a safe or unsafe field (assuming that real health effects are eventually found).

Notes:

Research on biological effects of EMF has been funded for over a decade by the Department of Energy, by the Electric Power Research Institute, and by agencies in Canada, Europe and Japan. The work is being performed at national laboratories, universities and private laboratories. Research is being done on humans, animals, tissues and cells.

Published April 1994

This Fact Sheet was prepared by the CRCPD Committee on Electromagnetic Environmental Effects, and was supported in part by grant number FD-U-00005-12 from the Food and Drug Administration. The opinions and statements expressed in this publication are those of the authors and are not necessarily the opinions or positions of CRCPD, the Food and Drug Administration, the Nuclear Regulatory Commission, or the Environmental Protection Agency.

This Fact Sheet is published by the Office of Executive Director, Conference of Radiation Control Program Directors, Inc. (CRCPD), 205 Capitol Avenue, Frankfort, KY 40601. For information regarding additional Fact Sheets, contact CRCPD.