

Electric and Magnetic Fields (EMF)

Electric and magnetic fields exist everywhere.

The generation, delivery, and use of electricity produce electric and magnetic fields (EMF). Electric fields are produced by voltage, the electric “pressure” that causes current to flow in a wire, while magnetic fields are produced by current, the movement of electric charge. Electric and magnetic fields can be imagined as invisible lines of force diminishing in strength with distance from their source.

Electric and magnetic fields also occur naturally. An electric field is present between the earth and the upper atmosphere; this field can increase and discharge as lightning during thunderstorms. The earth has a magnetic field that is the basis for the magnetic compass. Because these natural fields change little from one moment to the next, they are referred to as static fields.

In the electric power system in the United States, voltage and current flow back and forth, or alternate, at a rate, or frequency, of 60 cycles per second (60 hertz). Similarly, the electric and magnetic fields created by the power system alternate at 60 hertz. When people are exposed to these alternating electric and magnetic fields, very weak, imperceptible electric currents are produced in their bodies. Although these currents are weaker than those from natural electrical activity in the heart and nervous system, scientists have investigated the possibility that they can produce biological and health effects.

Possible health effects from exposure to EMF have been studied for more than a quarter of a century.

Questions about health risks from EMF exposure first arose in the 1960s and 1970s with the introduction of higher voltages for electricity transmission in the United States. During that period, research focused on electric fields because electric fields near high-voltage transmission lines produce more current in the body than the magnetic fields from these lines. Overall, studies of electric fields found no evidence of biological changes that could lead to health effects. EMF research began to focus on magnetic fields in 1979 when Wertheimer and Leeper published an epidemiologic study suggesting that magnetic fields from power lines in Denver might be linked to childhood cancers. In 1988 Savitz and colleagues published a second study that was generally consistent with these results. Since then, a large number of epidemiologic studies (which examine patterns of diseases and their possible causes in human populations) have investigated the possible role of magnetic fields in the development of cancer and other diseases. Studies of most health endpoints, including miscarriage, neurodegenerative diseases such as Alzheimer’s and Parkinson’s diseases, and various cancers other than leukemia, have produced either inconsistent or negative results. Studies of childhood leukemia, however, have shown a generally consistent association with magnetic fields in homes.

Along with human health studies, scientists have conducted hundreds of studies in laboratory animals and cells to investigate possible health effects of exposure to power-frequency magnetic fields and explore possible mechanisms by which these fields could interact with biological systems. The vast majority of laboratory studies of animals and cells exposed to magnetic fields at levels to which humans could be exposed do not report adverse effects.

Several expert panels convened by organizations concerned with public health have evaluated the possible health risks of exposure to magnetic fields. These organizations include the National Institute of Environmental Health Sciences (NIEHS) in the United States, the National Radiological Protection Board (NRPB) in the United Kingdom, and the International Agency for Research on Cancer (IARC), a branch of the World Health Organization. These panels and, more recently, a California Department of Health Services (CDHS) panel concluded, based on epidemiologic studies, that exposure to

magnetic fields of 3 to 4 milligauss or more may increase the risk of leukemia in children. (Only about five percent of U.S. residences have magnetic fields this high.) The NIEHS and CDHS also concluded that magnetic fields in the workplace cannot be dismissed as a possible cause of adult leukemia. CDHS identified other health effects, including adult brain cancer, miscarriage, and amyotrophic lateral sclerosis, or Lou Gehrig's disease, as possibly linked to magnetic field exposure. A comprehensive evaluation scheduled for completion in 2003 by the World Health Organization may shed further light on health risks.

There is no conclusive evidence that exposure to EMF causes health effects.

Although epidemiologic studies show that magnetic field exposure at or above 3 to 4 milligauss may increase the risk of childhood leukemia, it cannot be concluded that a cause-and-effect relationship exists. The reported association between magnetic fields and childhood leukemia is weak (children with exposures above 3 milligauss might have roughly double the risk of unexposed children). For such weak epidemiologic associations, supporting data from laboratory studies are usually critical for establishing a causal link. For example, exposures that are known to cause cancers in humans also cause cancers in rodents exposed in laboratories. Such laboratory evidence should also be supported by an understanding of the mechanisms by which the exposures interact with biological tissue. For magnetic fields, lifetime studies of rodents almost all report no adverse effects, and scientists have not identified a mechanism by which the low-level fields found in homes can possibly interact with tissue. In the absence of supporting laboratory and mechanistic evidence, scientists are investigating the possibility that the epidemiologic results have been generated by inadvertent errors in study design or that magnetic fields occur along with another exposure that could plausibly cause leukemia.

Scientists continue to investigate the possible relation between EMF and health effects.

EMF research is continuing throughout the world. At EPRI, the EMF research program is focused on resolving uncertainties about EMF and childhood leukemia. In fact, EPRI is the only U.S. organization currently funding a multidisciplinary research program in this area. The program includes investigation of the possible role of inadvertent error in epidemiologic study designs and a study of the possible influence of magnetic field exposure on the long-term survival of children who already have leukemia.

EPRI research is also exploring the hypothesis that an alternate exposure, contact current, is responsible for the magnetic field-childhood leukemia association. Contact current occurs when a person touches two conductive surfaces that are at different voltages, causing current to flow through the body. An important property of contact current is that imperceptible amounts of voltage produce appreciably higher electrical doses in tissue than those produced by exposure to magnetic fields in homes. EPRI research suggests that exposure to contact current is associated with exposure to magnetic fields. Although this finding supports the contact current hypothesis, a number of years of multidisciplinary research will be necessary before answers can be found.

EPRI scientists are also conducting new research on occupational EMF exposures in collaboration with the National Institute for Occupational Safety and Health (NIOSH). In addition, the EPRI program includes research in other areas of possible concern, including miscarriage, cardiovascular disease, and magnetic field interference with the functioning of implanted medical devices.

Contact Information For more information, contact the EPRI Customer Assistance Center (EPRI CAC) at 800.313.3774 or askepri@epri.com

© 2002 Electric Power Research Institute (EPRI), Inc. All rights reserved. Electric Power Research Institute and EPRI are registered service marks of the Electric Power Research Institute, Inc. EPRI. ELECTRIFY THE WORLD is a service mark of the Electric Power Research Institute, Inc.

 Printed on recycled paper in the United States of America

1007657