Power Lines, Electrical Devices and Extremely Low Frequency Radiation

What is extremely low frequency (ELF) radiation?

Radiation is the emission or sending out of energy from any source. X-rays are an example of radiation, but so is the light that comes from the sun and the heat that is constantly coming off our bodies.

When talking about radiation and cancer, many people think of specific kinds of radiation such as x-rays or the radiation in nuclear reactors. But these are not the only types of radiation that concern us when we think about radiation risks to human health.

Radiation exists across a spectrum from very high-energy (also referred to as high-frequency) radiation to very low-energy (or low-frequency) radiation. This is sometimes referred to as the **electromagnetic spectrum**.

Examples of high-energy radiation include x-rays and gamma rays. They, as well as some higher energy ultraviolet (UV) rays, are classified as **ionizing radiation**, which means that they have enough energy to remove an electron from (ionize) an atom. Ionizing radiation can damage the DNA inside cells, which can lead to mutations and the uncontrolled cell growth we know as cancer.

Extremely low frequency (ELF) radiation is at the low-energy end of the electromagnetic spectrum and is a type of **non-ionizing radiation**. Non-ionizing radiation has enough energy to move atoms around or make them vibrate, but not enough to directly damage DNA. ELF radiation has even lower energy than other types of non-ionizing radiation like radiofrequency radiation, visible light, and infrared.

With most types of radiation, the electric and magnetic fields are coupled. Because they

act as one, they are considered together as an electromagnetic field (EMF). But with ELF radiation, the magnetic field and the electrical field can exist and act independently, so they are often studied separately. Typically, we use the term “magnetic field” to indicate ELF radiation from a magnetic field, while we use “electric field” to mean ELF radiation from an electric field.

The possible link between electromagnetic fields and cancer has been a subject of controversy for several decades. It's not clear exactly how electromagnetic fields, a form of low-energy, non-ionizing radiation, can increase cancer risk. Plus, because we are all exposed to different amounts of these fields at different times, the issue has been hard to study.

Electric and magnetic fields

All radiation on the electromagnetic spectrum is produced by the interactions of 2 forces, referred to as **fields**. Radiation has both an electric field and a magnetic field.

Electric fields are the forces acting on charged particles (parts of atoms), like electrons or protons, which cause them to move. Electric current is simply the flow of electrons produced by an electric field. The strength of an electric field is often expressed as volts per meter (V/m) or, for stronger fields, as kilovolts per meter (kV/m), where a kilovolt is 1000 volts.

A **magnetic field** is created when charged particles are in motion. The strength of a magnetic field can be expressed in many different units, including tesla (T), microtesla (μT or one millionth of a tesla), and gauss (G), where one G equals 100 μT.

How are people exposed to ELF radiation?

Generating, transmitting, distributing, and using electricity all expose people to ELF radiation. Power lines, household wiring, and any device that uses electricity can generate ELF radiation. Thus any electric device, from refrigerators and vacuum cleaners to televisions and computer monitors (when they are on) are sources of ELF radiation. Even electric blankets expose people to ELF radiation.

How much electromagnetic radiation you are exposed to depends on the strength of the electromagnetic field, your distance from the source of the field, and the length of time you are exposed. The highest exposure occurs when the person is very close to a source putting out a strong field and stays there for a long period.

Does ELF radiation cause cancer?

Researchers use 2 main types of studies to try to figure out if something causes cancer.

- **Lab studies:** In lab studies, animals are exposed to different levels of the substance (sometimes at extremely high levels) to see if this exposure causes tumors or other health problems. Researchers might also expose normal human cells in a lab dish to see if this causes the types of changes that are seen in cancer cells. It's not always clear that the results from these types of studies directly apply to humans, but lab studies are a good way to find out if an exposure might possibly cause cancer.
- **Studies in people:** Other types of studies look at cancer rates in different groups of people. Such a study might compare the cancer rate in an exposed group to the rate in a group with lower exposures, or to a group not exposed at all. Sometimes the exposed group's cancer rate is compared to the cancer rate in the general population. But it can be hard to know what the results of these studies mean, because many other factors might affect the results. For example, people are typically exposed to many substances other than the one being studied, and these other exposures could affect the results.

In most cases neither type of study provides conclusive evidence on its own, so researchers usually look at both lab-based and human studies when trying to figure out if something can cause cancer.

Studies in the lab

Several large studies have looked at the possible effects of ELF magnetic fields on cancer in rats and mice. These studies expose the animals to magnetic fields much stronger than what people are normally exposed to at home, with fields ranging from 2 to 5000 microtesla (μT). Most of these studies have found no increase in the risk of any type of cancer. In fact, the risk of some types of cancer was actually lower in the animals exposed to the ELF radiation. One study did show an increased risk of tumors that start in thyroid cells, called C-cells, in male rats at some exposures. This increased risk was not seen in female rats or in mice, and was not seen at the highest field strength. These inconsistencies, and the fact that these findings were not consistently seen in the other studies, make it hard for scientists to conclude that the observed increased risk of tumors is from the ELF radiation.

Other studies in mice and rats have looked specifically for increases in leukemia and

lymphoma as a result of exposure to ELF radiation, but these studies have also not found a link.

Studies in people

Studying the effects of ELF radiation in people can be hard, for many reasons:

Exposure to ELF radiation is very common, so it's not possible to compare people who are exposed with people who aren't exposed. Instead, studies try to compare people exposed at higher levels with people exposed at lower levels.

It is very hard to determine how much ELF radiation a person has been exposed to, especially over a long period. As far as we know, the effects of ELF radiation do not add up over time, and there is no test that can measure how much exposure a person has had.

Researchers can get a snapshot of ELF exposures by having a person wear a device that records their exposure levels over hours or days. Or, researchers can measure the magnetic or electrical field strength in a person's home or workplace settings.

Other options include estimating exposure based on the wiring configuration of someone's workplace/home or on its distance from power lines. But these methods result in exposure estimates that have a lot of uncertainty and that can produce biased estimates of total exposure. They typically do not account for a person's ELF exposures while in other places, they don't measure ELF exposures in every location that person has ever lived or worked over their lifetime. As a result, there are no good ways to accurately estimate someone's long-term exposure, which is what matters most when looking for possible effects on cancer risk.

In children

- A number of studies have looked at a possible link between ELF radiation from **magnetic fields** in the home and childhood leukemia[1], with mixed results. Still, when the findings from these studies are combined, a small increase in risk is seen for children at the highest exposure levels compared to those with the lowest exposure levels. Studies looking at the effect of ELF *electric fields* on childhood leukemia have not found a link.

Studies have generally not found any strong links between ELF electric or magnetic fields and other types of childhood cancers.

In adults

Although several studies have looked at possible links between ELF exposures in adults and cancer, most have not found a link.

What expert agencies say

Several national and international agencies study different exposures in the environment to determine if they can cause cancer. (Something that causes cancer or helps cancer grow is called a *carcinogen*.) The American Cancer Society looks to these organizations to evaluate the risks based on evidence from laboratory, animal, and human research studies.

Based on animal and human evidence like the examples above, some expert agencies have evaluated the cancer-causing nature of ELF radiation.

The **International Agency for Research on Cancer (IARC)** is part of the World Health Organization (WHO). One of its major goals is to identify causes of cancer. In 2002, IARC considered the evidence for ELF magnetic and electric fields separately:

- It found “limited evidence” in humans for the carcinogenicity of ELF *magnetic* fields in relation to childhood leukemia, with “inadequate evidence” in relation to all other cancers. It found “inadequate evidence” for the carcinogenicity of ELF magnetic fields based on studies in lab animals.
- It found “inadequate evidence” for the carcinogenicity of ELF *electric* fields in humans.

Based on this assessment, IARC has classified ELF *magnetic* fields as “possibly carcinogenic to humans.” It has classified ELF *electric* fields as “not classifiable as to their carcinogenicity to humans.”

In 1999, the US **National Institute of Environmental Health Sciences (NIEHS)** described the scientific evidence suggesting that ELF exposure poses a health risk as “weak,” but noted that it cannot be recognized as entirely safe, and considered it to be a “possible” human carcinogen.

How can I avoid exposure to ELF radiation?

It’s not clear that exposure to ELF radiation is harmful, but there are things you can do to lower your exposure if you are concerned. Your exposure is based on the strength of

the ELF radiation coming from each source, how close you are to each, and how long you spend in the field.

The NIEHS recommends that people concerned about their exposure to EMF (and ELF radiation) find out where their major EMF sources are and move away from them or limit the time spent near them. For example, moving even an arm's length away from a source can dramatically lower exposure to its field.

Power lines

People who are concerned about ELF radiation exposure from high-power electrical lines should keep in mind that the intensity of any exposure goes down significantly as you get farther away from the source. On the ground, the strength of the electromagnetic field is highest directly under the power line. As you get farther away, you are exposed to less and less, with the level eventually matching normal home background levels. The electromagnetic field directly under a power line is typically in the range of what you could be exposed to when using certain household appliances.

If you are concerned about your exposure to electromagnetic sources around you (including power lines), you can measure the field strength with a device called a *gaussmeter*.

Hyperlinks

1. www.cancer.org/cancer/leukemia-in-children.html
2. http://www.cdc.gov/
3. www.epa.gov/
4. http://www.epa.gov/radiation/radiation-basics
5. http://www.cancer.gov/
6. http://www.cancer.gov/cancertopics/factsheet/Risk/magnetic-fields
7. http://www.niehs.nih.gov/
8. http://www.niehs.nih.gov/health/topics/agents/emf/index.cfm
9. http://www.who.int/
10. http://www.who.int/peh-emf/about/en/
11. http://www.cdc.gov/
12. www.epa.gov/
13. http://www.epa.gov/radiation/radiation-basics
14. http://www.cancer.gov/
15. http://www.cancer.gov/cancertopics/factsheet/Risk/magnetic-fields

16. http://www.niehs.nih.gov/
17. http://www.niehs.nih.gov/health/topics/agents/emf/index.cfm
18. http://www.who.int/
19. http://www.who.int/peh-emf/about/en/

Additional resources

Along with the American Cancer Society, other sources of information and support include:

Centers for Disease Control and Prevention (CDC) Toll-free number: 1-800-232-4636 (1-800-CDC-INFO) Website: www.cdc.gov (http://www.cdc.gov/)[2]

Environmental Protection Agency (EPA) Website: www.epa.gov (www.epa.gov/)[3] Radiation Basics:www.epa.gov/radiation/radiation-basics (http://www.epa.gov/radiation/radiation-basics)[4]

National Cancer Institute (NCI)

Toll-free number: 1-800-422-6237 (1-800-4-CANCER) Website: www.cancer.gov (http://www.cancer.gov/)[5] Magnetic Field Exposure and Cancer: www.cancer.gov/cancertopics/factsheet/Risk/magnetic-fields (http://www.cancer.gov/cancertopics/factsheet/Risk/magnetic-fields)[6]

National Institute of Environmental Health Sciences Website: www.niehs.nih.gov (http://www.niehs.nih.gov/)[7] Electric and Magnetic Fields: http://www.niehs.nih.gov/health/topics/agents/emf/index.cfm (http://www.niehs.nih.gov/health/topics/agents/emf/index.cfm)[8]

World Health Organization Website: www.who.int (http://www.who.int/)[9] Electromagnetic fields (EMF): www.who.int/peh-emf/about/en/ (http://www.who.int/peh-emf/about/en/)[10]

**Inclusion on this list does not imply endorsement by the American Cancer Society.*

References

Environmental Protection Agency. Radiation Basics. 2016. Accessed at www.epa.gov/radiation/radiation-basics on October 6, 2016.

International Agency for Research on Cancer. *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Volume 80: Non-Ionizing Radiation, Part 1: Static and Extremely Low-Frequency (ELF) Electric and Magnetic Fields*. 2002. Accessed at http://monographs.iarc.fr/ENG/Monographs/vol80/index.php on October 6, 2016.

Kheifets L, Ahlbom A, Crespi CM, et al. Pooled analysis of recent studies on magnetic fields and childhood leukaemia. *Br J Cancer*. 2010;103:1128-1135. Erratum in: *Br J Cancer*. 2011;104(1):228.

National Institute of Environmental Health Sciences. *Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields*.1999. Accessed at www.niehs.nih.gov/health/assets/docs_f_o/report_powerline_electric_mg_predates_508.pdf on October 10, 2016.

National Institute of Environmental Health Sciences. *Electric and Magnetic Fields Associated with the Use of Electric Power*. 2002. Accessed at www.niehs.nih.gov/health/materials/electric_and_magnetic_fields_associated_with_the_use_of_electric_power_questions_and_answers_english_508.pdf on October 6, 2016.

Pedersen C, Johansen C, Schüz J, Olsen JH, Raaschou-Nielsen O. Residential exposure to extremely low-frequency magnetic fields and risk of childhood leukaemia, CNS tumour and lymphoma in Denmark. *Br J Cancer*. 2015;113:1370-1374.

Schüz J. Exposure to extremely low-frequency magnetic fields and the risk of childhood cancer: Update of the epidemiological evidence. *Prog Biophys Mol Biol*. 2011;107:339-342.

Schüz J, Dasenbrock C, Ravazzani P, et al. Extremely low-frequency magnetic fields and risk of childhood leukemia: A risk assessment by the ARIMMORA consortium. *Bioelectromagnetics*. 2016 Mar 15. [Epub ahead of print]

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