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## Power Lines, Electrical Devices and Extremely Low Frequency Radiation

### What is extremely low frequency (ELF) radiation?

Radiation is the emission (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 made by nuclear reactors. But there are other types of radiation that act differently.

Radiation exists across a spectrum from very high-energy (high-frequency) radiation to very low-energy (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 UV radiation, are called *ionizing radiation*, which means they have enough energy to remove an electron from (ionize) an atom or molecule. This can damage the DNA inside of cells, which can result in 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 in a molecule around or cause them to vibrate, but not enough to remove charged particles such as electrons (ionize) and directly damage DNA. ELF radiation has even lower energy than other types of non-ionizing radiation like radiofrequency radiation, visible light, and infrared.

Extremely low frequency radiation has very large wavelengths – one wave can be 5000 kilometers (over 3000 miles) across. This means that people and other living things are in only a small fraction of a wavelength.

Electromagnetic radiation is actually made of 2 parts – the electric field and the magnetic field.

Electric fields come from unbalanced electric charges on conductors. The electric field acts on charged particles – like electrons or protons. It can cause these particles to move leading to the flow of electric current. The strength of an electric field is often expressed as volts per meter (V/m) or for stronger fields kilovolts per meter (kV/m), where 1000 volts is the same as a kilovolt.

A magnetic field only exists if the charges are in motion, such as with the flow of electric current. Direct current that is going in one direction and permanent magnets produce static (unchanging) magnetic fields. This is not a form of ELF radiation. Time-varying magnetic fields (including those in the extremely low frequency range) are produced by alternating current. The strength of a magnetic field can be expressed in many different units, including tesla (T), microtesla ( $\mu\text{T}$ ) (there are a million  $\mu\text{T}$  in a tesla), and gauss (G), where one G equals 100  $\mu\text{T}$ .

Magnetic fields can produce electric fields, and electric fields can produce magnetic fields.

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) individually, and so they are often studied separately. In this document, the term "magnetic field" is used to indicate ELF radiation from a magnetic field, while "electrical field" is used to mean ELF radiation from an electrical 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, could increase cancer

risk. Plus, because we are all exposed to different amounts of these fields at different times, the issue has been difficult to study.

## How are people exposed to ELF radiation?

Generating, transmitting, distributing, and using electricity all expose people to ELF radiation. Some sources include power lines, household wiring, and anything using electricity. This can include anything from refrigerators and vacuum cleaners to television sets and computer monitors (when they are on). Even electric blankets expose people to ELF radiation.

How much electromagnetic radiation someone is exposed to depends on the strength of the field, the distance from the source of the field, and the length of time the person is 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?

### Studies in the lab

Four large studies looked at the effects of ELF magnetic fields on cancer in rats and mice. These studies exposed the animals to magnetic fields much stronger than what people are normally exposed to at home, with fields ranging from 2 to 5000 microtesla ( $\mu\text{T}$ ). 3 of these studies found no increase in the risk of any type of cancer. In fact, some types of cancer were actually lower in the animals exposed to the ELF radiation. One study did show an increase risk of tumors and cancer that start in the C-cells of the thyroid in male rats at certain exposures. This increase risk was not seen in mice or female rats, and was not seen at the highest field strength. These inconsistencies, and the fact that these findings were not seen in the other studies, make it hard to conclude that the increased risk of tumors was really from the ELF radiation.

Other studies in mice and rats looked specifically for a link between leukemia and lymphoma and exposure to ELF radiation, but no link was found.

### Studies in people

Studying the effects of ELF radiation can be difficult because exposure to ELF radiation is so common that it is not really possible to do a study comparing people who are exposed to people who aren't. Instead, studies have to compare people exposed at higher levels to people exposed at lower levels. The strength of the magnetic fields in a home averages around 0.05 to 0.1 microtesla ( $\mu\text{T}$ ), but even within a building the strength of the field varies. Some studies have used 0.3 or 0.4  $\mu\text{T}$  as a cutoff for high exposure in the home, while studies looking at workplace exposures may use 0.5 to 1  $\mu\text{T}$  as a cutoff.

Also, because exposure to ELF magnetic fields generally causes no symptoms, people are often unable to tell when they were being exposed at higher levels during their lives. This makes it hard for researchers to get information about exposure levels by just asking people. Researchers often measure the current strength of a magnetic or electrical field and use this measurement to estimate what it may have been many years before. Sometimes they put a monitor on the person they are studying to see the level of exposure over hours or days. Other options include estimating exposure based on the wiring configuration of someone's home or the distance from power lines. All of these methods have a lot of related uncertainty. This makes it very difficult to accurately estimate someone's long-term exposure, which matters most when thinking about cancer risk.

### In children

In the studies that have looked at a possible link between ELF radiation from magnetic fields in the home and **childhood leukemia**, the results have been mixed. 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 that looked at the effect of ELF electric fields on childhood leukemia did not find a link.

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

## In adults

Most studies in adults have not found links between ELF magnetic fields and cancer.

## What expert agencies say

There are several national and international agencies that study different substances in the environment to determine if they can cause cancer. (A substance 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, 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). Its major goal is to identify causes of cancer. IARC considered the evidence for ELF magnetic and electric fields separately and found "limited evidence" in humans for the carcinogenicity of extremely low frequency *magnetic* fields in relation to childhood leukemia, with "inadequate evidence" in relation to all other cancers. It also found "inadequate evidence" for the carcinogenicity of extremely low-frequency *electric* fields in humans as well as for the carcinogenicity of extremely low-frequency magnetic fields in experimental animals. Based on this assessment, IARC has classified ELF *magnetic* fields as "possibly carcinogenic to humans." It also has stated that ELF *electric* fields are "not classifiable as to their carcinogenicity to humans."

In 1999, the National Institute of Environmental Health Sciences (NIEHS) described the scientific evidence suggesting that electromagnetic field (EMF) exposures pose a health risk as "weak," but stated that it was enough to "warrant limited concern."

## How can I avoid exposure to ELF radiation?

The NIEHS recommends that people concerned about their EMF (and ELF radiation) exposure finding out where their major EMF sources are and moving away from them or limiting the time spent near them. Moving even an arm's length away from a source will dramatically lower exposure.

## Television and computer screens

Like any appliance using electricity, television and computer screens give off ELF radiation. Screens that use cathode ray tubes (CRT) use magnetic fields to create images, and could expose people to higher levels of ELF radiation than flat panel screens. but either type can give off ELF radiation. The amount of energy given off by both CRT and flat screens is far below government exposure thresholds. At this time the available evidence does not support links between ELF radiation from television and computer screens and health problems. Still, some screens are designed to minimize the magnetic fields that they give off. These are labeled as being "TCO 99" or "TCO 03" compliant.

## Power lines

People who are concerned about ELF radiation exposure from power lines should keep in mind that the intensity of any exposure goes down dramatically as you get further away from the source. The strength of the field is highest directly under the power line. As you get further away, you are exposed to less and less, so that the level drops to normal home background levels. Also, although being directly under a power line exposes you to its highest strength field, it is often in the range of what you could be exposed to when using certain household appliances.

If you are concerned about living near power lines, you can measure the field strength with something called a gaussmeter. Options for lowering exposures may be expensive and difficult to implement, such as moving to a new home or having the power company bury the lines. But according to the NIEHS, it's not clear if such actions are warranted because scientists aren't sure if EMF (such as ELF radiation) poses any health hazards,

## Additional resources

### More information from your American Cancer Society

The following related information may also be helpful to you. These materials may be viewed on our web site or ordered from our toll-free number, at 1-800-227-2345.

[Known and Probable Human Carcinogens](#)

[Microwaves, Radio Waves, and Other Types of Radiofrequency Radiation](#)

[Radon](#)

[Smart Meters](#)

[Ultraviolet \(UV\) Radiation](#)

[X-rays, Gamma Rays and Cancer Risk](#)

### National organizations and Web sites\*

In addition to 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)

#### Environmental Protection Agency (EPA)

Website: [www.epa.gov](http://www.epa.gov)

Understanding Radiation: <http://www.epa.gov/radiation/understand/index.html>

#### National Cancer Institute (NCI)

Toll-free number: 1-800-422-6237 (1-800-4-CANCER)

Website: [www.cancer.gov](http://www.cancer.gov)

Magnetic Field Exposure and Cancer: [www.cancer.gov/cancertopics/factsheet/Risk/magnetic-fields](http://www.cancer.gov/cancertopics/factsheet/Risk/magnetic-fields)

#### National Institute of Environmental Health Sciences

Website: [www.niehs.nih.gov](http://www.niehs.nih.gov)

Electric and Magnetic Fields: <http://www.niehs.nih.gov/health/topics/agents/emf/index.cfm>

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

No matter who you are, we can help. Contact us anytime, day or night, for information and support. Call us at 1-800-227-2345 or visit [www.cancer.org](http://www.cancer.org).

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