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# 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 one example of radiation, but so is the light that comes from the sun and the heat that constantly comes 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**.

# ELECTROMAGNETIC SPECTRUM

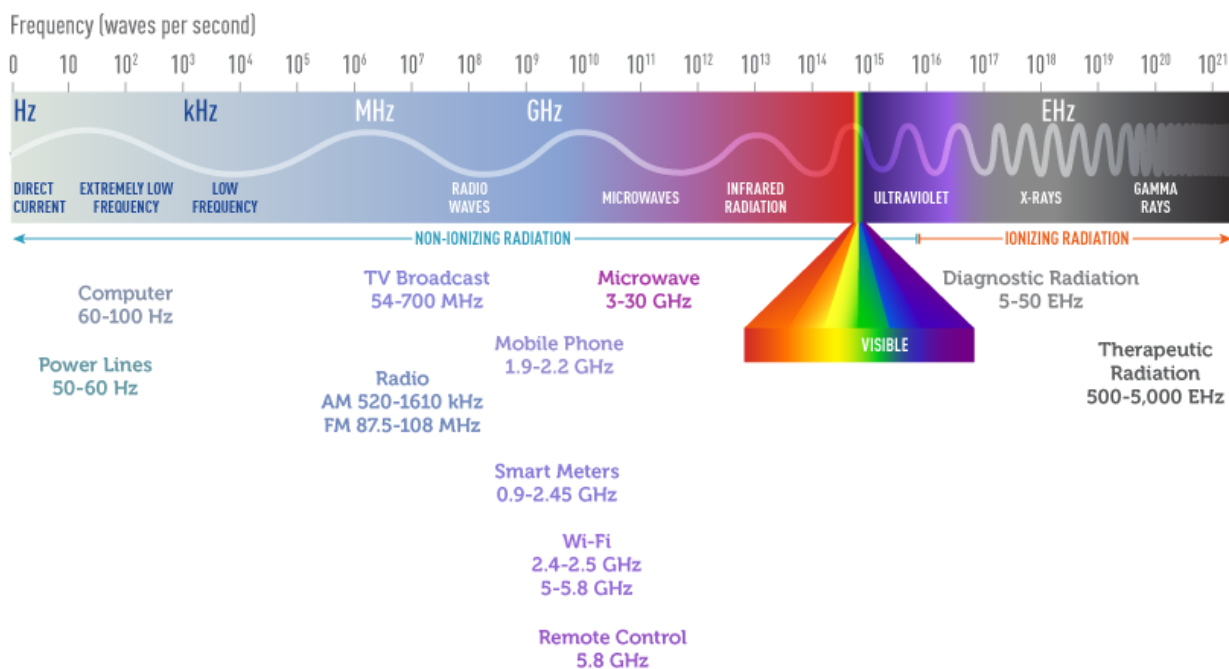


Image credit: National Cancer Institute

Examples of high-energy radiation include [x-rays and gamma rays](#)<sup>1</sup>. They, as well as some higher energy [ultraviolet \(UV\) rays](#)<sup>2</sup>, are classified as **ionizing radiation**, which means that they have enough energy to remove an electron from (ionize) an atom. This can damage the DNA inside cells, which can sometimes lead to 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 does not have enough energy to directly damage DNA. ELF radiation has even lower energy than other types of non-ionizing radiation like [radiofrequency radiation](#)<sup>3</sup> and infrared and visible light.

Although ELF radiation doesn't damage the DNA in cells the way ionizing radiation does and is generally thought to be safe, researchers are studying if there might be other ways that ELF radiation could somehow affect cancer risk.

## Electric and magnetic fields

Electromagnetic radiation is made of 2 parts: the electric field and the 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.
- A **magnetic field** is created when charged particles are in motion.

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 electric field can exist and act independently, so they are often studied separately.

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 hard to study.

## 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. This can include anything from refrigerators and vacuum cleaners to televisions and computer monitors (when they are on). 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 a person is very close to a source putting out a strong field and stays there for a long time.

## Does ELF radiation cause cancer?

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

- **Lab studies:** (studies done using lab animals or cells in lab dishes)
- **Studies in people** (epidemiologic studies)

Often neither type of study provides enough 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 (ELF-MF) 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. 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 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.

Although there is no clear link between ELF-MF and cancer in animal studies, there is some evidence from animal and cell-based research that ELF-MF may affect living organisms in some ways. For example:

- Some studies suggest that at certain levels of exposure, ELF-MF may affect how information from genes is used for cellular processes.
- Some studies have suggested that ELF-MF might stress cells, which could lead to the creation of reactive oxygen species inside the cells.

Results from different studies looking at these ideas have been inconsistent, and many studies have not found that ELF has any biological impact.

### 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 in different ways, but none of these are perfect:

- They can have a person wear a device that records their exposure levels over hours or days.
- They can measure the magnetic or electrical field strength in a person's home or workplace settings.
- They can estimate exposure based on the wiring configuration of someone's workplace/home or on its distance from power lines.

But all of these methods result in exposure estimates that have a lot of uncertainty. They typically don't account for a person's ELF exposures while in other places, and they don't measure ELF exposures in every location that person has ever lived or worked over their lifetime. As a result, there is no good way 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 the risk of [childhood leukemia](#)<sup>4</sup>, and have had 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 risk 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***

Several studies have looked at possible links between ELF exposures in adults and cancer. Most have not found a link, although a small number have suggested a possible 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 potential 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.

Between 2011 and 2015, the European research group **ARIMMORA (Advanced Research on Interaction Mechanisms of electroMagnetic exposures with Organisms for Risk Assessment)** did several studies to look for possible links between ELF-MF and cancer, especially childhood leukemia. The project concluded that their studies were consistent with the previously established IARC classification of ELF-MF as “possibly carcinogenic.”

## Can I avoid or limit my exposure to ELF radiation?

It's not clear that exposure to ELF radiation is harmful, and it's not possible to avoid all exposure to electromagnetic fields. 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/healthy/cancer-causes/radiation-exposure/x-rays-gamma-rays.html](http://www.cancer.org/healthy/cancer-causes/radiation-exposure/x-rays-gamma-rays.html)
2. [www.cancer.org/healthy/cancer-causes/radiation-exposure/uv-radiation.html](http://www.cancer.org/healthy/cancer-causes/radiation-exposure/uv-radiation.html)
3. [www.cancer.org/healthy/cancer-causes/radiation-exposure/radiofrequency-radiation.html](http://www.cancer.org/healthy/cancer-causes/radiation-exposure/radiofrequency-radiation.html)
4. [www.cancer.org/cancer/leukemia-in-children.html](http://www.cancer.org/cancer/leukemia-in-children.html)
5. <http://www.epa.gov>
6. <http://www.epa.gov/radiation/radiation-basics>
7. <http://www.cancer.gov>
8. <http://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/electromagnetic-fields-fact-sheet>
9. <http://www.niehs.nih.gov>
10. <http://www.niehs.nih.gov/health/topics/agents/emf/index.cfm>

11. <http://www.who.int>
12. <http://www.who.int/health-topics/electromagnetic-fields>
13. <http://www.epa.gov>
14. <http://www.epa.gov/radiation/radiation-basics>
15. <http://www.cancer.gov>
16. <http://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/electromagnetic-fields-fact-sheet>
17. <http://www.niehs.nih.gov>
18. <http://www.niehs.nih.gov/health/topics/agents/emf/index.cfm>
19. <http://www.who.int>
20. <http://www.who.int/health-topics/electromagnetic-fields>

### Additional resources

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

**Environmental Protection Agency (EPA)** Website: [www.epa.gov](http://www.epa.gov)  
(<http://www.epa.gov>)<sup>5</sup> Radiation Basics: [www.epa.gov/radiation/radiation-basics](http://www.epa.gov/radiation/radiation-basics)  
(<http://www.epa.gov/radiation/radiation-basics>)<sup>6</sup>

**National Cancer Institute (NCI)** Toll-free number: 1-800-422-6237 (1-800-4-CANCER)  
Website: [www.cancer.gov](http://www.cancer.gov) (<http://www.cancer.gov>)<sup>7</sup> Electromagnetic Fields and  
Cancer: [www.cancer.gov/about-cancer/causes-prevention/risk/radiation/electromagnetic-fields-fact-sheet](http://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/electromagnetic-fields-fact-sheet) (<http://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/electromagnetic-fields-fact-sheet>)<sup>8</sup>

**National Institute of Environmental Health Sciences** Website: [www.niehs.nih.gov](http://www.niehs.nih.gov)  
(<http://www.niehs.nih.gov>)<sup>9</sup> Electric & Magnetic  
Fields: [www.niehs.nih.gov/health/topics/agents/emf/index.cfm](http://www.niehs.nih.gov/health/topics/agents/emf/index.cfm)  
(<http://www.niehs.nih.gov/health/topics/agents/emf/index.cfm>)<sup>10</sup>

**World Health Organization** Website: [www.who.int](http://www.who.int) (<http://www.who.int>)<sup>11</sup>  
Electromagnetic fields (EMF): [www.who.int/health-topics/electromagnetic-fields](http://www.who.int/health-topics/electromagnetic-fields)  
(<http://www.who.int/health-topics/electromagnetic-fields>)<sup>12</sup>

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



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