INFORMATION REGARDING EMF FROM HEALTH ORGANIZATIONS AROUND THE WORLD

U.S. National Cancer Institute - *Electric and Magnetic fields Associated with the Use of Electric Power*

https://www.cancer.gov/about-cancer/causes-prevention/risk/myths

- **"Do power lines cause cancer?**

  No, not according to the best studies completed so far. Power lines emit both electric and magnetic energy. The electric energy emitted by power lines is easily shielded or weakened by walls and other objects. The magnetic energy emitted by power lines is a low-frequency form of radiation that does not damage genes."

https://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/electromagnetic-fields-fact-sheet

- "No mechanism by which ELF-EMFs or radiofrequency radiation could cause cancer has been identified."

- "Studies of animals have not provided any indications that exposure to ELF-EMFs is associated with cancer."

- "Numerous epidemiologic studies and comprehensive reviews of the scientific literature have evaluated possible associations between exposure to non-ionizing EMFs and risk of cancer in children. (Magnetic fields are the component of non-ionizing EMFs that are usually studied in relation to their possible health effects.) Most of the research has focused on leukemia and brain tumors, the two most common cancers in children. Studies have examined associations of these cancers with living near power lines, with magnetic fields in the home, and with exposure of parents to high levels of magnetic fields in the workplace. No consistent evidence for an association between any source of non-ionizing EMF and cancer has been found."

American Cancer Society – *Power Lines, Electrical Devices and Extremely Low Frequency Radiation*

https://www.cancer.org/healthy/cancer-causes/radiation-exposure/extremely-low-frequency-radiation.html

- "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."

Health Canada – *Power lines and electrical products: Extremely low frequency electric and magnetic fields*

https://www.canada.ca/en/health-canada/services/health-risks-safety/radiation/everyday-things-emit-radiation/power-lines-electrical-appliances.html

- "The potential health effects of extremely low frequency EMF has been studied extensively. While some people are concerned that long term exposure to extremely low frequency EMF may cause cancer, the scientific evidence does not support such claims."

World Health Organization – *Radiation: Electromagnetic Fields*

https://www.who.int/news-room/questions-and-answers/item/radiation-electromagnetic-fields

- "In the area of biological effects and medical applications of non-ionizing radiation approximately 25,000 articles have been published over the past 30 years. Despite the feeling of some people that more research needs to be done, scientific knowledge in this area is now more extensive than for most chemicals. Based on a recent in-depth review of the scientific literature, the WHO concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields."

NIH NATIONAL CANCER INSTITUTE

Common Cancer Myths and Misconceptions

Certain popular ideas about how cancer starts and spreads—though scientifically wrong—can seem to make sense, especially when those ideas are rooted in old theories. But wrong ideas about cancer can lead to needless worry and even hinder good prevention and treatment decisions. This page provides the latest science-based information about some common cancer myths and misconceptions.

Is cancer a death sentence?

In the United States, the likelihood of dying from cancer has dropped steadily since the 1990s. Five-year survival rates for some cancers, such as breast, prostate, and thyroid cancers, now are 90 percent or better. The 5-year survival rate for all cancers combined is currently about 67 percent. For more information, see the Annual Report to the Nation on the Status of Cancer.

It is important to note, however, that these rates are based on data from large numbers of people. How long an individual cancer patient will live and whether he or she will die from the disease depend on many factors, including whether the cancer is slow or fast growing, how much the cancer has spread in the body, whether effective treatments are available, the person's overall health, and more.

Will eating sugar make my cancer worse?

No. Although research has shown that cancer cells consume more sugar (glucose) than normal cells, no studies have shown that eating sugar will make your cancer worse or that, if you stop eating sugar, your cancer will shrink or disappear. However, a high-sugar diet may contribute to excess weight gain, and obesity is associated with an increased risk of developing several types of cancer. For more information, see the NCI fact sheet on Obesity and Cancer.

Do artificial sweeteners cause cancer?

No. Researchers have conducted studies on the safety of the artificial sweeteners (sugar substitutes) saccharin (Sweet 'N Low®, Sweet Twin®, NectaSweet®); cyclamate; aspartame (Equal®, NutraSweet®); acesulfame potassium (Sunett®, Sweet One®); sucralose (Splenda®); and neotame and found no evidence that they cause cancer in humans. All of these artificial sweeteners except for cyclamate have been approved by the Food and Drug Administration for sale in the United States. For more information, see the NCI fact sheet on Artificial Sweeteners and Cancer.

Is cancer contagious?

In general, no. Cancer is not a contagious disease that easily spreads from person to person. The only situation in which cancer can spread from one person to another is in the case of organ or tissue transplantation. A person who receives an organ or tissue from a donor who had cancer in the past may be at increased risk of developing a transplant-related cancer in the future. However, that risk is extremely low—about two cases of cancer per 10,000 organ transplants. Doctors avoid the use of organs or tissue from donors who have a history of cancer.

In some people, cancers may be caused by certain viruses (some types of human papillomavirus, or HPV, for example) and bacteria (such as *Helicobacter pylori*). While a virus or bacterium can spread from person to person, the cancers they sometimes cause cannot spread from person to person. For more information about cancer-causing viruses and bacteria, see the NCI fact sheet on Helicobacter pylori and Cancer and our pages on HPV and Cancer and Infectious Agents.

Does my attitude—positive or negative—determine my risk of, or likely recovery from, cancer?

To date, there is no convincing scientific evidence that links a person's "attitude" to his or her risk of developing or dying from cancer. If you have cancer, it's normal to feel sad, angry, or discouraged sometimes and positive or upbeat at other times. People with a positive attitude may be more likely to maintain social connections and stay active, and physical activity and emotional support may help you cope with your cancer. For more information, see the NCI fact sheet on Psychological Stress and Cancer.

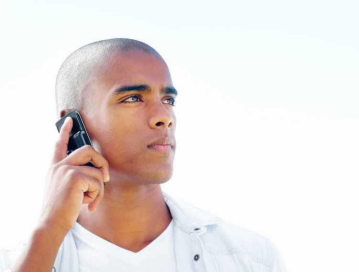
Can cancer surgery or a tumor biopsy cause cancer to spread in the body?

The chance that surgery will cause cancer to spread to other parts of the body is extremely low. Following standard procedures, surgeons use special methods and take many steps to prevent cancer cells from spreading during biopsies or surgery to remove tumors. For example, if they must remove tissue from more than one area of the body, they use different surgical tools for each area. For information about how cancer spreads in the body, see our page on Metastatic Cancer.

Will cancer get worse if exposed to air?

No. Exposure to air will not make tumors grow faster or cause cancer to spread to other parts of the body. For information about how cancer spreads in the body, see our page on Metastatic Cancer.

Do cell phones cause cancer?



No, not according to the best studies completed so far. Cancer is caused by genetic mutations, and cell phones emit a type of low-frequency energy that does not damage genes. For more information, see the NCI fact sheet on Cell Phones and Cancer Risk.

Do power lines cause cancer?

No, not according to the best studies completed so far. Power lines emit both electric and magnetic energy. The electric energy emitted by power lines is easily shielded or weakened by walls and other objects. The magnetic energy emitted by power lines is a low-frequency form of radiation that does not damage genes. For more information, see the NCI fact sheet on Electromagnetic Fields and Cancer.

Are there herbal products that can cure cancer?

No. Although some studies suggest that alternative or complementary therapies, including some herbs, may help patients cope with the side effects of cancer treatment, no herbal products have been shown to be effective for treating cancer. In fact, some herbal products may be harmful when taken during chemotherapy or radiation therapy because they may interfere with how these treatments work. Cancer patients should talk with their doctor about any complementary and alternative medicine products—including vitamins and herbal supplements—they may be using. For more information, see Complementary and Alternative Medicine.

If someone in my family has cancer, am I likely to get cancer, too?

Not necessarily. Cancer is caused by harmful changes (mutations) in genes. Only about 5 to 10 percent of cancers are caused by harmful mutations that are inherited from a person's parents. In families with an inherited cancer-causing mutation, multiple family members will often develop the same type of cancer. These cancers are called "familial" or "hereditary" cancers.

The remaining 90 to 95 percent of cancers are caused by mutations that happen during a person's lifetime as a natural result of aging and exposure to environmental factors, such as tobacco smoke and radiation. These cancers are called "non-hereditary" or "spontaneous" cancers. For more information about the risk of getting cancer, see the NCI fact sheet on Genetic Testing for Inherited Cancer Susceptibility Syndromes and Cancer Causes and Risk Factors.

If no one in my family has had cancer, does that mean I'm risk-free?

No. Based on the most recent data, about 38 percent of men and women will be diagnosed with cancer at some point during their lives. Most cancers are caused by genetic changes that occur throughout a person's lifetime as a natural result of aging and exposure to environmental factors, such as tobacco smoke and radiation. Other factors, such as what kind of food you eat, how much you eat, and whether you exercise, may also influence your risk of developing cancer. For more information, see Cancer Causes and Risk Factors.

Do antiperspirants or deodorants cause breast cancer?

No. The best studies so far have found no evidence linking the chemicals typically found in antiperspirants and deodorants with changes in breast tissue. For more information, see the NCI fact sheet on Antiperspirants/Deodorants and Breast Cancer.

Does hair dye use increase the risk of cancer?

There is no convincing scientific evidence that personal hair dye use increases the risk of cancer. Some studies suggest, however, that hairdressers and barbers who are regularly exposed to large quantities of hair dye

and other chemical products may have an increased risk of bladder cancer. For more information, see the NCI fact sheet on Hair Dyes and Cancer Risk.

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NIH NATIONAL CANCER INSTITUTE

Electromagnetic Fields and Cancer

What are electric and magnetic fields?

Electric and magnetic fields are invisible areas of energy (also called radiation) that are produced by electricity, which is the movement of electrons, or current, through a wire.

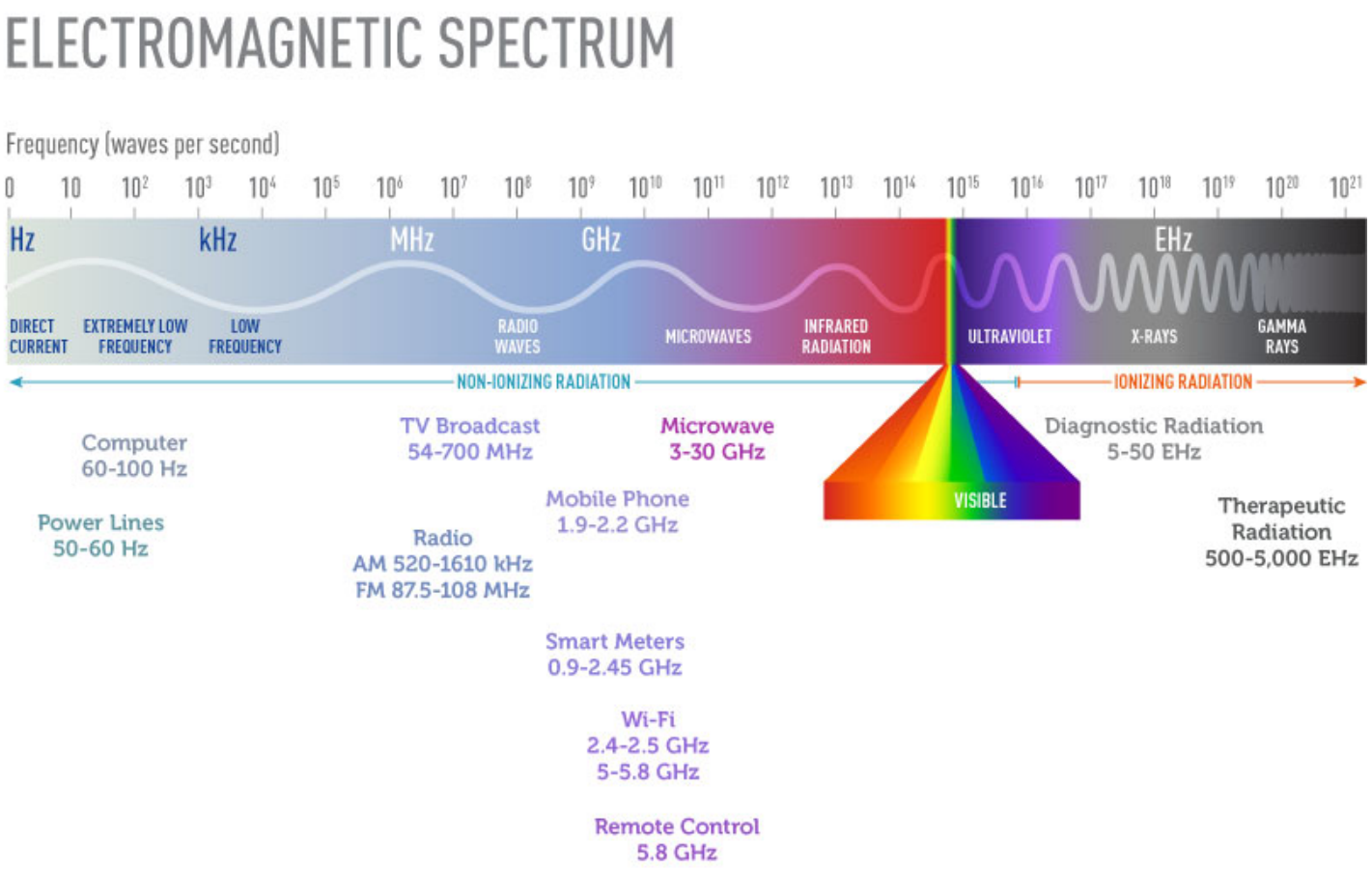
An electric field is produced by voltage, which is the pressure used to push the electrons through the wire, much like water being pushed through a pipe. As the voltage increases, the electric field increases in strength. Electric fields are measured in volts per meter (V/m).

A magnetic field results from the flow of current through wires or electrical devices and increases in strength as the current increases. The strength of a magnetic field decreases rapidly with increasing distance from its source. Magnetic fields are measured in microteslas (μT, or millionths of a tesla).

Electric fields are produced whether or not a device is turned on, whereas magnetic fields are produced only when current is flowing, which usually requires a device to be turned on. Power lines produce magnetic fields continuously because current is always flowing through them. Electric fields are easily shielded or weakened by walls and other objects, whereas magnetic fields can pass through buildings, living things, and most other materials.

Electric and magnetic fields together are referred to as electromagnetic fields, or EMFs. The electric and magnetic forces in EMFs are caused by electromagnetic radiation. There are two main categories of EMFs:

- Higher-frequency EMFs, which include x-rays and gamma rays. These EMFs are in the ionizing radiation part of the electromagnetic spectrum and can damage DNA or cells directly.
- Low- to mid-frequency EMFs, which include static fields (electric or magnetic fields that do not vary with time), magnetic fields from electric power lines and appliances, radio waves, microwaves, infrared radiation, and visible light. These EMFs are in the non-ionizing radiation part of the electromagnetic spectrum and are not known to damage DNA or cells directly. Low- to mid-frequency EMFs include extremely low frequency EMFs (ELF-EMFs) and radiofrequency EMFs. ELF-EMFs have frequencies of up to 300 cycles per second, or hertz (Hz), and radiofrequency EMFs range from 3 kilohertz (3 kHz, or 3,000 Hz) to 300 gigahertz (300 GHz, or 300 billion Hz). Radiofrequency radiation is measured in watts per meter squared (W/m^2).



The electromagnetic spectrum represents all of the possible frequencies of electromagnetic energy. It ranges from extremely long wavelengths (extremely low frequency exposures such as those from power lines) to extremely short wavelengths (x-rays and gamma rays) and includes both non-ionizing and ionizing radiation.

What are common sources of non-ionizing EMFs?

There are both natural and human-made sources of non-ionizing EMFs. The earth's magnetic field, which causes the needle on a compass to point North, is one example of a naturally occurring EMF.

Human-made EMFs fall into both the ELF and radiofrequency categories of non-ionizing part of the electromagnetic spectrum. These EMFs can come from a number of sources.

Extremely low frequency EMFs (ELF-EMFs). Sources of ELF-EMFs include power lines, electrical wiring, and electrical appliances such as shavers, hair dryers, and electric blankets.

Radiofrequency radiation. The most common sources of radiofrequency radiation are wireless telecommunication devices and equipment, including cell phones, smart meters, and portable wireless devices, such as tablets and laptop computers (1). In the United States, cell phones currently operate in a frequency range of about 1.8 to 2.2 GHz (2). (For more information about cell phones, see the NCI fact

sheet Cell Phones and Cancer Risk.)

Other common sources of radiofrequency radiation include:

- **Radio and television signals.** AM/FM radios and older VHF/UHF televisions operate at lower radiofrequencies than cell phones. Radio signals are AM (amplitude-modulated) or FM (frequency-modulated). AM radio is used for broadcasting over very long distances, whereas FM radio covers more localized areas. AM signals are transmitted from large arrays of antennas that are placed at high elevation on sites that are off limits to the general public because exposures close to the source can be high. Maintenance workers could receive substantial radiofrequency exposures from AM radio antennas, but the general public would not. FM radio antennas and TV broadcasting antennas, which are much smaller than AM antennas, are generally mounted at the top of high towers. Radiofrequency exposures near the base of these towers are below guideline limits (3), so exposure of the general population is very low. Sometimes small local radio and TV antennas are mounted on the top of a building; access to the roof of such buildings is usually controlled.
- **Radar, satellite stations, magnetic resonance imaging (MRI) devices, and industrial equipment.**These operate at somewhat higher radiofrequencies than cell phones (1).
- **Microwave ovens** used in homes, which also operate at somewhat higher radiofrequencies than cell phones (1). Microwave ovens are manufactured with effective shielding that has reduced the leakage of radiofrequency radiation from these appliances to barely detectable levels.
- **Cordless telephones**, which can operate on analogue or DECT (Digital Enhanced Cordless Telecommunications) technology and typically emit radiofrequencies similar to those of cell phones. However, because cordless phones have a limited range and require a nearby base, their signal strengths are generally much lower than those of cell phones (1).
- **Cell phone base stations.** Antenna towers or base stations, including those for mobile phone networks and for broadcasting for radio and for television, emit various types of radiofrequency energy. Because the majority of individuals in the general population are exposed only intermittently to base stations and broadcast antennas, it is difficult to estimate exposures for a population (4). The strength of these exposures varies based on the population density of the region, the average distance from the source, and the time of day or the day of the week (lower exposures on the weekends or at night) (1). A study that used using personal portable exposure meters to assess exposures to different sources of radiofrequency EMFs among children in Europe found that the single largest contributor to the total radiofrequency EMF exposure was the proximity to base stations (5).

  In general, exposures decrease with increasing distance from the source (6). Exposures among maintenance workers have been found to vary depending on their tasks, the type of antenna, and the location of the worker in relation to the source (1). Cumulative exposures of such workers are very difficult to estimate.
- **Televisions and computer screens** produce electric and magnetic fields at various frequencies, as well as static electric fields. The liquid crystal displays found in some laptop and desktop computers do not produce substantial electric or magnetic fields. Modern computers have conductive screens that reduce static fields produced by the screen to normal background levels.
- **Wireless local area networks**, commonly known as Wi-Fi. These are specific types of wireless networking systems and an increasingly common source of radiofrequency radiation. Wireless networks

use radio waves to connect Wi-Fi–enabled devices to an access point that is connected to the internet, either physically or through some form of data connection. Most Wi-Fi devices operate at radiofrequencies that are broadly similar to cell phones, typically 2.4 to 2.5 GHz, although in recent years Wi-Fi devices that operate at somewhat higher frequencies (5, 5.3, or 5.8 GHz) have appeared (7). Radiofrequency radiation exposure from Wi-Fi devices is considerably lower than that from cell phones (8). Both sources emit levels of radiofrequency radiation that are far below the guideline of 10 W/m^2 as specified by the International Commission on Non-Ionizing Radiation Protection (3).

- **Digital electric and gas meters, also known as "smart meters."** These devices, which operate at about the same radiofrequencies as cell phones, transmit information on consumption of electricity or gas to utility companies. Smart meters produce very low level fields that sometimes cannot be distinguished from the total background radiofrequency radiation levels inside a home (9).

For household appliances and other devices used in the home that require electricity, magnetic field levels are highest near the source of the field and decrease rapidly the farther away the user is from the source. Magnetic fields drop precipitously at a distance of about 1 foot from most appliances. For computer screens, at a distance of 12–20 inches from the screen that most persons using computers sit, magnetic fields are similarly dramatically lower.

Why are non-ionizing EMFs studied in relation to cancer?

Power lines and electrical appliances that emit non-ionizing EMFs are present everywhere in homes and workplaces. For example, wireless local networks are nearly always "on" and are increasingly commonplace in homes, schools, and many public places.

No mechanism by which ELF-EMFs or radiofrequency radiation could cause cancer has been identified. Unlike high-energy (ionizing) radiation, EMFs in the non-ionizing part of the electromagnetic spectrum cannot damage DNA or cells directly. Some scientists have speculated that ELF-EMFs could cause cancer through other mechanisms, such as by reducing levels of the hormone melatonin. There is some evidence that melatonin may suppress the development of certain tumors.

Studies of animals have not provided any indications that exposure to ELF-EMFs is associated with cancer (10–13). The few high-quality studies in animals have provided no evidence that Wi-Fi is harmful to health (8).

Although there is no known mechanism by which non-ionizing EMFs could damage DNA and cause cancer, even a small increase in risk would be of clinical importance given how widespread exposure to these fields is.

What have studies shown about possible associations between non-ionizing EMFs and cancer in children?

Numerous epidemiologic studies and comprehensive reviews of the scientific literature have evaluated possible associations between exposure to non-ionizing EMFs and risk of cancer in children (13–15). (Magnetic fields are the component of non-ionizing EMFs that are usually studied in relation to their possible

health effects.) Most of the research has focused on leukemia and brain tumors, the two most common cancers in children. Studies have examined associations of these cancers with living near power lines, with magnetic fields in the home, and with exposure of parents to high levels of magnetic fields in the workplace. No consistent evidence for an association between any source of non-ionizing EMF and cancer has been found.

Exposure from power lines. Although a study in 1979 pointed to a possible association between living near electric power lines and childhood leukemia (16), more recent studies have had mixed findings (17–25). Most of these studies did not find an association or found one only for those children who lived in homes with very high levels of magnetic fields, which are present in few residences.

Several studies have analyzed the combined data from multiple studies of power line exposure and childhood leukemia:

- A pooled analysis of nine studies reported a twofold increase in risk of childhood leukemia among children with exposures of 0.4 μT or higher. Less than 1% of the children in the studies experienced this level of exposure (26).
- A meta-analysis of 15 studies observed a 1.7-fold increase in childhood leukemia among children with exposures of 0.3 μT or higher. A little more than 3% of children in the studies experienced this level of exposure (27).
- More recently, a pooled analysis of seven studies published after 2000 reported a 1.4-fold increase in childhood leukemia among children with exposures of 0.3 μT or higher. However, less than one half of 1% of the children in the studies experienced this level of exposure (28).

For the two pooled studies and the meta-analysis, the number of highly exposed children was too small to provide stable estimates of the dose–response relationship. This means that the findings could be interpreted to reflect linear increases in risk, a threshold effect at 0.3 or 0.4 μT, or no significant increase.

The interpretation of the finding of increased childhood leukemia risk among children with the highest exposures (at least 0.3 μT) is unclear.

Exposure from electrical appliances. Another way that children can be exposed to magnetic fields is from household electrical appliances. Although magnetic fields near many electrical appliances are higher than those near power lines, appliances contribute less to a person's total exposure to magnetic fields because most appliances are used for only short periods of time. And moving even a short distance from most electrical appliances reduces exposure dramatically. Again, studies have not found consistent evidence for an association between the use of household electrical appliances and risk of childhood leukemia (29).

Exposure to Wi-Fi. In view of the widespread use of Wi-Fi in schools, the UK Health Protection Agency (now part of Public Health England) has conducted the largest and most comprehensive measurement studies to assess exposures of children to radiofrequency electromagnetic fields from wireless computer networks (30, 31). This agency concluded that radiofrequency exposures were well below recommended maximum levels and that there was "no reason why Wi-Fi should not continue to be used in schools and in other places" (32).

A review of the published literature concluded that the few high-quality studies to date provide no evidence

of biological effects from Wi-Fi exposures (7).

Exposure from cell phone base stations. Few studies have examined cancer risk in children living close to cell phone base stations or radio or television transmitters. Mobile phone base stations transmit and receive radiofrequency signals to and from mobile phones near the station. None of the studies that estimated exposures on an individual level found an increased risk of pediatric tumors (33–35).

Parental exposure and risk in offspring. Several studies have examined possible associations between maternal or paternal exposure to high levels of magnetic fields before conception and/or during pregnancy and the risk of cancer in their future children. The results to date have been inconsistent (36, 37). This question requires further evaluation.

Exposure and cancer survival. A few studies have investigated whether magnetic field exposure is associated with prognosis or survival of children with leukemia. Several small retrospective studies of this question have yielded inconsistent results (38–40). An analysis that combined prospective data for more than 3,000 children with acute lymphoid leukemia from eight countries showed that ELF magnetic field exposure was not associated with their survival or risk of relapse (41).

What have studies shown about possible associations between non-ionizing EMFs and cancer in adults?

Many studies have examined the association between non-ionizing EMF exposure and cancer in adults, of which few studies have reported evidence of increased risk (1).

Residential exposures. The majority of epidemiologic studies have shown no relationship between breast cancer in women and exposure to extremely low frequency EMFs (ELF-EMFs) in the home (42–45), although a few individual studies have suggested an association; only one reported results that were statistically significant (46).

Workplace exposures to ELF radiation. Several studies conducted in the 1980s and early 1990s reported that people who worked in some electrical occupations that exposed them to ELF radiation (such as power station operators and telephone line workers) had higher-than-expected rates of some types of cancer, particularly leukemia, brain tumors, and male breast cancer (13). Most of the results were based on participants' job titles and not on actual measurements of their exposures. More recent studies, including some that considered exposure measurements as well as job titles, have generally not shown an increasing risk of leukemia, brain tumors, or female breast cancer with increasing exposure to magnetic fields at work (46–51).

Workplace exposures to radiofrequency radiation. A limited number of studies have evaluated risks of cancer in workers exposed to radiofrequency radiation. A large study of U.S. Navy personnel found no excess of brain tumors among those with a high probability of exposure to radar (including electronics technicians, aviation technicians, and fire control technicians); however, nonlymphocytic leukemia, particularly acute myeloid leukemia, was increased in electronics technicians in aviation squadrons, but not in Navy personnel in the other job categories (52). A case–control study among U.S. Air Force personnel found the suggestion of an increased risk of brain cancer among personnel who maintained or repaired radiofrequency or

microwave-emitting equipment (53). A case–control study found the suggestion of an increased risk of death from brain cancer among men occupationally exposed to microwave and/or radiofrequency radiation, with all of the excess risk among workers in electrical and electronics jobs involving design, manufacture, repair, or installation of electrical or electronics equipment (54). There was no evidence that electrical utility workers who were exposed to pulsed electromagnetic fields produced by power lines were more likely to develop brain tumors or leukemia than the general population (55). Employees of a large manufacturer of wireless communication products were not more likely to die from brain tumors or cancers of the hematopoietic or lymphatic system than the general population (56). A large prospective study among police officers in Great Britain found no evidence for an association between radiofrequency EMF exposure from personal radio use and the risk of all cancers combined (57). A large multinational population-based case–control study found no clear evidence that occupational exposures to radiofrequency radiation are associated with increased risks of glioma or meningioma (58).

What do expert organizations conclude about the cancer risk from EMFs?

In 2002, the International Agency for Research on Cancer (IARC), a component of the World Health Organization, appointed an expert Working Group to review all available evidence on static and extremely low frequency electric and magnetic fields (13). The Working Group classified ELF-EMFs as "possibly carcinogenic to humans," based on limited evidence from human studies in relation to childhood leukemia. Static electric and magnetic fields and extremely low frequency electric fields were determined "not classifiable as to their carcinogenicity to humans" (13).

In 2015, the European Commission Scientific Committee on Emerging and Newly Identified Health Risks reviewed electromagnetic fields in general, as well as cell phones in particular. It found that, overall, epidemiologic studies of extremely low frequency fields show an increased risk of childhood leukemia with estimated daily average exposures above 0.3 to 0.4 μT, although no mechanisms have been identified and there is no support from experimental studies that explains these findings. It also found that the epidemiologic studies on radiofrequency exposure do not show an increased risk of brain tumors or other cancers of the head and neck region, although the possibility of an association with acoustic neuroma remains open (59).

Where can people find additional information on EMFs?

The National Institute of Environmental Health Sciences (NIEHS) website has information about EMFs and cancer.

The Occupational Safety and Health Administration website has information about workplace exposures to ELF-EMF.

The US Environmental Protection Agency website has information on power lines and other sources of EMF.

The European Commission also has general information on EMF.

The World Health Organization website also has information about EMFs and public health.

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Related Resources

Cell Phones and Cancer Risk

Reviewed: May 30, 2022

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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 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.*

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Power lines and electrical products: Extremely low frequency electric and magnetic fields

Power lines and electrical products emit extremely low frequency electric and magnetic fields (EMF). Learn about the safety of power lines and electrical products.

On this page

- About extremely low frequency EMF
- Sources of extremely low frequency EMF
- Power lines and your home
- Recommended human exposure limits
- What we do to keep you safe from extremely low frequency EMFs

About extremely low frequency EMF

Extremely low frequency electromagnetic fields (EMF) are invisible waves that travel through space and exert force on charged particles.

Extremely low frequency EMF:

- consist of electric fields and magnetic fields
- is in the frequency range of 1 Hertz (Hz) to 3 kilohertz (kHz) of the electromagnetic spectrum

An electric field is created whenever you plug a wire from an electrical

product, like a lamp, into an outlet. When you turn the lamp on, the flow of current, known as alternating current (AC) forms a magnetic field. Together, the electric and magnetic field radiates out like a wave and are known as electromagnetic fields or EMF.

In Canada, the electricity that is distributed to our homes and other buildings is AC with a frequency of 60 Hz. This is considered extremely low frequency EMF.

Sources of extremely low frequency EMF

Electrical products create extremely low frequency EMF when they are plugged into a wall outlet and are turned on (drawing a current). Common sources of extremely low frequency EMF are:

- household wiring
- electrical appliances and household electrical products
- power lines, transformer boxes and electrical substations

Power lines and your home

Power lines that distribute electricity around your home emit extremely low frequency EMF. These fields are strongest at their source. This means you are exposed to stronger extremely low EMFs when you are close to a source such as:

- right beside a transformer box
- directly under a high voltage power line

As you move away, your level of exposure rapidly decreases. When you are inside your home, the electric fields from transformer boxes and high voltage power lines are often weaker than the fields from household electrical appliances.

Recommended human exposure limits

The potential health effects of extremely low frequency EMF has been studied extensively. While some people are concerned that long term exposure to extremely low frequency EMF may cause cancer, the scientific evidence does not support such claims.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has issued guidelines for limiting exposure to extremely low frequency EMF. These guidelines help ensure that exposures to extremely low frequency EMF do not create electric currents that are stronger than the ones made naturally in your body. The electric signals used by your brain and nervous system make it possible for you to move, think and feel.

Extremely low frequency EMF exposures in Canadian homes, schools and offices are far below the limits recommended in the ICNIRP guidelines. You don't need to take precautions to protect yourself from these kinds of exposures.

Exposure to extremely low frequency EMF is not the same as electrical shock. Electrical shock can happen when an electrical product is used incorrectly. Learn how to use electrical products safely.

What we do to keep you safe from extremely low frequency EMFs

To protect your health and safety, Health Canada:

- monitors the science on electromagnetic fields
- conducts research on potential health effects from electromagnetic fields
- contributes to the World Health Organization's International EMF

Project

We do not regulate the delivery of electricity in Canada. For questions about power lines, transformer stations or other electrical infrastructure near your home, school or office you can contact:

- your local electricity provider
- your local public health office
- your municipal, provincial or territorial government

Related links

- About radiation
- International EMF Project
- International Agency for Research on Cancer
- Radiofrequency electromagnetic fields (EMF)
- World Health Organization: Extremely low frequency fields
- International Commission on Non-Ionizing Radiation Protection

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2020-12-04

World Health Organization

Radiation: Electromagnetic fields

4 August 2016 | Q&A

What are electromagnetic fields and where do they come from?

What makes the various forms of electromagnetic fields so different?

What happens when you are exposed to electromagnetic fields?

Biological effects or health effects? What is a health hazard?

Biological effects are measurable responses to a stimulus or to a change in the environment. These changes are not necessarily harmful to your health. For example, listening to music, reading a book, eating an apple or playing tennis will produce a range of biological effects. Nevertheless, none of these activities is expected to cause health effects. The body has sophisticated mechanisms to adjust to the many and varied influences we encounter in our environment. Ongoing change forms a normal

part of our lives. But, of course, the body does not possess adequate compensation mechanisms for all biological effects. Changes that are irreversible and stress the system for long periods of time may constitute a health hazard.

An adverse health effect causes detectable impairment of the health of the exposed individual or of his or her offspring; a biological effect, on the other hand, may or may not result in an adverse health effect.

It is not disputed that electromagnetic fields above certain levels can trigger biological effects. Experiments with healthy volunteers indicate that short-term exposure at the levels present in the environment or in the home do not cause any apparent detrimental effects. Exposures to higher levels that might be harmful are restricted by national and international guidelines. The current debate is centred on whether long-term low level exposure can evoke biological responses and influence people's well being.

Widespread concerns for health

A look at the news headlines of recent years allows some insight into the various areas of public concern. Over the course of the past decade, numerous electromagnetic field sources have become the focus of health concerns, including power lines, microwave ovens, computer and TV screens, security devices, radars and most recently mobile phones and their base stations.

The International EMF Project

In response to growing public health concerns over possible health effects from exposure to an ever increasing number and diversity of electromagnetic field sources, in 1996 the World Health Organization (WHO) launched a large, multidisciplinary research effort. The International EMF Project brings together current knowledge and available resources of key international and national agencies and scientific institutions.

Conclusions from scientific research

In the area of biological effects and medical applications of non-ionizing radiation approximately 25,000 articles have been published over the past 30 years. Despite the feeling of some people that more research needs to be done, scientific knowledge in this area is now more extensive than for most chemicals. Based on a recent in-depth

review of the scientific literature, the WHO concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields. However, some gaps in knowledge about biological effects exist and need further research.

Effects on general health

Some members of the public have attributed a diffuse collection of symptoms to low levels of exposure to electromagnetic fields at home. Reported symptoms include headaches, anxiety, suicide and depression, nausea, fatigue and loss of libido. To date, scientific evidence does not support a link between these symptoms and exposure to electromagnetic fields. At least some of these health problems may be caused by noise or other factors in the environment, or by anxiety related to the presence of new technologies.

Effects on pregnancy outcome

Many different sources and exposures to electromagnetic fields in the living and working environment, including computer screens, water beds and electric blankets, radiofrequency welding machines, diathermy equipment and radar, have been evaluated by the WHO and other organizations. The overall weight of evidence shows that exposure to fields at typical environmental levels does not increase the risk of any adverse outcome such as spontaneous abortions, malformations, low birth weight, and congenital diseases. There have been occasional reports of associations between health problems and presumed exposure to electromagnetic fields, such as reports of prematurity and low birth weight in children of workers in the electronics industry, but these have not been regarded by the scientific community as being necessarily caused by the field exposures (as opposed to factors such as exposure to solvents).

Cataracts

General eye irritation and cataracts have sometimes been reported in workers exposed to high levels of radiofrequency and microwave radiation, but animal studies do not support the idea that such forms of eye damage can be produced at levels that are not thermally hazardous. There is no evidence that these effects occur at levels experienced by the general public.

Electromagnetic fields and cancer

Despite many studies, the evidence for any effect remains highly controversial. However, it is clear that if electromagnetic fields do have an effect on cancer, then any increase in risk will be extremely small. The results to date contain many inconsistencies, but no large increases in risk have been found for any cancer in children or adults.

A number of epidemiological studies suggest small increases in risk of childhood leukemia with exposure to low frequency magnetic fields in the home. However, scientists have not generally concluded that these results indicate a cause-effect relation between exposure to the fields and disease (as opposed to artifacts in the study or effects unrelated to field exposure). In part, this conclusion has been reached because animal and laboratory studies fail to demonstrate any reproducible effects that are consistent with the hypothesis that fields cause or promote cancer. Large-scale studies are currently underway in several countries and may help resolve these issues.

Electromagnetic hypersensitivity and depression

Some individuals report "hypersensitivity" to electric or magnetic fields. They ask whether aches and pains, headaches, depression, lethargy, sleeping disorders, and even convulsions and epileptic seizures could be associated with electromagnetic field exposure.

There is little scientific evidence to support the idea of electromagnetic hypersensitivity. Recent Scandinavian studies found that individuals do not show consistent reactions under properly controlled conditions of electromagnetic field exposure. Nor is there any accepted biological mechanism to explain hypersensitivity. Research on this subject is difficult because many other subjective responses may be involved, apart from direct effects of fields themselves. More studies are continuing on the subject.

The focus of current and future research

Much effort is currently being directed towards the study of electromagnetic fields in relation to cancer. Studies in search for possible carcinogenic (cancer-producing) effects of power frequency fields is continuing, although at a reduced level compared to that of the late 1990's.

The long-term health effects of mobile telephone use is another topic of much current research. No obvious adverse effect of exposure to low level radiofrequency fields has been discovered. However, given public concerns regarding the safety of cellular telephones, further research aims to determine whether any less obvious effects might occur at very low exposure levels.

Key points

- **A wide range of environmental influences causes biological effects. 'Biological effect' does not equal 'health hazard'. Special research is needed to identify and measure health hazards.**
- **At low frequencies, external electric and magnetic fields induce small circulating currents within the body. In virtually all ordinary environments, the levels of induced currents inside the body are too small to produce obvious effects.**
- **The main effect of radiofrequency electromagnetic fields is heating of body tissues.**
- **There is no doubt that short-term exposure to very high levels of electromagnetic fields can be harmful to health. Current public concern focuses on possible long-term health effects caused by exposure to electromagnetic fields at levels below those required to trigger acute biological responses.**
- **WHO's International EMF Project was launched to provide scientifically sound and objective answers to public concerns about possible hazards of low level electromagnetic fields.**
- **Despite extensive research, to date there is no evidence to conclude that exposure to low level electromagnetic fields is harmful to human health.**
- **The focus of international research is the investigation of possible links between cancer and electromagnetic fields, at power line and radiofrequencies.**

What is the current state of research?

What are typical exposure levels at home and in the environment?

What are the current standards?

What precautions are being followed?

Are there pages on EMF in German, Italian and Swedish?

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