Skip navigation

Radiation Exposure and Cancer

What is 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 different types of radiation, and many of them are not linked to cancer.

Types of radiation

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*. From highest to lowest energy, the main forms of radiation are:

- Gamma rays
- X-rays
- Ultraviolet (UV) rays
- Visible light
- Infrared rays
- Microwaves
- Radiofrequency (radio) waves
- Extremely low-frequency (ELF) radiation

An important distinction that affects the health risks from radiation is whether the energy is ionizing or non-ionizing.

Ionizing radiation is high-frequency radiation that has enough energy to remove an electron from (ionize) an atom or molecule. Ionizing radiation has enough energy to damage the DNA in cells, which in turn may lead to cancer. Gamma rays, x-rays, some high-energy UV rays, and some sub-atomic particles such as alpha particles and protons are forms of ionizing radiation.

Non-ionizing radiation is low-frequency radiation that does not have enough energy to remove electrons or directly damage DNA. Low-energy UV rays, visible light, infrared rays, microwaves, and radio waves are all forms of non-ionizing radiation. Aside from UV rays, these types of radiation are not known to increase cancer risk.

It is important to understand the difference between these types of radiation. For example, the non-ionizing radiation given off by a cell phone or a television screen is not the same as the ionizing radiation you might get from x-rays taken in the hospital.

The types of radiation exposures discussed here include:

- Ionizing radiation from sources such as medical and other man-made forms of radiation, and natural background radiation from the earth and sky.
- Ultraviolet (UV) radiation from natural and man-made sources.
- Some sources of non-ionizing radiation, including power lines, cell phones, TV and computer screens, and microwaves.

Ionizing radiation

Ionizing radiation has enough energy to knock electrons off of atoms or molecules. This is called *ionization*. Ionized molecules are unstable and quickly undergo chemical changes.

If ionizing radiation passes through a cell in the body, it can lead to mutations (changes) in the cell's DNA, the part of the cell that contains its genes (blueprints). This could contribute to cancer, or to the death of the cell. The amount of damage in the cell is related to the dose of radiation it receives. The damage takes place in only a fraction of a second, but other changes such as the beginning of cancer may take years to develop.

Types of ionizing radiation include x-rays, gamma rays, some high-energy UV rays, and particles given off by radioactive materials such as alpha particles and protons. These forms of radiation have different energy levels and can penetrate cells to different extents, but all are capable of causing ionization.

Does ionizing radiation cause cancer?

Ionizing radiation is a proven human carcinogen (cancer causing agent). The evidence for this comes from many different sources, including studies of atomic bomb survivors in Japan, people exposed during the Chernobyl nuclear accident, people treated with high doses of radiation for cancer and other conditions, and people exposed to high levels of radiation at work, such as uranium miners.

Most studies on radiation and cancer risk have looked at people exposed to very high doses of radiation in the settings above. It is harder to measure the much smaller increase in cancer risk that might come from much lower levels of radiation exposure. Most studies have not been able to detect an increased risk of cancer among people exposed to low levels of radiation. For example, people living at high altitudes, who are exposed to more natural background radiation from cosmic rays than people living at sea level, do not have noticeably higher cancer rates.

Still, most scientists and regulatory agencies agree that even small doses of ionizing radiation increase cancer risk, although by a very small amount. In general, the risk of cancer from radiation exposure increases as the dose of radiation increases. Likewise, the lower the exposure is, the smaller the increase in risk. But there is no threshold below which ionizing radiation is thought to be totally safe.

Although radiation exposure affects the occurrence of various types of cancer, it does not affect their aggressiveness (tendency to grow and spread).

Types of cancer linked to ionizing radiation

Ionizing radiation increases the risk of certain types of cancer more than others.

The thyroid gland and bone marrow are particularly sensitive to radiation. Leukemia, a type of cancer that arises in the bone marrow, is the most common radiation-induced cancer. Leukemias may appear as early as a few years after radiation exposure.

Other types of cancer can also result from radiation exposure, although they may take longer to develop (usually at least 10 to 15 years). Some of the other cancers most strongly linked to radiation exposure in studies include:

- Lung cancer
- Skin cancer
- Thyroid cancer
- Multiple myeloma
- Breast cancer
- Stomach cancer

These are not necessarily the only cancer types that may be linked to radiation, however.

The types of cancer linked to radiation are also affected by the part of the body that is exposed. For example, people who get pelvic radiation therapy would not be expected to have higher rates of cancers in the head and neck because these areas weren't exposed to radiation.

Other factors may also play a role in how likely a person exposed to radiation is to develop cancer. Age is one such factor - children's growing bodies are more sensitive to radiation than adults. A person may also have gene changes that make their cells more vulnerable to radiation damage, which might in turn raise their risk more than in someone without these gene changes.

Sources of ionizing radiation

People may be exposed to ionizing radiation from 3 main sources:

- **Natural background radiation** comes from cosmic rays from our solar system and radioactive elements normally present in the soil. This is the major contributor to worldwide radiation exposure.

- **Medical radiation** comes in the form of diagnostic x-rays and other tests, as well as from radiation therapy. Radiation therapy is currently used to treat some types of cancer and involves dosages many thousand times higher than those used in diagnostic x-rays.
- **Non-medical, man-made radiation** can come from workplace and other sources, and is also a result of above ground nuclear weapons testing that took place before 1962.

Natural background radiation

We are all exposed to some amount of radiation just from being on this planet. This is known as *background radiation*. For most people, background radiation accounts for most of their exposure to ionizing radiation during the year. It comes from several different sources.

Cosmic rays: Cosmic rays are radioactive particles that hit the earth from outer space. They come from the sun and from other stars. The earth's atmosphere blocks a portion of these rays, but some of them reach the ground. Because the atmosphere blocks some cosmic rays, exposure is greater at higher altitudes. For example, people who live in Denver, Colorado, which is at a high elevation, are exposed to slightly more cosmic rays than people living at sea level. People are also exposed to higher levels of cosmic rays during airplane flights. Airline pilots and flight attendants, who spend many hours at high elevations, are exposed to more of these rays, but it is not clear if they have an increased risk of cancer because of it.

Radiation in the earth: People are also exposed to small amounts of radiation from radioactive elements that occur naturally in rocks and soil. Some of these may end up in building materials used in houses and other structures. Tiny amounts of radiation may even be found in drinking water and in some plant-based foods as a result of being in contact with the soil. For people who smoke, tobacco can account for a significant portion of the yearly radiation they receive.

Radon: The largest source of natural background radiation for most people is radon. This is an odorless, colorless gas that is formed from the breakdown of radioactive elements in the ground. Radon levels are usually higher inside buildings and homes, especially in levels closer to the ground such as basements. Radon levels can vary a great deal, depending on where you live. For more detailed information on radon and its possible health effects, see our document, *Radon*.

Medical radiation

Ionizing radiation is used in the diagnosis and treatment of some medical conditions. This can be in the form of radiation that penetrates from outside the body, or radioactive particles that are swallowed or inserted into the body.

Imaging tests: Certain types of imaging tests, such as x-rays, CT scans, and nuclear medicine tests (such as PET scans and bone scans) expose people to low levels of radiation in order to create internal pictures of the body. (MRI and ultrasound exams do not use ionizing radiation.)

The increased risk of cancer from exposure to any single test is likely to be very small. Still, concerns have been raised in recent years as the average amount of radiation a person is exposed to from medical tests has risen. Children's growing bodies are especially sensitive to radiation.

Because of the very small but real risk, and the fact that radiation exposure from all sources can add up over one's lifetime, imaging tests that use radiation should only be done if there is a good medical reason to do so. The usefulness of the test must always be balanced against the possible risks from exposure to the radiation. In some cases, other imaging tests such as ultrasound or MRI may be an option. But if there is a reason to believe that an x-ray or CT scan is the best way to look for cancer or other diseases, the patient will most likely be helped more than the small dose of radiation can hurt.

For more detailed information on the possible radiation risks from imaging tests, see our document, *Imaging (Radiology) Tests*.

Radiation therapy: Ionizing radiation is an effective way to treat certain kinds of cancer. During radiation therapy, high doses of ionizing radiation (much higher than those used for imaging tests) are directed at the cancer, resulting in the death of the cancer cells. However, this can lead to DNA mutations in other cells that survive the radiation, which may eventually lead to the development of a second cancer.

Overall, radiation therapy alone does not appear to be a very strong cause of second cancers. This is probably due to the fact that doctors try to focus the radiation on the cancer cells as much as possible, which means few normal cells are exposed to radiation. Still, some studies have linked radiation therapy with an increased risk of leukemia, thyroid cancer, early-onset breast cancer, and some other cancers. The amount of increased risk depends on a number of factors, include the dose of radiation, the location in the body, and the age of the person getting it (younger people are generally at greater risk later on).

If cancer does develop after radiation therapy, it does not happen right away. For leukemias, most cases develop within 5 to 9 years after exposure. In contrast, other cancers often take much longer to develop. Most of these cancers are not seen for 10 years after radiation therapy, and some are diagnosed even more than 15 years later.

When considering radiation exposure from radiation therapy treatment, the benefits generally outweigh the risks. However, some combinations of radiation therapy and chemotherapy are more risky than others. Doctors do their best to ensure the treatment that is given destroys the cancer while minimizing the risk that a secondary cancer will develop later on.

For more information, see our document, *Second Cancers Caused by Cancer Treatment*.

Other forms of man-made radiation

People may also be exposed to ionizing radiation from other man-made sources.

Nuclear tests and facilities: The United States government conducted above-ground nuclear tests in the South Pacific and in the state of Nevada between 1945 and 1962. Many people in the military at the time were part of training exercises in the area and were exposed to ionizing radiation from these tests. Others were exposed to radiation while working at facilities making the bombs or at other nuclear sites. More information on this topic is available in our document, *Cancer Among Military Personnel Exposed to Nuclear Weapons*.

Non-military people living near or downwind of nuclear test sites may have also been exposed to radioactive byproducts. Levels of radiation are likely to be higher near these sites, but some radioactive particles from the tests entered the atmosphere and traveled great distances, landing thousands of miles away from the original site. While exposure levels were likely to be higher at the time of testing, some radiation in the soil today is the result of these tests.

People who work in nuclear power plants may be exposed to higher levels of radiation than the general public, although their exposure levels are monitored carefully. Emissions of radiation from nuclear power plants are carefully monitored and controlled. According to the Environmental Protection Agency (EPA), nuclear power plant operations account for less than one-hundredth (1/100) of a percent of the average American's total radiation exposure.

Consumer products: Some consumer products contain small amounts of ionizing radiation.

For example, tobacco products contain low levels of radiation, which may come from the soil it's grown in or the fertilizer used to help it grow. Tobacco may account for a significant portion of the yearly radiation that smokers are exposed to.

Some building materials used in the home or other structures may contain low levels of naturally occurring radiation. This can vary depending on what they're made of, but the levels are unlikely to contribute much to a person's overall exposure to radiation, according to the EPA.

Many smoke detectors contain a small amount of a very low-level radioactive material that helps detect the smoke. This material is sealed in a container and does not pose a significant risk of radiation exposure.

Food irradiation: Ionizing radiation can be used to kill bacteria and other germs on certain foods, which may make them safer to eat and help them last longer. Some people may be concerned that irradiated food may itself contain radiation.

It's important to understand that the radiation does not stay in the food. According to the United States Department of Agriculture (USDA), irradiating food does *not* cause it to become radioactive and does not change nutritional value or flavor of the food.

Airport security scanners: In recent years, some airports have begun to use whole body scanners as a way to detect objects hidden by clothing. These scanners are different from the metal detectors most people are familiar with.

One type of body scanner, based on backscatter technology, uses very weak x-rays aimed at the surface of the body to capture a whole body image. The Transportation Security Administration (TSA) says the radiation from such a scan is about the same amount a person gets from cosmic rays when flying for 2 minutes in an airplane at 30,000 feet. A person would need to get more than 1,000 backscatter scans in a year to reach the same dose they'd get from a standard chest x-ray, according to the American College of Radiology (ACR).

The other type of body scanner is based on millimeter wave technology. Neither millimeter wave scanners nor metal detectors use ionizing radiation.

Ultraviolet (UV) radiation

Ultraviolet rays are invisible rays that come mainly from the sun, although they can also come from man-made sources such as tanning beds and welding torches.

In terms of energy, UV rays straddle the border between ionizing and non-ionizing radiation. They have more energy than visible light, but not as much as x-rays. Ultraviolet rays often have enough energy to damage the DNA in cells, which means they can cause cancer. But because they don't have enough energy to penetrate deeply into the body, their main effect is on the skin.

Most skin cancers are a direct result of exposure to the UV rays in sunlight. Both basal cell and squamous cell cancers (the most common types of skin cancer) tend to be found on sun-exposed parts of the body, and their occurrence is related to lifetime sun exposure. The risk of melanoma, a more serious but less common type of skin cancer, is also related to sun exposure, although perhaps not as strongly.

While UV rays make up only a tiny fraction of the sun's wavelengths, they are mainly responsible for the damaging effects of the sun on the skin.

Scientists often divide UV radiation into 3 wavelength ranges:

- UVA rays are the weakest of the ultraviolet rays. They can cause skin cells to age and can cause some indirect damage to cells' DNA. UVA rays are mainly linked to long-term skin damage such as wrinkles, but are also thought to play a role in some skin cancers.
- UVB rays are slightly stronger. They are mainly responsible for direct damage to the DNA, and are the rays that cause sunburns. They are also thought to cause most skin cancers.
- UVC rays are the strongest UV rays. Fortunately, because of this, they react with ozone high in our atmosphere and do not reach the ground. Therefore UVC rays are not present in sunlight and are not normally a risk factor for skin cancer. But they can be found in some man-made sources, such as arc welding torches and mercury lamps.

For more information on UV radiation and cancer risk, see our document, *Skin Cancer Prevention and Early Detection*.

Non-ionizing radiation

Non-ionizing radiation is low-frequency radiation that does not have enough energy to directly damage DNA.

Common types of non-ionizing radiation include some ultraviolet (UV) rays, visible light, infrared rays, microwaves, and radiofrequency rays (radio waves), and electromagnetic fields. Electrical devices, heaters, and cell phones all emit (send out) non-ionizing radiation.

Concerns have been raised about a possible link between some types of non-ionizing radiation and cancer. The way in which it might do this isn't clear. Non-ionizing radiation doesn't damage DNA directly, but it may be able to affect cells in other ways. The possible links between some of types of non-ionizing radiation and cancer are discussed below. But at this time, non-ionizing radiation has not been established as being able to cause cancer.

Power lines and electrical devices

Electric currents create extremely low-frequency (ELF) electromagnetic fields, which are at the low-energy end of the electromagnetic spectrum. We are all exposed to electromagnetic fields from the earth itself and from man-made sources. Examples of man-made sources include power lines, household wiring, and electrical appliances (when they are on).

The possible link between electromagnetic fields and cancer has been a subject of controversy for several decades. Because we are all exposed to different amounts of these fields at different times, the issue has been difficult to study.

One of the main concerns has been whether ELF affects the risk of childhood cancers such as leukemia and brain tumors. In the studies that have looked at a possible link with childhood leukemia, the results have been mixed. If there is an increased risk it is likely to be small, but a weak link cannot be ruled out entirely. Studies of other childhood cancers have generally not found any strong links to electromagnetic fields.

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

It's not clear exactly how electromagnetic fields, a form of low-energy, non-ionizing radiation, could increase cancer risk. Studies of lab animals have generally not found that magnetic fields increase the risk of cancer. The absence of a link in animal studies makes it less likely that human exposure to electromagnetic fields, at home or at work, affects cancer risk.

The National Institute of Environmental Health Sciences (NIEHS) describes the scientific evidence suggesting that electromagnetic field exposures pose a health risk as "weak". But because a possible increase in cancer risk can't be ruled out completely, the NIEHS has advised that people concerned about EMF exposure may want to consider practical ways to reduce their exposure, such as finding out where their major EMF sources are and limiting the time spent near them. There are more costly actions, such as burying power lines or moving out of a home,

that might also lower EMF exposure. But because scientists aren't sure if EMF poses any health hazards, it's not clear if such actions are warranted, according to the NIEHS.

Television and computer screens

Modern television and computer screens give off several kinds of radiation, most of which is in the extremely low frequency (ELF) range. Concerns have been raised about possible health problems associated with the use of these screens, including cancer and birth defects. The amount of energy given off by these screens is far below government exposure standards, and at this time the available evidence does not support links to either of these health problems. Research in this area continues.

Cell phones and cell phone towers

Cell phones and cell phone towers use radiofrequency and low-level microwave radiation to transmit and receive signals. Neither cell phones nor cell towers have been conclusively linked to increased risks of cancer, but most researchers and government agencies agree that more research on cell phones is needed, especially with regard to long-term use and use among children. For more detailed information, refer to our documents, *Cellular Phones* and *Cellular Phone Towers*.

Radiofrequency radiation (radio waves)

Radiofrequency radiation is emitted from radio and television broadcast transmitters, citizen band radios, and electric heaters. There is little evidence that these exposures affect cancer risk.

Microwaves

Microwaves have energy levels in between radio waves and infrared waves. Like other forms of non-ionizing radiation, they do not have enough energy to directly damage DNA. Microwave radiation is used in microwave ovens and radar equipment. Cell phones may also use some low-energy microwaves.

Microwave ovens

Microwave ovens work by using very high levels of microwaves to heat foods. The microwaves are contained within the oven itself. When microwave ovens are used according to instructions, there is no evidence that they pose a health risk to people. Nor do microwaves make food radioactive.

Exposure to high levels of microwaves can have effects on health. Such exposure could lead to a painful burn or to the development of cataracts in the lenses of the eyes. These injuries are caused only by exposure to large amounts of microwave radiation, however, and the small amount that can leak from a microwave oven does not cause these problems.

Some older models of pacemakers might be affected if the person with the pacemaker gets too close to a microwave oven while it is on. This is unlikely to be a concern with modern pacemakers, which are shielded from outside electrical activity.

Radar

Most forms of radar use waves in the microwave range. Questions have been raised about exposure to radar and the risk of developing cancer, such as in police officers who use radar guns in traffic enforcement. To date there is very little evidence to support such a connection, but studies to look at this possibility are ongoing, and governmental recommendations have been made to reduce any possible risk.

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.

Cancer Among Military Personnel Exposed to Nuclear Weapons

Cellular Phones

Cellular Phone Towers

Guide to Quitting Smoking

Imaging (Radiology) Tests

Known and Probable Human Carcinogens

Radon

Second Cancers Caused by Cancer Treatment

Skin Cancer Prevention and Early Detection

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)
Web site: www.cdc.gov

Environmental Protection Agency (EPA)
Web site: www.epa.gov
Understanding Radiation: www.epa.gov/radiation/understanding-radiation-overview.html

National Cancer Institute (NCI)
Toll-free number: 1-800-422-6237 (1-800-4-CANCER)
Web site: www.cancer.gov
Magnetic Field Exposure and Cancer: www.cancer.gov/cancertopics/factsheet/Risk/magnetic-fields

National Institute of Environmental Health Sciences
Web site: www.niehs.nih.gov
Electric and Magnetic Fields: www.niehs.nih.gov/health/topics/agents/emf/index.cfmww

**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.

References

American College of Radiology. 2010. ACR Statement on Airport Full-body Scanners and Radiation. Accessed at www.acr.org/HomePageCategories/News/ACRNewsCenter/StatementonAirportFullbodyScanners.aspx on February 2, 2010.

Environmental Protection Agency. Radiation Risks and Realities. 2007. Accessed at www.epa.gov/radiation/docs/402-k-07-006.pdf on February 2, 2010.

Environmental Protection Agency. Understanding Radiation: Health Effects. 2009. Accessed at www.epa.gov/radiation/understand/health_effects.html on January 29, 2010.

Food and Drug Administration. Microwave Oven Radiation. 2010. Accessed at www.fda.gov/Radiation-EmittingProducts/ResourcesforYouRadiationEmittingProducts/Consumers/ucm142616.htm on February 5, 2010.

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 February 5, 2010.

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/docs/niehs-report.pdf on February 5, 2010.

National Research Council of the National Academies. *Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2*. 2006. Accessed at www.nap.edu/openbook.php?record_id=11340 on January 27, 2010.

Transportation Security Administration. Imaging Technology. 2010. Accessed at www.tsa.gov/approach/tech/imaging_technology.shtm on February 2, 2010.

United States Department of Agriculture. Irradiation and Food Safety: Answers to Frequently Asked Questions. 2005. Accessed at www.fsis.usda.gov/Fact_Sheets/Irradiation_and_Food_Safety/index.asp on February 2, 2010.

Last Medical Review: 03/29/2010
Last Revised: 03/29/2010

Cancer Information

Programs & Services

- Prostate Cancer Support
- TLC Hair Loss & Mastectomy Products
- Hope Lodge® Lodging
- Rides To Treatment
- Online Support Communities

ACS Events

- Relay For Life
- College Relay For Life
- Cancer Prevention Study (CPS-3)
- Coaches vs. Cancer
- DetermiNation
- Making Strides Against Breast Cancer

About ACS

- About Us
- Contact Us
- Local Offices
- Volunteer
- Employment
- Press Room
- Report Fraud or Abuse

More ACS Sites

- Bookstore
- ACS-CAN
- Choose You
- Gift Shop
- Global Health
- More Birthdays
- Mobile Site

[+]Feedback

Using This Site:

- Help
- Site Map
- Privacy
- Accessibility
- Terms of Use
- State Fundraising Notices


Better Business Bureau


Health On The Net


National Health Council