



[cancer.org](http://cancer.org) | 1.800.227.2345

---

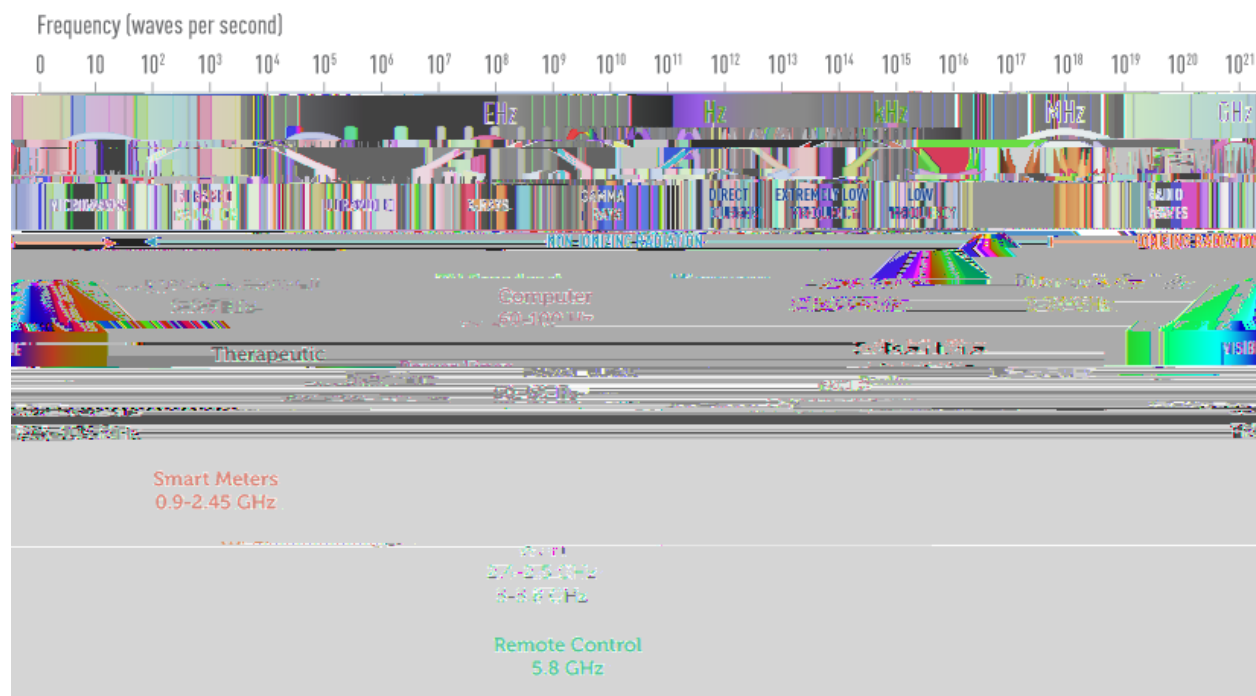
## X-rays, Gamma Rays, and Cancer Risk

There are many types of radiation. But when talking about radiation and cancer risk, it is often x-rays and gamma rays that people are concerned about.

- [What Are X-rays and Gamma Rays?](#)
  - [How Are People Exposed to X-rays and Gamma Rays?](#)
  - [Do X-rays and Gamma Rays Cause Cancer?](#)
  - [Do X-rays and Gamma Rays Cause Health Problems Other than Cancer?](#)
  - [Can I Avoid or Limit My Exposure to X-rays and Gamma Rays?](#)
- 

## What Are X-rays and Gamma Rays?

# ELECTROMAGNETIC SPECTRUM



X-rays and gamma rays can come from natural sources, such as [radon gas](#)<sup>1</sup>, radioactive elements in the earth, and cosmic rays that hit the earth from outer space.

## Doses of radiation

Radiation exposure dose can be expressed in different ways.

- The **absorbed dose** is the amount of energy deposited per unit of mass. Most often this is measured in grays (Gy). A milligray (mGy), which is 1/1000th of a Gy, may also be used.
- The **equivalent dose** is the absorbed dose multiplied by a converting factor based on the medical effects of the type of radiation. It is often expressed in sieverts (Sv) or millisieverts (mSv), which is 1/1000th of a Sv.

For x-rays and gamma rays (and beta particles), the equivalent dose in Sv is the same as the absorbed dose in Gy.

Less common radiation dose units include rads, rems, and roentgens.

## Hyperlinks

1. [www.cancer.org/cancer/risk-prevention/radiation-exposure/radon.html](http://www.cancer.org/cancer/risk-prevention/radiation-exposure/radon.html)
2. [www.cancer.org/cancer/risk-prevention/sun-and-uv/uv-radiation.html](http://www.cancer.org/cancer/risk-prevention/sun-and-uv/uv-radiation.html)

## References

National Toxicology Program. Ionizing radiation: x-radiation and gamma radiation. *Rep Carcinog*. 2011;12:237-240.

Last Revised: November 10, 2022

---

# How Are People Exposed to X-rays and Gamma Rays?

- [Natural background radiation](#)
- [Medical radiation](#)
- [Non-medical sources of man-made radiation](#)

People can be exposed to x-rays and gamma rays from 3 main sources:

- **Natural background radiation** from cosmic rays from outer space and from radioactive elements normally in rocks and soil. This is the major contributor to worldwide radiation exposure.
- **Medical radiation** used for imaging tests such as x-rays, CT scans, and PET scans, as well as for radiation therapy. Radiation therapy is used to treat some types of cancer, and it generally uses doses much higher than those used in imaging tests.
- **Non-medical, man-made radiation** exposure can happen in certain workplaces, or in communities as a result of above ground nuclear weapons testing or nuclear accidents. Radiation is also used in small amounts in some consumer products, as well as in food irradiation.

## Natural background radiation

We are all exposed to some amount of radiation just from being on this planet. This is known as **background radiation**. In the United States this averages about 3 millisieverts (mSv) per year. For most people, background radiation is most of their exposure to ionizing radiation during the year. It comes from several 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](#)<sup>1</sup> 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. Some people, such as people who work in mines, are exposed to higher radon levels at work.

For more on radon and its possible health effects, see [Radon and Cancer](#)<sup>20.6y8 0 g 0 0.28 0 g 0 0l (clTm 0 0 0 rg /G</sup>

depending on how long it is used. The amount of radiation used in many imaging tests has gone down over time as technology has improved.

**In children:** Exposure levels for a child can be higher than they would be for an adult when using the same amount of radiation, so the settings on the scanner need to be adjusted to account for body size.

For children, exposure to radiation from imaging tests is of particular concern, because:

- Children (especially younger children) are much more sensitive to radiation than adults.
- Children are expected to live longer than adults, so they have more time to develop problems from radiation exposure.
- With tests like CT scans, children might get a higher radiation dose than necessary if the CT scanner settings are not adjusted for their smaller body size.

These factors mean that for a young child, the risk of developing a radiation-related cancer could be several times higher than for an adult exposed to the same imaging test.

The risks from these tests aren't known for sure, but to be safe, most doctors recommend that children only get these tests when they're absolutely needed, and that when such tests are done, they use only the minimum amount of radiation needed to get the image.

To learn more, see [Understanding Radiation Risk from Imaging Tests](#)<sup>4</sup>.

## **Radiation therapy**

X-rays, gamma rays, and other forms of ionizing radiation are an effective way to treat some types of cancer. During [radiation therapy](#)<sup>5</sup>, 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 sometimes lead to DNA changes (mutations) in other cells that survive the radiation, which may eventually lead to the development of a second cancer. Radiation therapy is also sometimes used to treat serious medical conditions besides cancer.

For more information about cancer risks from radiation therapy for cancer, see [Second Cancers Related to Treatment](#)<sup>6</sup>.



millions of people living in the area to radiation, either directly or from radioactive elements released into the air that ended up deposited on the ground. The emergency clean-up workers were exposed to the highest levels of radiation.

In 2011, an earthquake and tsunami struck the coast of Japan that resulted in damage to the Fukushima Daiichi Nuclear Power Plant in Fukushima Prefecture, Japan. Radiation was released into the air, contaminating soil, food, and water (both fresh and seawater). An area of more than 300 square miles around the plant was found to be contaminated with radiation, although at lower levels than within the plant. Because of high radiation levels, many areas were evacuated. The health effects of this disaster are still being studied.

### **Workplace exposures**

Some people can be exposed to radiation at work. For example:

- 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.
- People who work in uranium mines are monitored because of their exposure to radiation in the form of radon.
- People who work in health or dental care, particularly those who work with x-ray (or other imaging test) equipment or who work with radioactive isotopes, may also be exposed to radiation at work. Radiation exposure may also occur at some research labs.

In the United States, people who are likely to be exposed to radiation in the workplace are monitored carefully. Exposure is limited to an effective dose of 100 mSv over 5 years, with a maximum of 50 mSv in any single year.

### **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 exposure for people who smoke.

Some **building materials** used in the home or other structures may contain low levels of naturally occurring radiation, which can be given off in the form of radon gas. The



amount of radiation 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. To learn more, see [Radon and Cancer](#)<sup>7</sup>.

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 US Food and Drug Administration (FDA), irradiating food does **not** make it radioactive and does **not** change its nutritional value, nor does it noticeably change the taste, texture, or appearance of the food.

## Hyperlinks

1. [www.cancer.org/cancer/risk-prevention/tobacco.html](http://www.cancer.org/cancer/risk-prevention/tobacco.html)
2. [www.cancer.org/cancer/risk-prevention/radiation-exposure/radon.html](http://www.cancer.org/cancer/risk-prevention/radiation-exposure/radon.html)
3. [www.cancer.org/cancer/diagnosis-staging/tests/imaging-tests/imaging-radiology-tests-for-cancer.html](http://www.cancer.org/cancer/diagnosis-staging/tests/imaging-tests/imaging-radiology-tests-for-cancer.html)
4. [www.cancer.org/cancer/diagnosis-staging/tests/imaging-tests/understanding-radiation-risk-from-imaging-tests.html](http://www.cancer.org/cancer/diagnosis-staging/tests/imaging-tests/understanding-radiation-risk-from-imaging-tests.html)
5. [www.cancer.org/cancer/managing-cancer/treatment-types/radiation/basics.html](http://www.cancer.org/cancer/managing-cancer/treatment-types/radiation/basics.html)
6. [www.cancer.org/cancer/survivorship/long-term-health-concerns/second-cancers-in-adults/treatment-risks.html](http://www.cancer.org/cancer/survivorship/long-term-health-concerns/second-cancers-in-adults/treatment-risks.html)
7. [www.cancer.org/cancer/risk-prevention/radiation-exposure/radon.html](http://www.cancer.org/cancer/risk-prevention/radiation-exposure/radon.html)

## References

American College of Radiology/Radiological Society of North America. Radiation Dose. 2021. Accessed at <https://www.radiologyinfo.org/en/info/safety-xray> on November 4, 2022

Brenner DJ, Hall EJ. Computed tomography--an increasing source of radiation exposure. *N Engl J Med*. 2007;357:2277-2284.

Cardis E, Howe G, Ron E, et al. Cancer consequences of the Chernobyl accident: 20 years on. *J Radiol Prot*. 2006;26:127-140.

National Toxicology Program. Ionizing radiation: x-radiation and gamma radiation. *Rep Carcinog*. 2011;12:237-240.

National Cancer Institute. Radiation Risks and Pediatric Computed Tomography (CT): A Guide for Health Care Providers. 2018. Accessed at <https://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/pediatric-ct-scans> on November 3, 2022.

Ozasa K, Shimizu Y, Sakata R, et al. Risk of cancer and non-cancer diseases in the atomic bomb survivors. *Radiat Prot Dosimetry*. 2011;146:272-275.

US Food and Drug Administration. Food Irradiation: What You Need to Know. 2022. Accessed at <https://www.fda.gov/food/buy-store-serve-safe-food/food-irradiation-what-you-need-know> on November 3, 2022.

Zablotska LB, Bazyka D, Lubin JH, et al. Radiation and the risk of chronic lymphocytic and other leukemias among Chernobyl cleanup workers. *Environ Health Perspect*. 2013 Jan;121(1):59-65. Epub 2012 Oct 24.

Last Revised: November 10, 2022

---

## Do X-rays and Gamma Rays Cause Cancer?

X-rays and gamma rays are known human **carcinogens** (cancer-causing agents). The evidence they can cause cancer 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 high doses of

- [What do studies show?](#)
- [What do expert agencies say?](#)

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 x-rays or gamma rays. For example, people living at high altitudes, who are exposed to more [natural background radiation](#)

For most of these cancers, the risk was found to be highest for those exposed as children, and was lower as the age at exposure increased. Those exposed while still in the womb (in utero) had lower risks than those exposed during childhood.

Exposure to higher doses of radiation exposure was linked to higher risk of cancer, but even low amounts of radiation were linked to an increased risk of getting and dying from cancer. There was no clear cut-off for a safe level of radiation exposure.

These cancers took years to develop, but some cancers appeared sooner than others. Deaths from leukemia started to go up about 2 to 3 years after exposure, with the number of cases peaking after about 10 years and going down after that. Solid tumors took longer to develop. For example, excess deaths from lung cancer began to be seen about 20 years after exposure.

### **Chernobyl accident**

Children and teens living near the Chernobyl plant at the time of the accident had an increased risk of thyroid cancer linked to exposure to radioactive iodine. This increased risk was not seen in adults living in the area.

Workers in cleanup operations from 1986 to 1990 had an increased risk of leukemia (all types). These people had higher and more prolonged radiation exposures than the people living near the plant.

### **Nuclear weapons testing**

Studies suggest that some people who were children when above-ground nuclear testing was being done in the US may develop thyroid cancer as a result of exposure to radioactive iodine in milk.

### **Radiation therapy**

#### ***To treat benign conditions***

Radiation therapy is now used mainly to treat cancer. But in the past, before the risks of radiation were clearer, it was also used to treat some benign (non-cancerous) diseases. Studies of people treated for these conditions have helped us learn about how radiation affects cancer risk.

For example, some studies have suggested links between:

- The use of radiation to treat **peptic ulcer disease** and a higher risk of cancers of the stomach and pancreas.
- The use of radiation to treat **ringworm of the scalp** (a fungal infection, also called tinea capitis) and an increased risk of basal cell skin cancers.
- The injection of radium to treat **ankylosing spondylitis** (an autoimmune disease) and an increased risk of leukemia, bone sarcoma, and possibly some other cancers.
- The use of radiation to treat some benign **head and neck conditions** and a higher risk of cancers of the salivary gland, brain and spinal cord tumors, and thyroid cancer.

### ***To treat cancer***

Studies have linked [radiation therapy to treat cancer](#)<sup>1</sup> with an increased risk of leukemia, thyroid cancer, early-onset breast cancer, and some other cancers later in life. The increase in risk depends on a number of factors, including:

- The dose of radiation
- The part of the body being treated
- The person's age (younger people are generally at greater risk)
- The use of other treatments such as chemotherapy at or around the same time

Other factors might also play a role in how likely it is that a person exposed to radiation will develop cancer. For example, some genetic conditions can make a person's cells more vulnerable to radiation damage, which might in turn raise their risk more than in someone without these gene changes.

### ***Cancers after radiation therapy don't happen right away***

If cancer does develop after radiation therapy, it doesn't happen right away. Most leukemias develop within about 5 to 9 years after exposure. In contrast, most other cancers are not seen for at least 10 years after radiation therapy, and some are diagnosed more than 15 years later.

When considering getting radiation therapy to treat cancer, the benefits generally outweigh the risks. Overall, radiation therapy alone does not appear to be a very strong cause of second cancers. This is probably because doctors focus the radiation on the cancer cells as much as possible, while limiting the exposure of nearby normal cells.



breast cancer years later.

- Teens and young women who had many **x-rays of the spine** to monitor scoliosis have been found to have an increased risk of breast cancer later on.
- People with meningioma (a brain tumor that is most often benign) have been found to be more likely to have had certain types of **dental x-rays** every year.
- Some studies have suggested a link between higher doses of radiation from **CT scans** in children to increased risks of leukemia and brain tumors, although the overall risk was still low.

## What do expert agencies say?

Several national and international agencies study different exposures in the environment to determine if they can cause cancer. (An exposure 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 the available evidence.**

Based on studies done on people and studies done in the lab, several expert agencies have evaluated the cancer-causing nature of x-rays and gamma rays.

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. Based on the data available, IARC classifies x- and gamma radiation as a “known human carcinogen.”

The **qal8.77 Tm 0 3eb621.08 rgwdf the World Cfh /GS5ro identify causes of cancer. Based o12 T**





study. *Lancet*. 2012;380:499-505.

Ron E. Cancer risks from medical radiation. *Health Phys*. 2003;85:47-59.

Claus EB, Calvocoressi L, Bondy ML, et al. Dental x-rays and risk of meningioma. *Cancer*. 2012 Sep 15;118(18):4530-7. Epub 2012 Apr 10.

Last Revised: November 10, 2022

## Do X-rays and Gamma Rays Cause Health Problems Other than Cancer?

X-rays and gamma rays can cause a number of other problems besides cancer. What problems occur depends on factors such as the radiation dose, the timing of the exposure, and what areas of the body are exposed.

Exposure to high doses of radiation over a short period of time can cause **radiation sickness** (sometimes called **radiation poisoning** or **acuteradiation syndrome**) and even death. Some of the symptoms of radiation sickness include fainting, confusion, nausea and vomiting, diarrhea, hair loss, skin and mouth sores, and bleeding. The atomic bomb blasts in Hiroshima and Nagasaki led to many cases of radiation sickness. Some cases have also resulted from nuclear power plant accidents, such as the one in Chernobyl.

Doses of radiation such as those given in radiation therapy also cause side effects.

**Short-term side effects** depend on the area being treated but might include skin changes (ranging from mild reddening to something like a severe burn), nausea, vomiting, diarrhea, and low blood cell counts.

There is also a risk of **long-term side effects**, which again vary depending on the area being treated. For example:

- Radiation to the head and neck area can lead to problems with dry mouth and trouble swallowing.
- Radiation can weaken bones, making them more likely to break later on.
- Radiation to the bone marrow (where new blood cells are made) can lead to long-

- term problems with blood cell counts and even a disease called **aplastic anemia**.
- Radiation to the pelvic area might lead to infertility (problems getting pregnant or fathering children).

Lower doses of radiation, such as from [imaging tests](#)<sup>1</sup>, are not known to cause short-term health problems.

## Hyperlinks

1. [www.cancer.org/cancer/diagnosis-staging/tests/imaging-tests/imaging-radiology-tests-for-cancer.html](http://www.cancer.org/cancer/diagnosis-staging/tests/imaging-tests/imaging-radiology-tests-for-cancer.html)

## References

Environmental Protection Agency. Radiation Health Effects. 2022. Accessed at <https://www.epa.gov/radiation/radiation-health-effects> on November 4, 2022.

National Research Council of the National Academies. *Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2*. 2006. Accessed at <https://nap.nationalacademies.org/read/11340/chapter/1> on November 4, 2022.

Last Revised: November 10, 2022

---

# Can I Avoid or Limit My Exposure to X-rays and Gamma Rays?

We are all [exposed to some amount of radiation](#) just from being on this planet. You can, however, limit your exposure to some sources of radiation, such as x-rays from imaging tests, radiation in the workplace, and radon in your home.

- [Radiation from imaging tests](#)

- [Radiation in the workplace](#)
- [Radon](#)

We are all [exposed to some amount of radiation](#) just from being on this planet. You can, however, limit your exposure to some sources of radiation, such as x-rays from imaging tests, radiation in the workplace, and radon in your home.

## **Radiation from imaging tests**

The increased risk of cancer from exposure to any single [imaging test](#)<sup>1</sup> is likely to be very small. But radiation exposure from all sources can add up over one's lifetime, so 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.

Sometimes, other imaging tests that don't use radiation such as ultrasound or MRIe possible risks

exposure, including the Occupational Safety and Health Administration (OSHA), the Nuclear Regulatory Commission, and the Department of Energy. Each agency is responsible for a different set of workplaces, but all follow the same general principles. Ifre21meof whi

**Written by**

The American Cancer Society medical and editorial content team  
(<https://www.cancer.org/cancer/acs-medical-content-and-news-staff.html>)

Our team is made up of doctors and oncology certified nurses with deep knowledge of cancer care as well as editors and translators with extensive experience in medical writing.

American Cancer Society medical information is copyrighted material. For reprint requests, please see our Content Usage Policy ([www.cancer.org/about-us/policies/content-usage.html](http://www.cancer.org/about-us/policies/content-usage.html)).

**cancer.org | 1.800.227.2345**