Media centre

Ionizing radiation, health effects and protective measures

Fact sheet

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Key facts

- Ionizing radiation is a type of energy released by atoms in the form of electromagnetic waves or particles.
- People are exposed to natural sources of ionizing radiation, such as in soil, water, and vegetation, as well as in human-made sources, such as x-rays and medical devices.
- Ionizing radiation has many beneficial applications, including uses in medicine, industry, agriculture and research.
- As the use of ionizing radiation increases, so does the potential for health hazards if not properly used or contained.
- Acute health effects such as skin burns or acute radiation syndrome can occur when doses of radiation exceed certain levels.
- Low doses of ionizing radiation can increase the risk of longer term effects such as cancer.

What is ionizing radiation?

Ionizing radiation is a type of energy released by atoms that travels in the form of electromagnetic waves (gamma or X-rays) or particles (neutrons, beta or alpha). The spontaneous disintegration of atoms is called radioactivity, and the excess energy emitted is a form of ionizing radiation. Unstable elements which disintegrate and emit ionizing radiation are called radionuclides.

All radionuclides are uniquely identified by the type of radiation they emit, the energy of the radiation, and their half-life.

The activity — used as a measure of the amount of a radionuclide present — is expressed in a unit called the becquerel (Bq): one becquerel is one disintegration per second. The half-life is the time required for the activity of a radionuclide to decrease by decay to half of its initial value. The half-life of a radioactive element is the time that it takes for one half of its atoms to disintegrate. This can range from a mere fraction of a second to millions of years (e.g. iodine-131 has a half-life of 8 days while carbon-14 has a half-life of 5730 years).

Radiation sources

People are exposed to natural radiation sources as well as human-made sources on a daily basis. Natural radiation comes from many sources including more than 60 naturally-occurring radioactive materials found in soil, water and air. Radon, a naturally-occurring gas, emanates from rock and soil and is the main source of natural radiation. Every day, people inhale and ingest radionuclides from air, food and water.

People are also exposed to natural radiation from cosmic rays, particularly at high altitude. On average, 80% of the annual dose of background radiation that a person receives is due to naturally occurring terrestrial and cosmic radiation sources. Background radiation levels vary geographically due to geological differences. Exposure in certain areas can be more than 200 times higher than the global average.

Human exposure to radiation also comes from human-made sources ranging from nuclear power generation to medical uses of radiation for diagnosis or treatment. Today, the most common human-made sources of ionizing radiation are medical devices, including X-ray machines.

Exposure to ionizing radiation

Radiation exposure may be internal or external, and can be acquired through various exposure pathways.

Internal exposure to ionizing radiation occurs when a radionuclide is inhaled, ingested or otherwise enters into the bloodstream (for example, by injection or through wounds). Internal exposure stops when the radionuclide is eliminated from the body, either spontaneously (such as through excreta) or as a result of a treatment.

External exposure may occur when airborne radioactive material (such as dust, liquid, or aerosols) is deposited on skin or clothes. This type of radioactive material can often be removed from the body by simply washing.

Exposure to ionizing radiation can also result from irradiation from an external source, such as medical radiation exposure from X-rays. External irradiation stops when the radiation source is shielded or when the person moves outside the radiation field.

People can be exposed to ionizing radiation under different circumstances, at home or in public places (public exposures), at their workplaces (occupational exposures), or in a medical setting (as are patients, caregivers, and volunteers).

Exposure to ionizing radiation can be classified into 3 exposure situations. The first, planned exposure situations, result from the deliberate introduction and operation of radiation sources with specific purposes, as is the case with the medical use of radiation for diagnosis or treatment of patients, or the use of radiation in industry or research. The second type of situation, existing exposures, is where exposure to radiation already exists, and a decision on control must be taken – for example, exposure to radon in homes or workplaces or exposure to natural background radiation from the environment. The last type, emergency exposure situations, result from unexpected events requiring prompt response such as nuclear accidents or malicious acts.

Medical use of radiation accounts for 98 % of the population dose contribution from all artificial sources, and represents 20% of the total population exposure. Annually worldwide, more than 3600 million diagnostic radiology examinations are performed, 37 million nuclear medicine procedures are carried out, and 7.5 million radiotherapy treatments are given.

Health effects of ionizing radiation

Radiation damage to tissue and/or organs depends on the dose of radiation received, or the absorbed dose which is expressed in a unit called the gray (Gy). The potential damage from an absorbed dose depends on the type of radiation and the sensitivity of different tissues and organs.

> The *effective dose* is used to measure ionizing radiation in terms of the potential for causing harm. The sievert (Sv) is the unit of effective dose that takes into account the type of radiation and sensitivity of tissues and organs. It is a way to measure ionizing radiation in terms of the potential for causing harm. The Sv takes into account the type of radiation and sensitivity of tissues and organs.
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> The Sv is a very large unit so it is more practical to use smaller units such as millisieverts (mSv) or microsieverts (μSv). There are one thousand μSv in one mSv, and one thousand mSv in one Sv. In addition to the amount of radiation (dose), it is often useful to express the rate at which this dose is delivered (dose rate), such as microsieverts per hour (μSv/hour) or millisievert per year (mSv/year).

Beyond certain thresholds, radiation can impair the functioning of tissues and/or organs and can produce acute effects such as skin redness, hair loss, radiation burns, or acute radiation syndrome. These effects are more severe at higher doses and higher dose rates. For instance, the dose threshold for acute radiation syndrome is about 1 Sv (1000 mSv).

If the radiation dose is low and/or it is delivered over a long period of time (low dose rate), the risk is substantially lower because there is a greater likelihood of repairing the damage. There is still a risk of long-term effects such as cancer, however, that may appear years or even decades later. Effects of this type will not always occur, but their likelihood is proportional to the radiation dose. This risk is higher for children and adolescents, as they are significantly more sensitive to radiation exposure than adults.

Epidemiological studies on populations exposed to radiation, such as atomic bomb survivors or radiotherapy patients, showed a significant increase of cancer risk at doses above 100 mSv. More recently, some epidemiological studies in individuals exposed to medical exposures during childhood (paediatric CT) suggested that cancer risk may increase even at lower doses (between 50-100 mSv).

Prenatal exposure to ionizing radiation may induce brain damage in foetuses following an acute dose exceeding 100 mSv between weeks 8-15 of pregnancy and 200 mSv between weeks 16-25 of pregnancy. Before week 8 or after week 25 of pregnancy human studies have not shown radiation risk to fetal brain development. Epidemiological studies indicate that the cancer risk after fetal exposure to radiation is similar to the risk after exposure in early childhood.

WHO response

WHO has established a radiation program to protect patients, workers, and the public against the health risks of radiation exposure under planned, existing and emergency exposure situations. Focusing on public health aspects of radiation protection, this programme covers activities related to radiation risk assessment, management and communication.

In line with its core function on "setting norms and standards and promoting and monitoring their implementation", WHO has cooperated with 7 other international organizations for the revision and update of the international radiation basic safety standards (BSS). WHO has adopted the new international BSS in 2012, and is currently working to support the implementation of the BSS in its Member States.

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Publications

WHO Publications on ionizing radiation