Cancer Association of South Africa (CANSA)

CANSA Fact Sheet
on
Radiation and Radiation Therapy

Introduction

Energy emitted from a source is generally referred to as radiation. Examples include heat or light from the sun, microwaves from a microwave oven, X-rays from an X-ray tube and gamma rays from radioactive elements.

Ionizing radiation is radiation with enough energy so that during an interaction with an atom, it can remove tightly bound electrons from the orbit of an atom, causing the atom to become charged or ionized.

[Picture Credit: Ionizing Radiation]

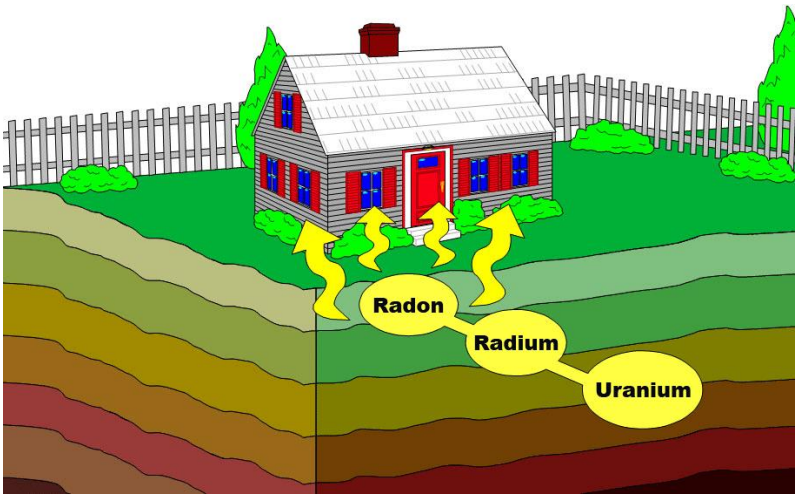
Sources of Radiation

Radiation is, and always has been, around. Natural, 'background' radiation has been with mankind since the birth of the universe. Today modern medical procedures utilise various types of radiation to save lives and heal patients.

Natural Radiation Sources

Radon - one cannot see it, smell it, or taste it, but radon is the leading source of natural radiation exposure and the second leading cause of lung cancer.

[Picture Credit: Radon]



Where does it come from? Usually from soil, but it is found everywhere. The ground that we all walk on and build our homes

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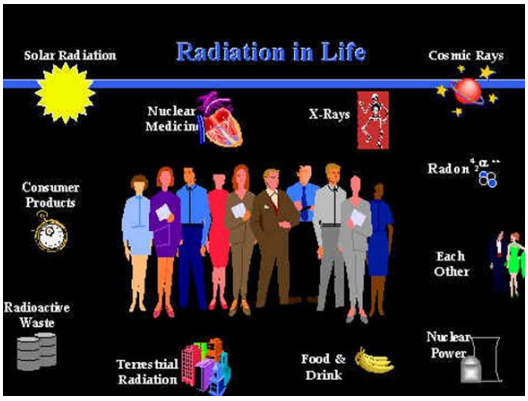
upon contains varying levels of naturally occurring radioactive elements that decay into radon gas, which can seep into homes and become a health concern.

Cosmic (space) radiation - outer space is full of various types of radiation, such as heavily charged particles and gamma rays. Fortunately, Earth has an atmosphere that helps absorb and filter it out, which protects earth's inhabitants from high doses of cosmic radiation. However, some radiation is able to make it through the atmosphere. The dose of cosmic radiation that one receives varies depending on the altitude of the area in which one lives. Since air is thinner at higher elevations, less cosmic radiation is filtered out than it is at lower altitudes with thicker air.



[Picture Credit: Radiation]

Other natural radiation sources - other natural sources, such as radiation naturally present in the bodies of humans and radiation from elements in the ground are also present.

The exposure of human beings to ionizing radiation from natural sources is a continuing and inescapable feature of life on earth. For most individuals, this exposure exceeds that from all man-made sources combined. There are two main contributors to natural radiation exposures: high-energy cosmic ray particles incident on the earth's atmosphere and radioactive nuclides that originated in the earth's crust and are present everywhere in the environment, including the human body itself. Both external and internal exposures to humans arise from these sources.

Man-made Radiation Exposure

Medical radiation exposure - the National Council on Radiation Protection and Measurement (NCRP) published a study in 2009 that found that nearly half of the radiation to which Western populations are exposed comes from medical sources such as CT scans, X-rays, and nuclear medicine. While individual exposure from medical sources varies considerably depending on the number and types of procedures that one undergoes, the NCRP has indicated that medical radiation exposure is much more common now than ever before.

[Picture Credit: X-Rays]

Other Man made Sources of Radiation Exposure - while the primary source of man-made radiation exposure comes from medical sources, there are various other sources that exposes mankind to small amounts of radiation.

Man-made Radiation

Although all living things are exposed to natural background radiation, exposure to man-made radiation sources differs for the following groups:

- Members of the public
- Occupationally exposed individuals (workers)

[Picture Credit: Television]

Members of the Public

In general, the following man-made sources expose the public to radiation:

Medical Sources (by far, the most significant man-made source)

- Diagnostic X-rays
- Nuclear medicine procedures (iodine-131, cesium-137, and others)

Consumer Products

- Building and road construction materials
- Combustible fuels including gas and coal
- X-ray security systems
- Television sets
- Fluorescent lamp starters
- Smoke detectors (americium)
- Luminous watches (tritium)
- Lantern mantles (thorium)
- Tobacco (polonium-210)
- Ophthalmic glass used in eyeglasses
- Some ceramics

To a lesser degree, the public is also exposed to radiation from the nuclear fuel cycle, from uranium mining and milling to disposal of used (spent) fuel. In addition, the public receives some minimal exposure from the transportation of radioactive materials and fallout from nuclear weapons testing and reactor accidents (such as Chernobyl).

Occupationally Exposed Individuals

In general, occupationally exposed individuals work in the following areas:

- Fuel cycle facilities
- Industrial radiography
- Radiology departments (medical)
- Nuclear medicine departments
- Radiation oncology departments
- Nuclear power plants
- Government and university research laboratories

Such individuals are exposed to varying amounts of radiation, depending on their specific jobs and the sources with which they work (including cobalt-60, cesium-137, americium-241, and other isotopes).

Medical Radiation

Hospitals, doctors, and dentists use a variety of nuclear materials and procedures to diagnose, monitor, and treat a wide assortment of metabolic processes and medical conditions in humans. It is estimated that diagnostic X-rays or radiation therapy have been administered to about 7 out of every 10 individuals. As a result, medical procedures using radiation have saved thousands of lives through the detection and treatment of conditions ranging from hyperthyroidism to bone cancer.

The most common of these medical procedures involve the use of X-rays - a type of radiation that can pass through human skin and deeper tissue. When X-rayed, bones and other structures cast shadows because it is denser than the skin, and those shadows can be detected on photographic film

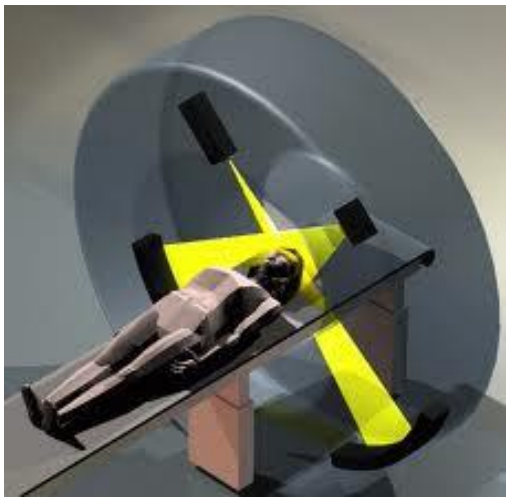
X-ray machines have also been connected to computers in machines called computerised axial tomography (CAT) or computed tomography (CT) scanners. These instruments provide doctors with colour images that show the shapes and details of internal organs. This helps physicians locate and identify tumours, size anomalies or other physiological or functional organ problems.

In addition, hospitals and radiology centres administer slightly radioactive substances to patients, which are attracted to certain internal organs such as the pancreas, kidney, thyroid, liver or brain, to diagnose clinical conditions.

Radiation therapy, radiation oncology, or radiotherapy, sometimes abbreviated to XRT or DXT, is the medical use of ionizing radiation, generally as part of cancer treatment to control or kill malignant (cancerous) cells.

[Picture Credit: Radiation Therapy]

Radiation therapy may be curative in a number of types of cancer if it is localised to one area of the body. It may also be used as part of adjuvant therapy, to prevent tumour recurrence after surgery to remove a primary malignant tumour. Radiation therapy is synergistic with chemotherapy, and is often used before, during, and after chemotherapy in susceptible cancers.



Measuring Radiation Exposure

When scientists measure radiation, they use different terms depending on whether they are discussing radiation coming from a radioactive source, the radiation dose absorbed by a person, or the risk that a person will suffer health effects (biological risk) from exposure to radiation. This fact sheet explains some of the terminology used to discuss radiation measurement.

Units of Measure

Most scientists in the international community measure radiation using the *System Internationale* (SI), a uniform system of weights and measures that evolved from the metric system. Different units of measure are used depending on what aspect of radiation is being measured. The amount of radiation being given off, or emitted, by a radioactive material is measured using the conventional unit **curie** (Ci), named for the famed scientist Marie Curie or the SI unit **becquerel** (Bq). The radiation dose absorbed by a person (that is, the amount of energy deposited in human tissue by radiation) is measured using the conventional unit **rad** or the SI unit **gray** (Gy). The biological risk of exposure to radiation is measured using the conventional unit **rem** or the SI unit **sievert** (Sv).

Detecting Radiation

Ionizing radiation is not detectable by one's senses. It cannot be seen, heard, smelled, tasted, or felt. For these reasons, simple visual inspection is insufficient to identify radioactive materials, and radiation sources can be virtually impossible to recognise without special markings.

To address these problems, scientists have developed the following major types of instruments to detect and identify radioactive materials and ionizing radiation:

- Personal Radiation Detector (PRD)
- Handheld Survey Meter
- Radiation Isotope Identification Device (RIID)
- Radiation Portal Monitor (RPM)
- Personal Dosimeter

World Health Organization - Key Facts of Ionizing Radiation

- 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, vegetation, and 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.

Radiation Therapy

Radiation therapy treats cancer by using high energy to kill tumour cells. The goal is to kill or damage cancer cells without hurting healthy cells.

Radiotherapy destroys cancer cells in the area of the body it is aimed at, but the treatment also affects some of the normal cells nearby. Radiotherapy affects people in different ways, so it is difficult to predict exactly how a particular patient will react. Some people have only mild side effects but for others the side effects may be more severe.

The main side effects of radiotherapy treatment include tiredness and weakness, sore skin, and loss of hair in the treatment area.

Tiredness and weakness - most people feel tired while they are having radiotherapy, particularly if they are having treatment over several weeks. This is because the body is repairing the damage to healthy cells. Tiredness can also be due to low levels of red blood cells (anaemia). One may also feel weak and as though one does not have the energy to do one's normal daily activities. This may last for a few weeks after the treatment ends.

Sore skin - some people get sore skin in the area being treated. The skin may look reddened or darker than usual. It may also get dry and itchy. The staff in the radiotherapy department can advise on the best way of coping with this.

Loss of hair - radiotherapy makes the hair fall out in the treatment area. Hair in other parts of the body is not affected. The hair should begin to grow back again a few weeks after the treatment ends.

Possible long term side effects - for many people the side effects of radiotherapy wear off within a few weeks of the treatment ending and they can go back to a normal life. But for some people radiotherapy can cause long term side effects. The possibility of long term side effects can depend on the type of cancer and its size and position. It may also depend on how close the cancer is to nerves or other important organs or tissues.

It is important to ask one's doctor, specialist nurse or radiographer about the possibility of long term side effects. Depending on the position of the cancer the possible long term effects may include:

- A change in skin colour in the treatment area
- A dry mouth
- Dental caries

- Breathing problems
- Loss of ability to become pregnant or father a child (infertility)
- Low sex drive
- Erection problems (impotence)
- Long term soreness and pain
- Bowel changes
- Bladder inflammation

Radiation therapy can change the amount and consistency of one's saliva. This increases one's risk of tooth decay and gum disease. Having good oral hygiene is important in lowering the risk of these conditions. A **dentist** may also recommend special fluoride treatments during and after radiation therapy to reduce the risk of any dental and gum problems.

Goals of Radiation Therapy
There are several different possible goals of radiation treatment:
Curative - for curative purposes, treatment is usually prolonged. Reactions to the radiation range from mild to severe.

Relief from Symptoms - this treatment seeks to relieve symptoms of the cancer and to prolong survival, making life more comfortable. This type of treatment is not necessarily done with the intent of curing the patient. Frequently this type of treatment is done to prevent or eliminate pain caused by cancer that has metastasized to bones.

Radiation instead of surgery - radiation in place of surgery is effective against a limited number of cancers. The treatment is most effective if the cancers are caught early while still small and non-metastatic. Radiation may be used instead of surgery if the location of the cancer makes surgery difficult or impossible to perform without severe risks to the patient. Surgery is the preferred treatment for lesions that are located in an area where radiation treatment might cause more damage than the surgery. The time that it takes for the two treatments is also very different. Surgery can be performed quickly after a diagnosis; radiation treatment may take weeks to be fully effective.

There are pros and cons for both procedures. Radiation therapy can be used to preserve organs and/or to avoid surgery and its risks. Radiation destroys rapidly dividing cells within the tumour, while surgical procedures may miss some of the outer cells. However, large tumour masses often contain oxygen-poor cells in the centre that do not divide as rapidly as the cells near the surface of the tumour. Because these cells are not rapidly dividing, they are not as sensitive to radiation therapy. For this reason, larger tumours cannot be destroyed with radiation alone. Radiation and surgery are often combined during treatment.

The Benefits of Radiation Therapy
The benefits of radiation therapy include:

- It destroys quickly dividing cells at the margins of tumours. Surgery may miss these cells leading to recurrence of disease.
- It can successfully eradicate growth without permanently damaging the adjacent normal tissue. If these tumours can be treated early before metastasis, there is a very high rate of curability.

- In conjunction with other treatments, it may cure tumours that are not responsive to any single agent.
- Radioactive seed implants can deliver high doses of radiation directly to the tumour sparing nearby healthy cells. Has less severe side effects than external radiation therapy.
- Preoperative radiation therapy can kill tumour cells at margins of the tumour site. It can keep the cancer under control and prevent metastases, and also convert technically inoperable tumours into operable ones.
- Postoperative radiation therapy can destroy cancer cells still present around the margins after a tumour has been surgically removed.

Long-term Effects of Radiation Therapy

A late effect is a side effect that occurs months or years after cancer treatment. Many people who have received treatment for cancer have a risk of developing long-term side effects. In fact, evaluating and treating late effects is an important part of survivorship care.

Nearly any treatment can cause late effects, and these are specific to the treatment one received. Below is a list of some of the more common late effects. Talk with a Oncology health professional about any concerns about a specific late effect.

Heart problems - both chemotherapy and radiation therapy to the chest can cause heart problems. Survivors who may have a higher risk include:

- Anyone who received treatment for Hodgkin lymphoma as a child
- Anyone 65 and older
- Those who received higher doses of chemotherapy
- Those who received trastuzumab (Herceptin) and doxorubicin (Adriamycin, Doxil)

The Future of Radiation Therapy

Radiation therapy is an active area of research. One of the key objectives is the design of treatments that are more selective in their effects, damaging cancer cells and sparing normal cells. We will look at one current treatment being studied; Radiogenic therapy and Equivalent Uniform Dose (EUD) in conjunction with Intensity Modulated Radiation Therapy (IMRT).

Radiogenic therapy has been proposed as a method of using radiation technology to induce the formation of cytotoxic (cell killing) agents within cancer cells. Using lower doses of radiation with a biological agent may yield the same results as higher dose radiation alone, but with reduced toxicity.

There are three groups of radiogenic therapy:

- Stimulation by radiation to directly or indirectly produce cytotoxic agents. The objective of this technique is to control genes with a radiation-inducible promoter so that they can produce cytotoxic proteins or enzymes that can then activate a drug. The activated form of the drug will kill the cancer cells.

- Auger-emitting radio-labelled molecules. These therapies can control cancer by delivering targeted radiation to specific receptor bearing cells. Auger electrons are emitted by radioactive isotopes (Iodine-125 or Indium-111). The electrons have very short ranges and therefore have the potential to be delivered to specific sets of target cells, sparing healthy cells.
- Radiation-induced genes that produce a protein that can be targeted by a cytotoxic agent.

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Handheld Survey Meter
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Ionizing Radiation
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Radiation Portal Monitor
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Radiation Therapy
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Radon
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RIID
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