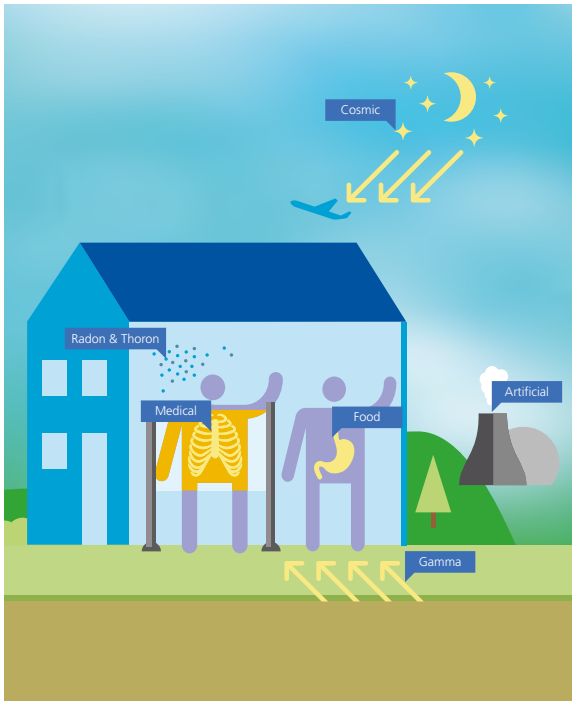
Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

Health Information and Quality Authority
An tÚdarás Um Fhaisnéis agus Cáilíocht Sláinte

# Ionising Radiation National Dose Report

# Introduction

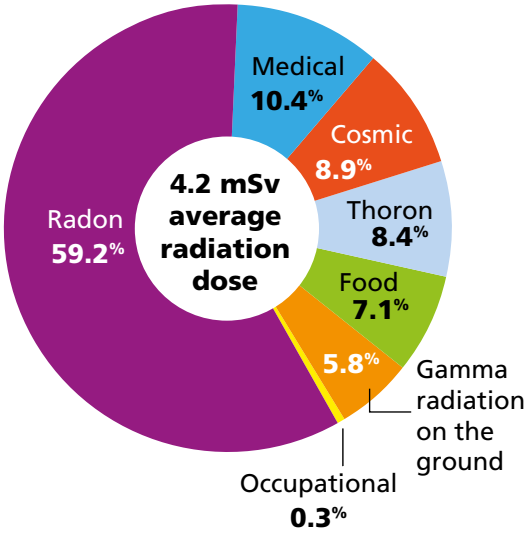
## Sources of Ionising Radiation




- People are exposed to a variety of sources of natural and artificial radioactivity in their daily lives both at home and at work. The average estimated annual radiation dose to a person in Ireland from all sources of radiation is estimated as **4.2 mSv**.
- Natural radiation comes from naturally occurring elements in the earth's crust (terrestrial radiation) which gives rise to the radioactive gases radon and thoron that can accumulate in buildings.
- Other sources of natural radiation include radiation from outer space (cosmic radiation) and radiation from the food and water that we consume. Natural radiation accounts for the majority of our exposure to radioactivity.
- Artificial radiation includes radiation from medical procedures, fallout from nuclear weapons testing that occurred in the past, fallout from past nuclear accidents as well as authorised releases of radioactivity from nuclear facilities abroad.

- The average estimated annual radiation dose to a person in Ireland from all sources of radiation is 4.2 mSv. This is consistent with the estimated radiation dose in 2014 (4 mSv) and consistent with the radiation dose *"between 1 – 20 mSv"* specified by international organizations including the IAEA and ICRP.
- The **Environmental Protection Agency** (EPA) is responsible for the protection of the public and workers from the harmful effects of natural and artificial radiation. Responsibility for protection of patients during the use of radiation in medical procedures rests with the **Health Information and Quality Authority** (HIQA).
- The EPA and HIQA have completed a review of the radiation doses received by the Irish population.

## Distribution of average radiation dose in Ireland

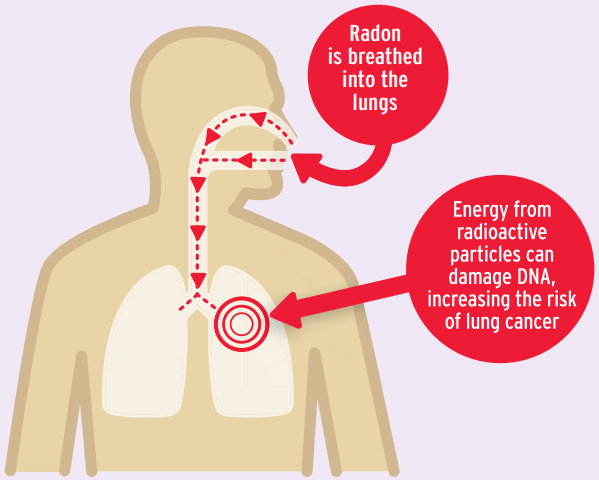



WATCH THE VIDEO

# Radon in indoor air

**59.2%**

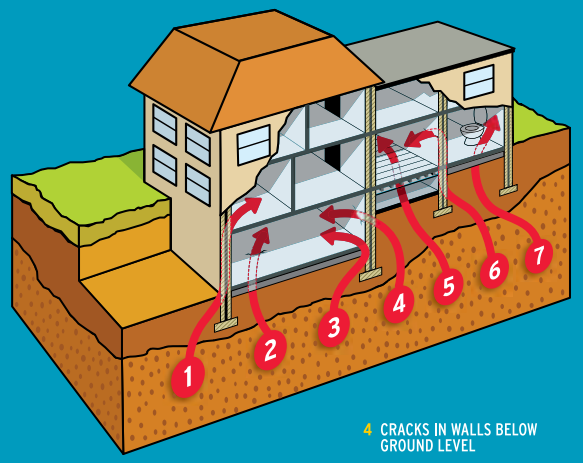
## RADON IS ONE OF THE LEADING CAUSES OF LUNG CANCER




What is the Radon level in your area?

- The average indoor radon concentration is **98 Bq/m³**. This results in an overall annual average radiation dose of **2.47 mSv**.
- Radon is a colourless and odourless radioactive gas that seeps into buildings (***see diagram on right***).
- Exposure to radon gas is the most significant source of radiation dose to the Irish public.
- Radon can cause lung cancer when you are exposed to high levels over a long period of time. Every year in Ireland, radon causes about 350 cases of lung cancer.
- Homes in some parts of Ireland are more likely to have a radon problem than homes in other areas. These are called high radon areas. EPA's radon risk map will tell you if a home is in a high radon area. High radon areas are shown in red.
- Employers located in high radon areas are required to test their premises for radon.
- Learn more:
  Website: **www.radon.ie**
  Freephone: 1800 300 600
  Email: **radon@epa.ie**
- It is easy to test for radon and it is easy to reduce the levels of radon in a home. The EPA recommends that every house is tested for radon.

## HOW DOES **RADON GET INTO HOMES?**




1 CAVITIES IN WALLS
2 CRACKS IN SOLID FLOORS
3 CONSTRUCTION JOINTS
4 CRACKS IN WALLS BELOW GROUND LEVEL
5 GAPS IN SUSPENDED FLOORS
6 CRACKS IN WALLS
7 GAPS AROUND SERVICE PIPES

*TYPICAL ENTRY ROUTES INTO A DWELLING*

# Medical Exposure

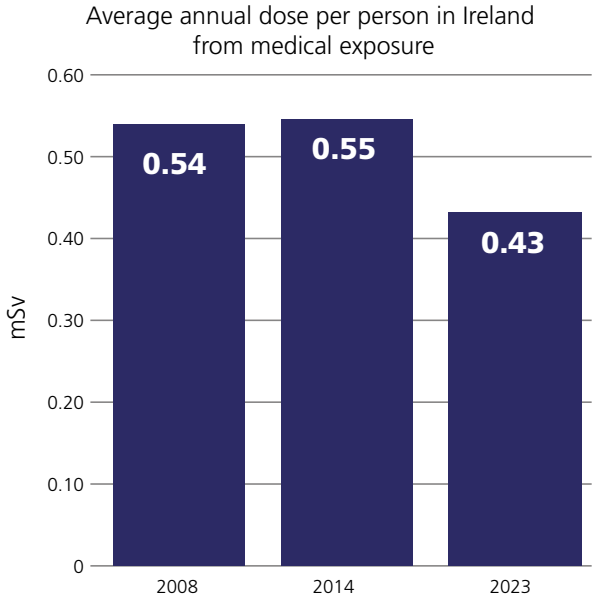
10.4%

For medical exposure to ionising radiation, the responsibility to establish population doses lies with the Health Information and Quality Authority (HIQA).

The average annual dose per person from diagnostic medical exposure (excluding radiotherapy treatments) considers how much radiation a person may be exposed to as a result of medical exposure to ionising radiation. HIQA calculates this using information from its diagnostic reference level (DRL) surveys and current population numbers.

More information on HIQA's regulation of medical exposures to ionising radiation and ongoing work to establish national diagnostic reference levels can be found on the **HIQA website**.


WATCH THE VIDEO




## Average annual dose per person in Ireland from medical exposure

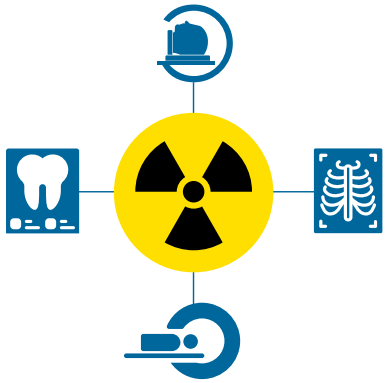
In 2023, HIQA established that the average annual dose per person in Ireland from medical exposure was **0.43 mSv**.

This is a decrease from when the average annual dose per person was first established in 2008 as **0.54 mSv**.

Although subsequent work in 2014 established an average dose per person of **0.55 mSv**, the current decrease in the average annual dose may, in part, be explained by the increase in population from 4.6 million in 2014 to 5.1 million in 2023. This decrease in the average annual dose may also be explained by the use of new technologies and improvements in procedure optimisation.

# Medical Exposure

10.4%



The average annual dose from medical exposure is made up of doses received from a number of different imaging techniques.

These techniques are:

- computed tomography (CT)
- general X-ray
- fluoroscopic procedures (fluoroscopy and fluoroscopically guided intervention)
- positron emission tomography (PET)
- nuclear medicine
- dental radiography.

The largest contributor to the average annual dose from medical exposure is CT.

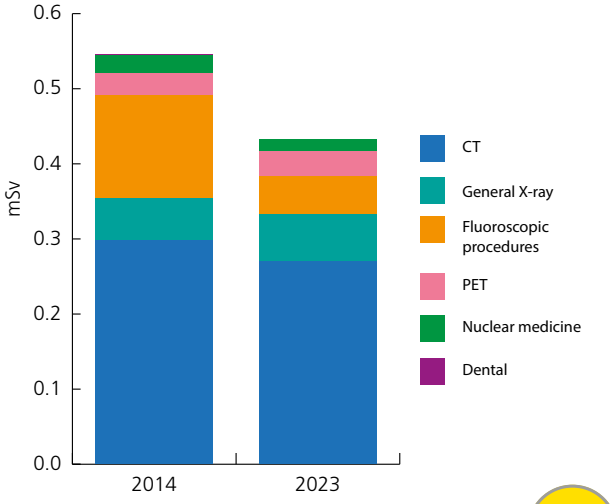
CT accounts for 62% of the dose from all medical exposure to ionising radiation, but only accounts for 11% of procedures performed.

Over the past 10 years, dose figures for CT, general X-ray and mammography, PET and nuclear medicine have remained relatively consistent.

HIQA observed a decrease in dose from fluoroscopic procedures. A number of possible reasons for this have been identified in the report **available here**.

More information on distributions of dose and examination frequency for each imaging technique can be **found here**.

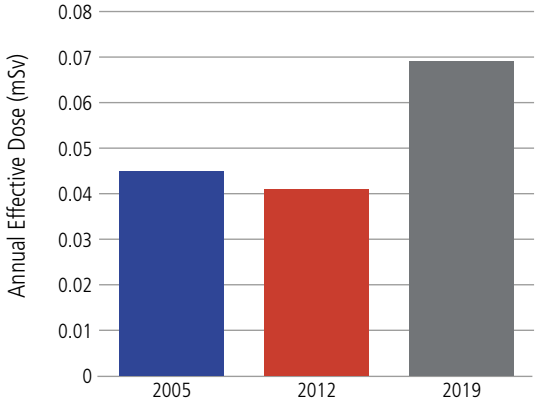
Average annual dose per person in Ireland from imaging techniques



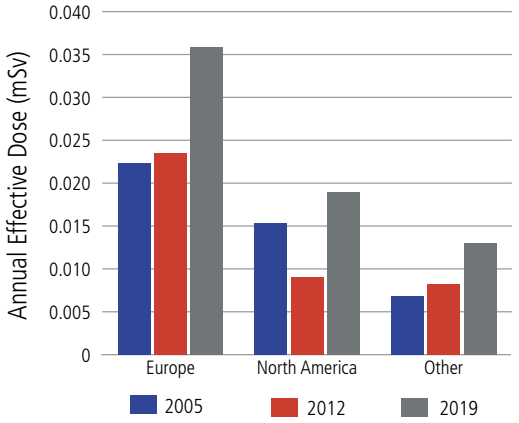
# Cosmic radiation

8.9%

- The total annual dose received due to cosmic radiation is estimated to be **0.37 mSv**. This dose is made up of exposure to cosmic radiation on the ground (**0.30 mSv**) and as a result of air travel (**0.07 mSv**).
- Cosmic radiation consists of high-energy particles that originate from the sun and from outside of the solar system.
- The cosmic radiation on the ground at Ireland's latitude (54°N) gives an individual annual dose of **0.30 mSv** (this dose takes into account the time spent indoors).
- Aeroplane passengers are exposed to elevated levels of cosmic radiation, especially at higher altitudes and latitudes. The annual average cosmic radiation dose received as a result of air travel is **0.07 mSv**. (2019 travel data was used due to COVID travel restrictions in 2020 to 2022)
- The annual average cosmic radiation dose received as a result of air travel has increased when compared to previous estimates due to an increase in the number of flights Irish people are taking and as a result of a change in the places they are flying. Aircrew and frequent flyers are exposed to higher levels of radiation doses from cosmic radiation, because of how often, and how high, they fly. The doses received by air crew are included in in the occupational exposures section of this report.




Annual effective doses from cosmic radiation due to air travel in 2005, 2012 and 2019, in mSv.



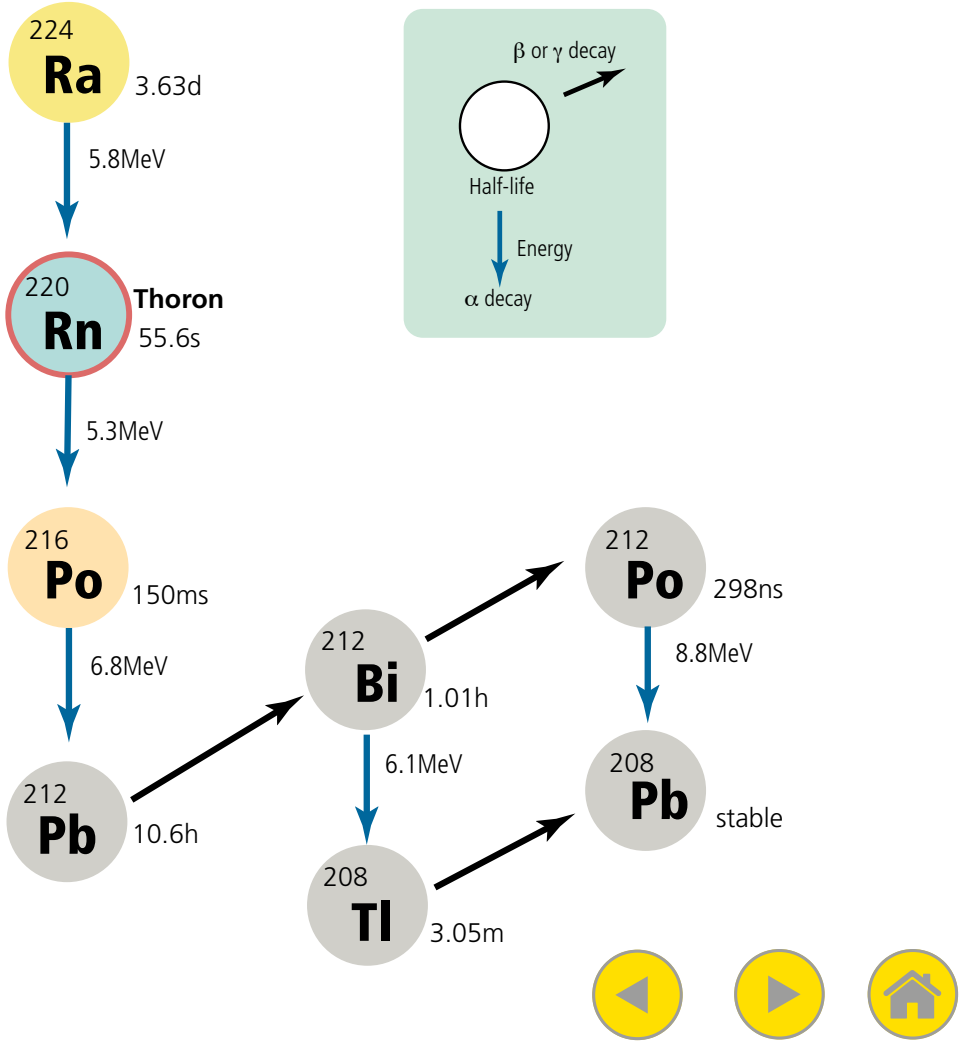

Annual effective doses for air travel to different regions in 2005, 2012 and 2019, in mSv.

# Thoron in indoor air

**8.4%**

- On average, a person receives **0.35 mSv** per year from exposure to thoron and its decay products.
- Thoron (Rn-220), like radon, is a naturally occurring radioactive gas.
- Thoron has a half-life of 56 seconds and can only migrate a short distance before it decays. For this reason, building materials rather than the soil beneath the house are usually the principal source of thoron in indoor air.
- The progeny of thoron (see figure) can also be a significant source of exposure as they can travel further in indoor air.
- When Thoron gases and its progeny are inhaled, the lung tissue is impacted by the alpha particles deposited in the airways.
- Work is underway to update the results of a pilot Thoron survey, conducted between 2007 and 2009, with a new national thoron survey to be conducted in 2024.

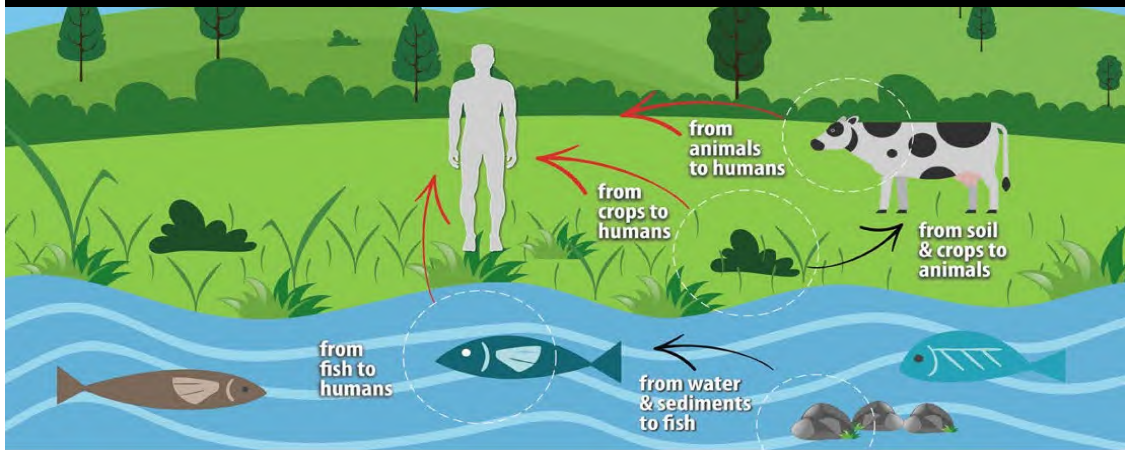
## Decay chains of Thoron and its progeny



# Radioactivity in food and drinking water

**7.1%**

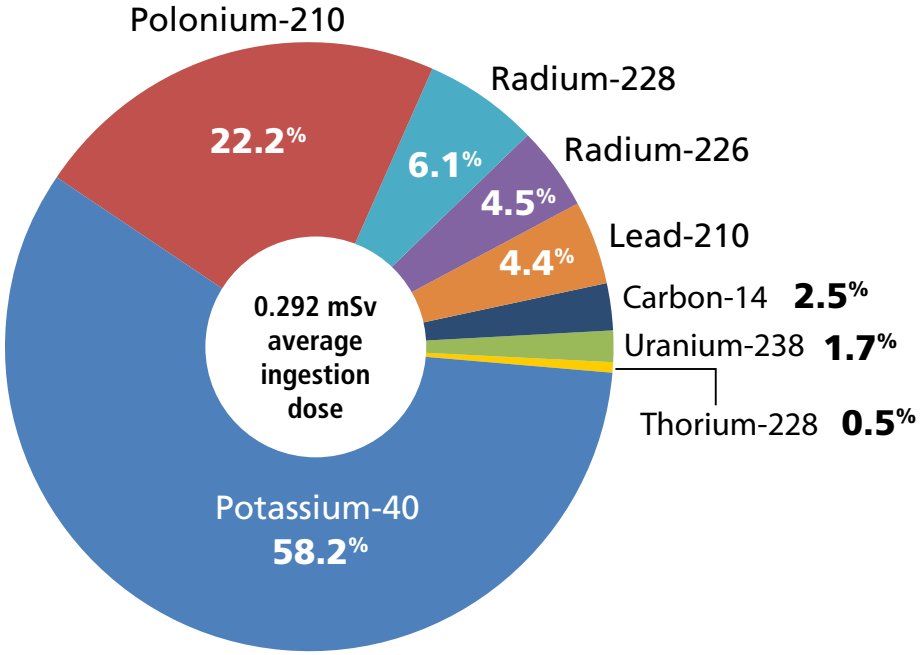
## Sources of radiation in food and drinking water




IAEA, 2017

- The current estimate of the average annual dose from the ingestion of radioactivity in food and water is **0.30 mSv**.
- Naturally occurring radioactivity in food accounts for 99% (**0.29 mSv**) of the radiation dose with 1% (**0.004 mSv**) as a result of artificial radioactivity.
- Radioactivity from both natural and artificial radioactive sources is present in all plants, animals and water.
- The radiation dose received from the consumption of food and drinking water is dependent on the concentration of radionuclides in the food and water and on how much food and water a person consumes.
- The largest contributor to the food dose is from the naturally occurring radionuclides: Potassium-40, Polonium-210, Lead-210, Radium-226 and Radium-228.
- The ingestion dose from artificial radionuclides from past accidents, nuclear weapons fallout and Sellafield discharges is negligible. (**EPA monitoring programme**).
- The EPA's radioactivity in drinking water monitoring programme has monitored over 1,250 public and private water supplies throughout the country. The dose contribution from radioactivity in drinking water remains very low (**< 0.1 mSv/ year**).

## Ingestion dose from Natural radionuclides



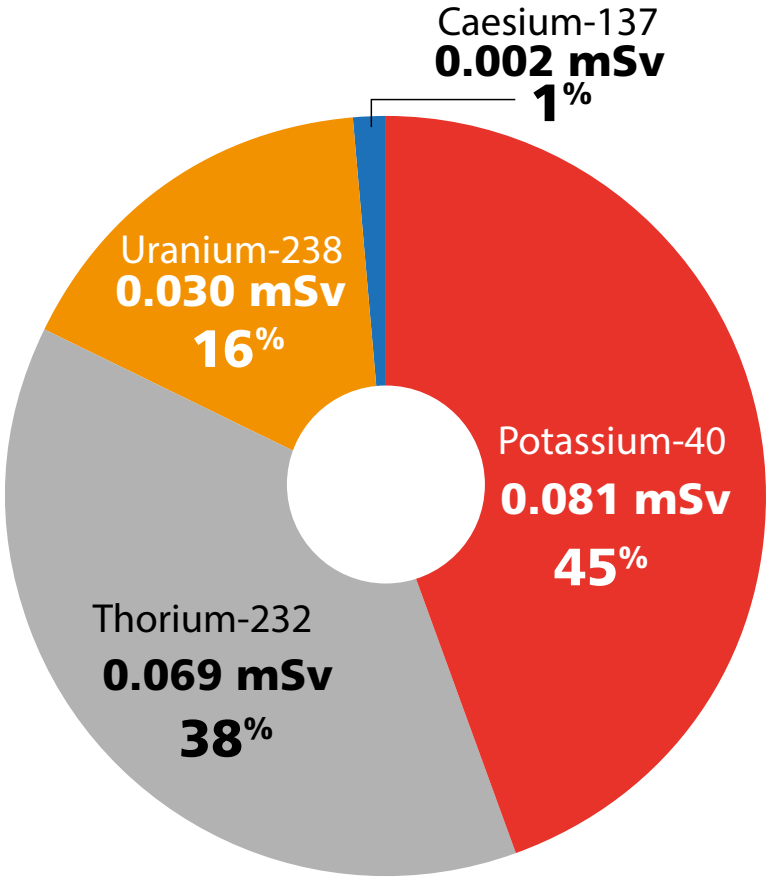

**Select a pie segment for more information**

# Radioactivity in the environment

**5.8%**

- The estimated annual average dose from Gamma radiation in the ground is **0.24 mSv**.
- Naturally occurring radioactive elements have been present in rocks and soils since the formation of the earth. Exposure from natural radionuclides in the ground varies with location and is mainly due to differences in geology and soil.
- The main sources of exposure from natural radioactivity in the ground is as a result of Gamma radiation from Potassium-40 (K-40) , Uranium-238 (U-238) and Thorium-232 (Th-232).
- There is an additional contribution from artificial radioactivity present in Irish soils as a result of fallout from nuclear weapons testing in the past, nuclear accidents (for example, the accident at Chornobyl), and authorized releases from nuclear facilities abroad.
- The dose contribution from radioactivity on the ground was estimated using data from the Geological Survey Ireland's (GSI's) **TELLUS survey**.

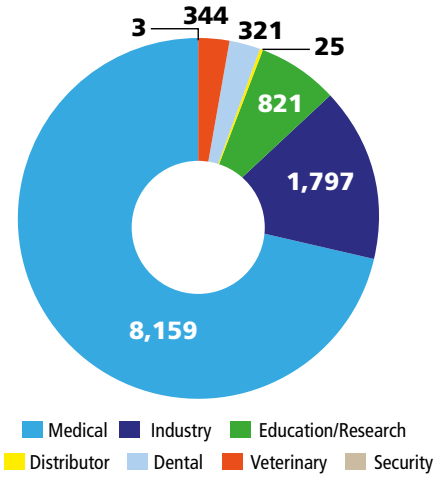
## Effective annual average gamma dose in TELLUS regions



# Occupational exposure

**0.3%**


Number of Workers Monitored




- The estimated annual dose from occupational exposure is **0.0115 mSv**.
- Occupational exposures consider the doses incurred by people as a result of their work. These include, for example: air crew who are exposed to higher levels of Cosmic radiation and people who may potentially be exposed to artificial sources of radiation in the fields of medicine, industry and education/research.
- The average annual occupational exposure of air crew to cosmic radiation in 2019 (prior to the COVID-19 pandemic) was 0.0115 mSv. This is based on data reported by Irish airlines to the EPA and summarised in this table: See chart.
- Data on occupational exposure from the medical, industrial and research sectors is submitted to the EPA annually.
- A review of the dosimetry data submitted to the EPA was conducted in 2020 and the overall contribution of this exposure pathway to annual dose was negligible.

## The number of workers receiving Annual Cumulative Radiation Doses in excess of 0.1 mSv

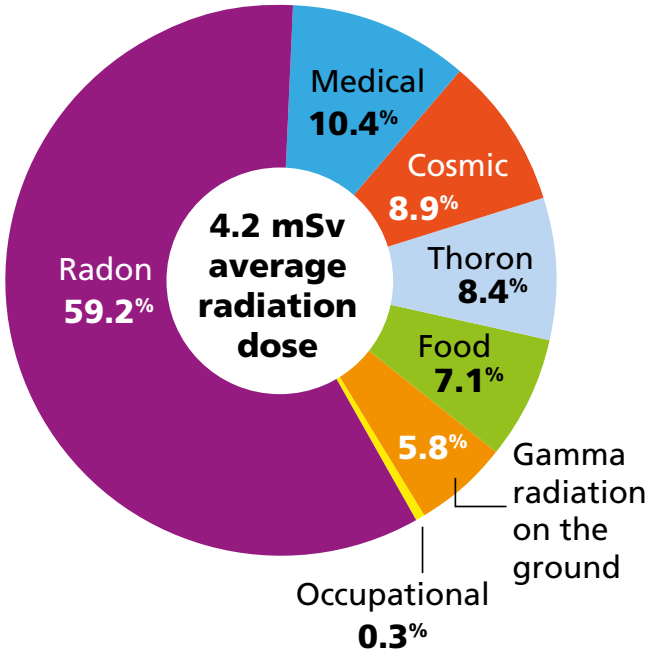
| Sector / Field | No. of Workers | Number who received doses > 0.1 mSv | % of sector >0.1 mSv |
|---|---|---|---|
| Distributor | 25 | 3 | 12.00% |
| Medical | 8,159 | 765 | 9.38% |
| Dental | 321 | 8 | 2.49% |
| Industry | 1,797 | 34 | 1.89% |
| Miscellaneous | 61 | 1 | 1.64% |
| Education / Research | 821 | 2 | 0.24% |
| Security | 3 | 0 | 0.00% |
| Veterinary | 344 | 0 | 0.00% |
| **Total** | **11,531** | **813** | **7.05%** |

# Summary and conclusions

The EPA and HIQA have completed a review of the average annual dose to a person in Ireland from all sources of radiation. This review takes into consideration the impact of restrictions introduced because of the COVID-19 pandemic. The average estimated annual radiation dose to a person in Ireland is estimated as **4.2 millisievert (mSv)**.

- **Natural sources** of radioactivity account for almost **90%** of all radiation exposures in Ireland. Artificial sources contribute approximately 10% and are dominated by the beneficial use of radiation in medicine. Doses from other artificial sources such as Sellafield, Chornobyl, occupational exposure, etc., account for less than 1%.
- **Radon** is the principal source of radiation exposure in Ireland, representing just over **59%** (**2.47 mSv per year**) of the average radiation dose. This dose is received mostly in people's homes.
- **Medical exposures** are the largest component of the average radiation dose from artificial sources of radiation. HIQA estimates the average annual medical dose to be **10.4%** (**0.43 mSv**) of the overall average radiation dose.
- People receive just under **9% (0.37 mSv)** of their radiation dose from **Cosmic radiation**. Almost 20% of this dose is received while flying and the remainder of this dose is constant due to Ireland's location in the world.
- The radiation dose received from Thoron in indoor air is estimated to be **0.35 mSv** (just over **8%** of the annual dose).
- The radiation dose received from the consumption of food and drinking water is estimated to be **0.3 mSv**. Naturally occurring radioactivity in food accounts for 99% of this radiation dose with 1% as a result of artificial radioactivity.
- The average annual radiation dose received from Gamma radiation in the ground is **0.24 mSv** (almost **6%** of the estimated annual radiation dose).
- The estimated annual dose from **occupational exposure**, radiation doses incurred by individuals as a result of their work, is **0.0115 mSv**.

## Distribution of average radiation dose in Ireland




Sources of Radiation
Natural and Artificial

# Glossary

- **Equilibrium factor (F):** This is the ratio between radon decay product concentration and radon concentrations.
- **IAEA:** International Atomic Energy Agency
- **ICRP:** International Commission on Radiological Protection
- **Ionising radiation:** Ionising radiation is the energy produced from natural or artificial sources. It has more energy than non-ionising radiation, enough to cause chemical changes by breaking chemical bonds. This effect can cause damage to living tissue.
- **Progeny:** The short-lived radioactive decay products of radon and of Thoron.
- **Radioactivity:** is measured in units called becquerels (Bq). One becquerel corresponds to one radioactive disintegration per second. When measuring radioactive discharges to the environment or referring to the content of radioactive sources used in medicine, industry and education, it is more usual to talk in terms of kilobecquerels (kBq), megabecquerels (MBq), gigabecquerels (GBq) or terabecquerels (TBq).

  1 kBq = 1000 Bq

  1 MBq = 1,000,000 Bq

  1 GBq = 1,000,000,000 Bq

  1 TBq = 1,000,000,000,000 Bq

- Much lower concentrations of radioactivity are normally found in the environment and so the measurement is often reported in units of millibecquerels (mBq). There are one thousand millibecquerels in a becquerel.

  1 Bq = 1,000 mBq

- **Radiation Dose:** When radiation interacts with body tissues and organs, the radiation dose received is a function of factors such as the type of radiation, the part of the body affected, the exposure pathway, etc. This means that one becquerel of radioactivity will not always deliver the same radiation dose. A unit called 'effective dose' has been developed to take account of the differences between different types of radiation so that their biological impact can be compared directly. Effective dose is measured in units called sieverts (Sv).

  The sievert is a large unit, and in practice it is more usual to measure radiation doses received by individuals in terms of fractions of a sievert.

  1 sievert

  = 1,000 millisievert (mSv)

  = 1,000,000 microsievert (μSv)

  = 1,000,000,000 nanosievert (nSv)

# Acknowledgements and Disclaimer

## Acknowledgements

The EPA and HIQA wishes to express appreciation to the following for their assistance in various ways towards the preparation of this report.

- Radon Measurement Services
- Geological Survey of Ireland
- National Radiation Protection Office (NRPO), HSE

The report was prepared under the direction of Mr Andy Fanning, EPA Programme Manager Environment & Health. The project was managed by Dr Kevin Kelleher and the principal author was Dr Kilian Smith, EPA.

Special thanks are due to the following EPA and HIQA staff that provided material for the report and commented on specific aspects:

**EPA contributors:**

- Ms Aoife Kinahan, EPA
- Mr Simon O'Toole, EPA
- Mr Hugh Synnott, EPA
- Mr David Dawson, EPA
- Mr Gray Gately, EPA
- Ms Alison Dowdall, EPA
- Mr Michael Murray, EPA
- Ms Veronica Smith, EPA
- Mr Fergal Dolan, UCD

**HIQA contributors:**

- Mr Lee O'Hora, HIQA
- Ms Noelle Neville, HIQA
- Dr Agnella Craig, HIQA
- Mr John Tuffy, HIQA
- Mr Sean Egan, HIQA

Advice and comment on this dose assessment work was also received from the EPA's Radiological Protection Advisory Committee.

Production of the report was completed by Yellowstone and was managed by the Communications section of the EPA, particularly Ms Emily Williamson.

Finally, many thanks to other EPA and HIQA staff (both current and past) who provided invaluable technical support and assistance in the preparation of this report.

## Disclaimer



ISBN: 978-1-80009-185-6

June 2024

web only