RÉPUBLIQUE FRANÇAISE
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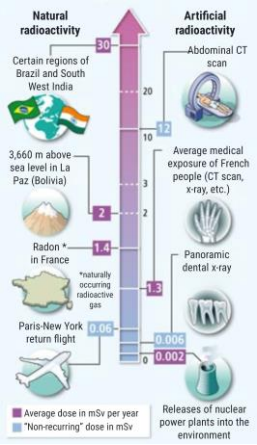
IRSN
INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

IRSN and public protection against exposure to low doses of ionizing radiation

IRSN FACT SHEETS

June 2021
www.irsn.fr

Some examples of human exposure sources *(expressed in effective dose)*



What is a dose of ionizing radiation?

- When ionizing radiation penetrates living material, it transfers a certain amount of energy to it, known as the "dose" and expressed as a unit called gray (Gy), which is equivalent to one joule per kilogram of material.
- When radiation is absorbed by an organism, biological effects can be observed; they differ according to the type of radiation (alpha, beta, gamma, neutron, etc.) and the irradiated tissue or organ (bone marrow, colon, lung, breast, etc.). The sum of the doses over all organs is the "effective dose". This is expressed in sievert (Sv), a unit that reports the degree of harmfulness specific to each type of radiation and the radiosensitivity of each tissue or organ.
- Ionizing radiation can have a direct influence on DNA, disrupting cell reproduction. It can also damage essential cellular structures, sometimes leading to the onset of diseases, such as cancer.
- Two types of effects are observed, depending on the absorbed dose:
  - **at high doses, specific short-term radiation effects** (from a few days to a few months after exposure), such as radiation-induced burns, hair loss, changes in blood count levels, etc.;
  - **at low to moderate doses, non-specific ionizing radiation effects, which may occur randomly in the longer term** (between a few years or decades after exposure), such as cancer, cardiovascular disease, or eye lens opacity.

The notion of low doses: an evolving concept

- The notion of "low doses" is far from fixed. It has evolved as knowledge on the effects of exposure to ionizing radiation on the body has advanced. Over time, the levels considered as "low doses" have steadily decreased.
- Today, one of the most commonly accepted definitions is the one given by the United Nations Scientific Committee on the Effects of Ionizing Radiation (UNSCEAR), which considers cumulative doses below 100 mGy as "low".

Concepts subject to interpretation

- The concept of "low doses" is not only evolving, but is also understood differently according to points of view (scientists, healthcare workers, industry, politicians, etc.). Within the scientific community itself, its acceptance varies according to the disciplines concerned (biologists, epidemiologists, ecotoxicologists, radiotoxicologists, etc.).
- A second controversial concept is the "linear no-threshold model" which expresses the proportionality between the doses received and the health risk. This extrapolation, based on the effects observed at high doses, used by international committees to allow simple management of radiological risks, is discussed on the basis of the observation of biological mechanisms that are non-linear with dose. Nevertheless, today, epidemiological results on cancer still argue in favor of using the simple linear model for radiation protection.
- Furthermore, the existence or not of non-cancer effects at low doses, particularly on the cardiovascular system and the eye lens, is also debated. Determination of the effect of co-exposure to multiple stressors (radiological, chemical, etc.), for example, the combined effect of radon and tobacco in the onset of lung cancer, is complex and still poorly characterized.

Contribution of epidemiological studies on various cohorts

- Prior to the 1990s, knowledge on health risks due to ionizing radiation was mainly based on the results of epidemiological follow-up of survivors of the Hiroshima and Nagasaki bombings, as well as that of patients treated with radiotherapy.
- From the 1990s onwards, epidemiological studies considered other populations, such as medical staff, patients undergoing diagnosis examinations, nuclear workers, and the general population. Today, the some 30 years of follow-up of these cohorts have improved our knowledge of radiation-induced risks, taking into account daily exposure situations and the specific nature of the different populations (European, American, Asian, etc.). The statistical power of these studies has increased significantly, enabling meaningful scientific results to be obtained for exposures below 100 mSv.
- An worldwide dynamic has begun with studies published over the past two years by major international stakeholders – such as the U.S. National Council for Radiation Protection and Dosimetry (NCRP), the International Commission on Radiological Protection (ICRP), and the U.S. National Cancer Institute (NCI) – which confirm the concordance of effects observed at low doses.

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As a public expert, IRSN advances scientific knowledge to manage all nuclear and radiation risks. Through its research, methods, and interactions with all stakeholders, IRSN assesses these risks and their consequences independently. It thus contributes to their prevention, detection, and the limitation of their possible effects, in order to protect the population and the environment.

Some key lessons learned about low doses

- Radiobiology studies first showed that there was no single form of dose-response relationship for all cellular biological processes. They also demonstrated that exposure to ionizing radiation can have indirect effects on other cellular constituents, such as water molecules, in addition to direct effects on DNA, which may also play a role in the development of diseases induced by exposure to ionizing radiation.
- Another lesson is that individual characteristics (age, sex, genetic predisposition, etc.) can modulate the risk of developing cancer. The impact of these individual sensitivities to exposure to ionizing radiation is currently under debate.

IRSN's contribution to international research on low doses

- The Institute participated in the structuring of European research in this area with the creation, in 2009, of MELODI (Multidisciplinary European Low Dose Initiative), a structure for the governance of research on low doses, and, in 2010, of the DoReMi (Low dose research towards multidisciplinary integration) network of excellence, followed by the OPERRA (2013) and CONCERT (2017) programs financed by the European Commission.
- IRSN also participates in or leads international studies on different exposure situations:
  - **natural exposure to radon**: IRSN has conducted several years of studies on uranium miners and the effect of domestic exposure to radon. The results obtained helped demonstrate the risk of lung cancer associated with radon, even at low exposure levels. Today, the Institute is working on the European **RadoNorm** project;
  - **post-accident exposure**: after conducting the **EPICE** study on the health consequences of the Chernobyl accident, the Institute is now looking into the health consequences of the Fukushima accident, under a cooperation agreement with the Fukushima Medical University (FMU) in Japan;
  - **exposure of nuclear workers**: IRSN has set up a cohort of over 80,000 nuclear workers in France and is participating in the international **INWORKS** project. The project includes over 300,000 employees in France, the UK, and the U.S.A. The results confirm that low doses result in a slight increase in the risk of cancer as well as cardiovascular and cerebrovascular disease. They also highlight the need to strengthen communication on low dose risks and reflection on "risk acceptability";
  - **medical exposure**: the Institute has assembled a cohort of over 100,000 children exposed to a first CT scan between 2000 and 2011 in various French university hospitals. Early results suggest an increased risk of brain tumor and dose-associated leukemia in children not predisposed to cancer. However, the short follow-up and the low number of cancer cases in the cohort do not, as it stands, provide sufficient statistical power to confirm this result. In this respect, international partnerships are underway, including under the European **EPI-CT** and **MEDIRAD** projects.
- In parallel with epidemiological research, IRSN conducts research on the biological effects of low doses, in the field of human and environmental toxicology. These aim to better understand the biological mechanisms generated by exposure to ionizing radiation, whether in connection with cancer, non-cancer diseases, or on mechanisms of transgenerational effects (biological modifications in non-exposed offspring of exposed individuals).

IRSN's contribution to dosimetry monitoring and information on low doses

- In France, IRSN publishes periodic radiation monitoring reports on professionals exposed to ionizing radiation, on patients exposed for medical reasons (ExPRI reports), or on the entire French population (ExPOP reports). It also publishes fact sheets, such as radon in homes and ways to reduce levels.
- Internationally, the Institute is actively involved in the activities of the major radiation protection bodies, such as ICRP, UNSCEAR, the International Atomic Energy Agency (IAEA), and the OECD Nuclear Energy Agency (NEA).