# HOW DANGEROUS IS IONISING RADIATION?

**By**

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Radiation is a general term and covers many different forms of radiation, e.g. visible light, ultraviolet light, microwaves, radio waves, X-rays, etc. Radiation can be divided into two broad categories - ionising radiation and non-ionising radiation. Ionising radiation is the particular type of radiation emitted by radioactive substances. It differs from non-ionising radiation in that it is very energetic and has the capacity to ionise matter when it interacts with it.

Matter is composed of atoms. The atoms in matter are normally electrically neutral, i.e. positive and negative charges are balanced. Ionising radiation can strip negatively charged electrons off atoms to produce positively charged atoms, and the process is called ionisation. It is disruptive of the orderly structure of matter. If the matter is biological body tissue there is a risk that the damage will initiate the development of a cancer, or, if the damaged tissue is in the germ line, lead to a genetic defect in a future generation.

Broadly speaking, the general public is exposed to ionising radiation from 2 sources - natural and artificial. The world is naturally radioactive and always has been. The main form of artificial radiation is medical ionising radiation (principally diagnostic x-rays). Other forms of artificial radiation include emissions from nuclear industry, fallout from nuclear weapons tests and stray radiation from miscellaneous appliances (e.g. televisions).

Under normal circumstances the great majority of the ionising radiation we receive comes from natural sources (mostly from the radioactive gas radon). Most of the artificial ionising radiation that we receive comes from medicine. Under normal circumstances we receive very little radiation from the nuclear industry, nuclear fallout and miscellaneous appliances.

Natural ionising radiation is composed of cosmic radiation, internal radiation and terrestrial radiation. Cosmic radiation showers down onto the earth from outer space. Our bodies are naturally radioactive because the earth is radioactive and this radioactivity gets into our food and hence enters our bodies. We are also irradiated externally by rocks on the earth's surface. The largest component of our exposure to natural ionising radiation is the radioactive gas radon which escapes into the air from rocks in the earth. There is little or nothing we can do to protect ourselves from cosmic, internal, or external radiation from rocks, but luckily we can take steps to minimise our exposure to radon (see article on Radon).

When ionising radiation interacts with biological tissue it deposits energy there. The amount of energy deposited per unit mass of tissue is called the absorbed dose, and the size of this biological dose determines the probability that an ill-health effect will ensue. The unit of dose is called the Sievert (Sv). One thousandth of a Sv is a millisievert (mSv). When calculating overall doses of radiation to the population (collective dose), you multiply the average individual dose by the total number of exposed people. Collective dose is expressed as man-sieverts, man-milisieverts, etc. The average individual annual dose in Ireland from ionising radiation is about 3mSv. Of the annual collective dose received by the Irish population approximately 86.9% comes from natural radiation, 12.6% from medical radiation, 0.03% from nuclear discharges, 0.17% from nuclear fallout, and 0.4% from miscellaneous sources.

It is very important to understand the risk from ionising radiation in order to decide how to take sensible protective precautions. Ill-effects resulting from exposure to radiation are divided into early and late effects. Early effects are associated only with accumulation of large doses of radiation (greater than 1Sv) over a short period (hours-days). These effects include radiation sickness (diarrhoea, vomiting) and possible death within days or weeks. The radiation dose that is lethal within 30 days for 50% of those exposed to it, is about 3 Grays (at these high acute doses, the term Gray is used instead of Sievert). An acute dose of 8 Grays or more will almost certainly result in early death, an acute dose of 1.5 Grays or less will very probably not.

These high doses could only be received as a result of a nuclear war, or being close to a nuclear accident. A more practical and important matter is to know the risks associated with low doses of radiation (in the mSv range) accumulated over long periods, i.e. the sort of doses that we receive in our everyday lives. These doses carry a risk of long term effects - cancer and hereditary defects. With cancer there is a long latent period between the initial biological damage from the radiation and the subsequent clinical manifestation of the tumour. This can range from several years to 40 years, and longer. Hereditary effects, of course, cannot be expressed until the next generation at the earliest.

For late cancer effects, the relationship between risk of fatal cancer and dose is known reasonably accurately for larger doses, i.e. significant fractions of a Sievert and upwards. It is known with much less precision for lower doses. The main reason for this is that at low doses the effects are small and therefore difficult to detect with statistical validity. If the effects were large there would be no difficulty in detecting and quantifying them. Consider the difficulties. Because the effects are small you must study a large population exposed to a low level of radiation. You must have a similarly large population of controls against whom you will compare your test group. The two groups must be similar to each other in every way, except that the test group received a defined amount of dose extra to the controls. You must know accurately how much extra radiation the test group received. You must carefully monitor the groups for clinical symptoms over a period of 50 and more years, because of the latency phenomenon in cancer. It is easy to see that such a study is very difficult.

The current general scientific consensus on the form of the relationship between risk (of fatal cancer) and dose (for lower doses over protracted time) is the linear-no-threshold model, i.e. risk is directly proportional to dose all the way down to zero dose. Risk is reduced to zero only at zero dose, and there is no low threshold of dose below which there is no risk. This is the basis for the statement often heard - 'there is no safe level of radiation'. This statement is frequently misunderstood as meaning that radiation is equally dangerous regardless of the dose. The truth is that a tiny dose carries a tiny risk, a medium dose carries a medium risk, a large dose carries a large risk. The popular saying would be more accurately phrased - 'there is no absolutely safe level of radiation'. Another consequence of the linear model is that a given collective dose has the same health consequences no matter how it is distributed, e.g. 1,000 people each receiving 1mSv will have the same consequences as 100 people each receiving 10mSv.

The single most useful body of data used to determine the risk of ionising radiation is the Japanese study of the survivors of the atomic bombings at Hiroshima and Nagasaki in 1945. Other useful data has come from long term follow-up studies of patients who received defined doses of radiation in therapeutic medicine, e.g. in the treatment of ringworm.

Two major international committees continually evaluate the radiation risk data - The International Committee on Radiological Protection (ICRP) and the United Nations Sub-Committee on Atomic Radiation (UNSCEAR), and issue their findings and recommendations. These bodies have come up with a nominal mortality risk of 5% per Sv for fatal cancer from irradiation at low doses for a population of all ages. In other words, if 1 million people, of all ages, each receive 1mSv of ionising radiation this will result in 50 fatal cancers attributable to exposure to the radiation. 1mSv to each of 1 million people will also result in the expression of 6 serious hereditary defects in their descendants over all future generations.

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