Executive summary

Health Council of the Netherlands. Risks of exposure to ionising radiation. The Hague: Health Council of the Netherlands, 2007; publication no. 2007/03.

Exposure to ionising radiation results in health risks. Much is known about this subject, especially with regards to the effects of short exposure to high doses. Research into the relationship between exposure to low doses and effects in the long term is far more difficult to conduct. Studies on this subject are still ongoing. One of the most important of these studies is the research done on survivors of the atomic blasts in Hiroshima and Nagasaki. This research continually produces new data, which leads to a better understanding of the long-term effects of exposure to low doses of radiation.

The Health Council of the Netherlands has published a number of advisory reports that include scientific analyses of the data on the risks of radiation as well as conclusions on the situation in the Netherlands. The most recent advisory report in this series was published in 1991. Many publications on this subject have appeared since then. The present advisory report therefore reflects the current level of knowledge.

Exposure

Bodily tissues differ from one another in their sensitivity to exposure to ionising radiation. Accordingly, a weighting factor for each tissue type has been developed in order to facilitate estimation of the total exposure risk. The International Commission for Radiological Protection (ICRP) recently issued new recommendations for these tissue weighting factors. Calculating the radiation load for the population in the Netherlands with these new weighting factors leads to a mean value – an effective dose of 2.5 milliSievert (mSv) – which hardly deviates from earlier values. More than one half of this dose is produced by radon found in building materials and other sources and by diagnostic applications in medicine. The highest effective doses in medical diagnostics are produced by abdominal CT scans, angiography and interventional radiology. There has been a steady increase in the total number of diagnostic radiology procedures. The mean dose per capita has remained constant, however, through digitalisation and other improvements.

Among those affected through occupational exposure, airline industry employees and those involved in the production of isotopes receive the highest effective mean annual dose (1.34 mSv). They are followed by workers engaged in materials research with non-destructive mobile testing units (1.06 mSv) and those who are employed in interventional radiology (0.47 mSv).

Effects

The biological effects of ionising radiation are either deterministic or stochastic in nature. Deterministic effects (also known as “tissue reactions”) appear above a specific threshold dose. The higher the dose, the more pronounced the effect. The appearance of stochastic effects involves an element of chance: the effect (e.g. cancer) either appears or it does not. The higher the dose, the greater the risk of health impairment.

Much is known about tissue reactions resulting from exposure to ionising radiation. The nature of the effect, as well as the relationship between its intensity and the radiation dose, are dependent on the body part exposed. During protracted intervention procedures supported by the use of medical radiology the threshold dose for skin damage may be exceeded. Erythema can be a symptom in the short term. In the long term, this burning may lead to the death of skin cells and the formation of connective tissue.

Until recently, less was known about stochastic effects. Radiation exposure can cause DNA changes in the short term that are not immediately observable. In the long term, damage may lead to cancer or genetic effects.

Cancer

An increased cancer risk in the long term is the most detrimental health effect of exposure to ionising radiation. The types of cancers that appear after exposure to ionising radiation are difficult to differentiate, however, from ‘spontaneous’ cancers.

Epidemiological research on 120,000 survivors of the atomic blasts in Japan (the Japanese life span study) is the most important source of information. Other data comes from research into patients who underwent X-ray treatment for benign disorders. This data produces risk assessments for doses of less than 10 gray (Gy) that correspond to the results of the Japanese life span study. Such correlation is not found with higher doses, as used in the curative treatment of cancer patients. The risk calculated from this data is lower, probably because higher doses lead to cellular mortality. The risk assessment derived from the most recent – and largest – study conducted among workers in radiology and nuclear industries is in fact higher than the estimate based on the Japanese life span study. However, the margin of error is so wide that the estimates are not inconsistent.

The accident with the reactor at Chernobyl has led to a substantial increase in the incidence of thyroid cancer in Ukraine, Belarus and the Russian Federation, especially among young children. Other age groups in Belarus also exhibit an increased incidence of thyroid cancer. The accident’s effects on the population of the Netherlands are negligible.

Damage to later generations

Since the Health Council published its advisory report in 1991, considerable advances have been made in estimating the genetic risks associated with exposure to ionising radiation. The total risk of genetic effects per Gy, including multi-factorial and congenital defects, is now calculated to be 0.4 to 0.6 percent of the naturally occurring incidence of these effects.

Knowledge about congenital defects as a result of exposure to ionising radiation comes from tests on laboratory animals. Other contributions to this knowledge come from findings in Japanese children who were *in utero* at the time of the atomic blasts and who were exposed to radiation. In the Netherlands, the chance is small that a foetus will be exposed to a radiation dose that exceeds the 1 mSv limit. There are nevertheless situations in which this could potentially occur, for example during a diagnostic radiology examination of the expectant mother.

New insights into genetic damage are expected to lead to programmes in which certain groups of people who are at increased risk can be monitored in detail. These include people with highly sensitive DNA, for example carriers of a gene mutation that increases their propensity for developing hereditary types of breast cancer. The protocols of current programmes for detecting these types of cancers may require adjustment. However, it is too early to know for sure.

Risk assessments

Risk assessments provide an indication of the size of the risk that an effect will occur, in relation to the dose received.

Current risk assessments are based on data on exposure to relatively high doses and dose rates. If this data is extrapolated to low doses and low dose rates, an overestimation of the risk will most likely be the result. The extrapolated risk is therefore divided by the DDREF (dose and dose rate effectiveness factor). The most recent scientific insights give no cause for adjusting the DDREF of 2.

Research into mortality due to cancer among survivors of the Japanese atomic blasts shows that the older they were at the time of radiation exposure, the lower their risk. Women have a higher risk than men. Today, more than sixty years after the atomic blasts, survivors still have a generally higher risk.

In 1990, the ICRP calculated for the combined risks of cancer mortality and hereditary effects a risk factor of 7.3 percent per Sv on average for the population. Based on the latest insights, the ICRP has reduced this value to 5.7 percent per Sv. This has primarily to do with the reduced probability estimate for genetic effects.

The Committee has concluded that no compelling new evidence has come to light for adjusting the risk factors published in the 1991 advisory report *Radiation risks*. An argument could be made for a marginal reduction, but this would not be statistically significant considering the degree of uncertainty in the risk factors.

Recommendations for improvements in diagnostic radiology

In collective terms, the largest radiation dose from artificial sources is generated in the field of medical diagnostic radiology. It is therefore important to continue to strive for a reduction in exposure by improving the dose and the image quality. The concept of ALARA (as low as reasonably achievable) is the basic principle of responsible radiation applications. The dose should be as low as possible while still producing acceptable results. The report includes a number of specific recommendations for the improvement of equipment and procedures in digital radiology, interventional radiology and computerised tomography.