U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

FACT SHEET

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Biological Effects of Radiation

Background

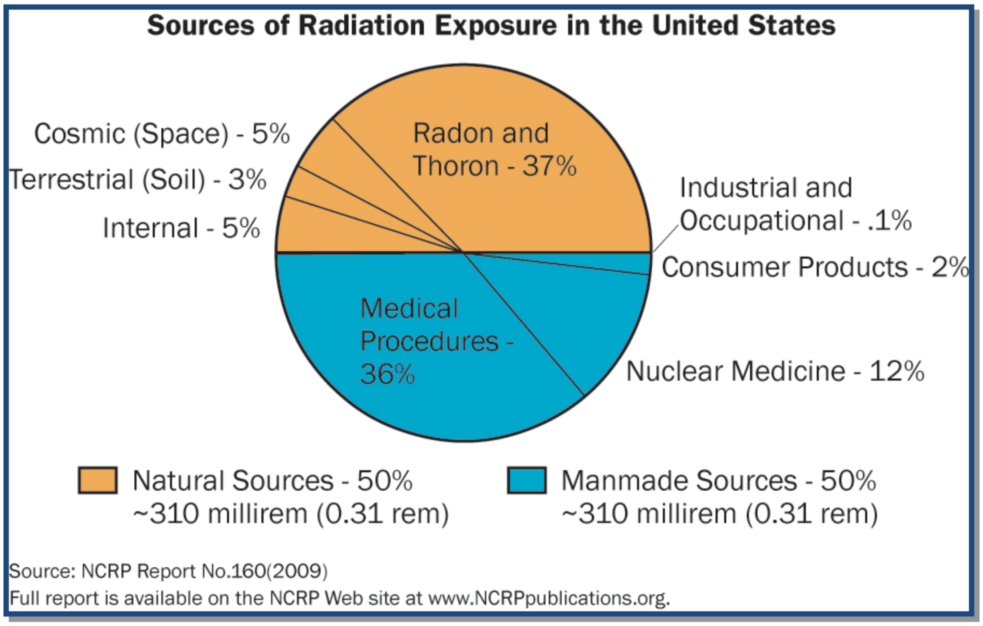
Radiation is all around us. It is naturally present in our environment and has been since the birth of this planet. Consequently, life has evolved in an environment which has significant levels of ionizing radiation. It comes from outer space (cosmic), the ground (terrestrial), and even from within our own bodies. It is present in the air we breathe, the food we eat, the water we drink, and in the construction materials used to build our homes. Certain foods such as bananas and brazil nuts naturally contain higher levels of radiation than other foods. Brick and stone homes have higher natural radiation levels than homes made of other building materials such as wood. Our nation's Capitol, which is largely constructed of granite, contains higher levels of natural radiation than most homes.

Levels of natural or background radiation can vary greatly from one location to the next. For example, people residing in Colorado are exposed to more natural radiation than residents of the east or west coast because Colorado has more cosmic radiation at a higher altitude and more terrestrial radiation from soils enriched in naturally occurring uranium. Furthermore, a lot of our natural exposure is due to radon, a gas from the earth's crust that is present in the air we breathe.

About half of the total annual average U.S. individual’s radiation exposure comes from natural sources. The other half is mostly from diagnostic medical procedures. The average annual radiation exposure from natural sources is about 310 millirem (3.1 millisieverts or mSv). Radon and thoron gases account for two-thirds of this exposure, while cosmic, terrestrial, and internal radiation account for the remainder. No adverse health effects have been discerned from doses arising from these levels of natural radiation exposure.

Man-made sources of radiation from medical, commercial, and industrial activities contribute about another 310 mrem to our annual radiation exposure. One of the largest of these sources of exposure is computed tomography (CT) scans, which account for about 150 mrem. Other medical procedures together account for about another 150 mrem each year. In addition, some consumer products such as tobacco, fertilizer, welding rods, exit signs, luminous watch dials, and smoke detectors contribute about another 10 mrem to our annual radiation exposure.

The pie chart on the following page shows a breakdown of radiation sources that contribute to the average annual U.S. radiation dose of 620 mrem. Nearly three-fourths of this dose is split between radon/thoron gas and diagnostic medical procedures. Although there is a distinction between natural and man-made radiation, they both affect us in the same way.


Sources of Radiation Exposure in the United States

Source: NCRP Report No.160(2009)
Full report is available on the NCRP Web site at www.NCRPpublications.org.

Above background levels of radiation exposure, the NRC requires that its licensees limit maximum radiation exposure to individual members of the public to 100 mrem (1mSv) per year, and limit occupational radiation exposure to adults working with radioactive material to 5,000 mrem (50 mSv) per year. NRC regulations and radiation exposure limits are contained in Title 10 of the Code of Federal Regulations, Part 20.

Biological Effects of Radiation

We tend to think of biological effects of radiation in terms of their effect on living cells. For low levels of radiation exposure, the biological effects are so small they may not be detected. The body has repair mechanisms against damage induced by radiation as well as by chemical carcinogens. Consequently, biological effects of radiation on living cells may result in three outcomes: (1) injured or damaged cells repair themselves, resulting in no residual damage; (2) cells die, much like millions of body cells do every day, being replaced through normal biological processes; or (3) cells incorrectly repair themselves resulting in a biophysical change.

The associations between radiation exposure and the development of cancer are mostly based on populations exposed to relatively high levels of ionizing radiation (e.g., Japanese atomic bomb survivors, and recipients of selected diagnostic or therapeutic medical procedures). Cancers associated with high-dose exposure (greater than 50,000 mrem) include leukemia, breast, bladder, colon, liver, lung, esophagus, ovarian, multiple myeloma, and stomach cancers. Department of Health and Human Services literature also suggests a possible association between ionizing radiation exposure and prostate, nasal cavity/sinuses, pharyngeal and laryngeal, and pancreatic cancer.

The period of time between radiation exposure and the detection of cancer is known as the latent period and can be many years. Those cancers that may develop as a result of radiation exposure are indistinguishable from those that occur naturally or as a result of exposure to other carcinogens. Furthermore, National Cancer Institute literature indicates that other chemical and physical hazards and lifestyle factors (e.g., smoking, alcohol consumption, and diet) contribute significantly to many of these same diseases.

Although radiation may cause cancers at high doses and high dose rates, currently there are no data to establish unequivocally the occurrence of cancer following exposure to low doses and dose rates – below about 10,000 mrem (100 mSv).

Even so, the radiation protection community conservatively assumes that any amount of radiation may pose some risk for causing cancer and hereditary effect, and that the risk is higher for higher radiation exposures. A linear, no-threshold (LNT) dose response relationship is used to describe the relationship between radiation dose and the occurrence of cancer. This dose-response hypothesis suggests that any increase in dose, no matter how small, results in an incremental increase in risk. The LNT hypothesis is accepted by the NRC as a conservative model for determining radiation dose standards, recognizing that the model may over estimate radiation risk.

High radiation doses tend to kill cells, while low doses tend to damage or alter the genetic code (DNA) of irradiated cells. High doses can kill so many cells that tissues and organs are damaged immediately. This in turn may cause a rapid body response often called Acute Radiation Syndrome. The higher the radiation dose, the sooner the effects of radiation will appear, and the higher the probability of death. This syndrome was observed in many atomic bomb survivors in 1945 and emergency workers responding to the 1986 Chernobyl nuclear power plant accident. Approximately 134 plant workers and firefighters battling the fire at the Chernobyl power plant received high radiation doses – 80,000 to 1,600,000 mrem (800 to 16,000 mSv) – and suffered from acute radiation sickness. Of these, 28 died within the first three months from their radiation injuries. Two more patients died during the first days as a result of combined injuries from the fire and radiation.

Because radiation affects different people in different ways, it is not possible to indicate what dose is needed to be fatal. However, it is believed that 50% of a population would die within thirty days after receiving a dose of between 350,000 to 500,000 mrem (3500 to 5000 mSv) to the whole body, over a period ranging from a few minutes to a few hours. This would vary depending on the health of the individuals before the exposure and the medical care received after the exposure. These doses expose the whole body to radiation in a very short period of time (minutes to hours). Similar exposure of only parts of the body will likely lead to more localized effects, such as skin burns.

Conversely, low doses – less than 10,000 mrem (100 mSv) – spread out over long periods of time (years) don't cause an immediate problem to any body organ. The effects of low doses of radiation, if any, would occur at the cell level, and thus changes may not be observed for many years (usually 5-20 years) after exposure.

Genetic effects and the development of cancer are the primary health concerns attributed to radiation exposure. The likelihood of cancer occurring after radiation exposure is about five times greater than a genetic effect (e.g., increased still births, congenital abnormalities, infant mortality, childhood mortality, and decreased birth weight). Genetic effects are the result of a mutation produced in the reproductive cells of an exposed individual that are passed on to their offspring. These effects may appear in the exposed person's direct offspring, or may appear several generations later, depending on whether the altered genes are dominant or recessive.

Although radiation-induced genetic effects have been observed in laboratory animals (given very high doses of radiation), no evidence of genetic effects has been observed among the children born to atomic bomb survivors from Hiroshima and Nagasaki.

NRC regulations strictly limit the amount of radiation that can be emitted by a nuclear facility, such as a nuclear power plant. A 1991 study by the National Cancer Institute, “Cancer in Populations Living Near Nuclear Facilities,” concluded that there was no increased risk of death from cancer for people living in counties adjacent to U.S. nuclear facilities. At the NRC’s request, the National Academy of Sciences is currently engaged in a state-of-the-art update to the earlier study. The new study will examine cancer rates in communities around operating and decommissioned nuclear power plants, as well as nuclear fuel cycle facilities.

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