Linear No Threshold Model of Radiation Risk

Exposure to high levels of ionizing radiation can result in detrimental health effects including cancer.

Radiation dose or exposure to humans is measured in units of rem or millirem (one thousandth of a rem). Dose rate is measured in millirem per year. For example, exposure from natural background radiation averages 300 millirem/year in the U.S. Therefore, in a normal lifetime of 75 years, we could expect to be exposed to approximately 22,500 millirem or 22.5 rem. This background radiation comes from soil and rock, the food we eat, cosmic rays and indoor radon.

Scientists have estimated the cancer risk from high levels of radiation exposure based upon cancers observed in the survivors of the nuclear explosions in Hiroshima and Nagasaki. These survivors were exposed to 100s of rem (or 100,000s of millirem) instantaneous dose plus subsequent long-term exposure from fallout.

Based on these A-bomb survivor studies and other studies, scientists have estimated the cancer incidence risk from radiation exposure to be approximately 0.114 per 100 rem[1]. That is to say, if a person receives 100 rem exposure he/she has an 11% chance of developing cancer. Application of this risk/dose correlation to lower and lower doses is called the "linear no threshold" (LNT) model. In effect, it postulates that there is a theoretical, non-zero risk at low doses and low dose rates, even at and below the levels of background radiation.

Thus, using the LNT model, the theoretical cancer incidence risk due to 1 millirem would be 0.00000114 or 1-in-a-million.

Using the LNT model, the theoretical cancer incidence risk from background radiation for a 75 year lifetime would be 75 years x 300 millirem/year x 0.00000114 = 0.026 or 2.6%

Using the LNT model, the theoretical cancer incidence risk from radiation exposure from clean soil, containing naturally occurring radionuclides, would be would be 75 years x 40 millirem/year x 0.00000114 = 0.0034 or 0.34%.

These theoretical cancer incidence risks are incremental additional risks over and above the inherent cancer risk in the U.S. of approximately 42%.

It is important to understand that the LNT model is a theoretical statistical model, and that its use at low dose rates is viewed by many as conservative. There is little scientific evidence that small variations in radiation exposure, much less than the variability in natural background radiation levels, result in any increase in cancer risks. Although the BEIR VII report recommended continued use of the LNT model at low doses below 10 rem, it stated that, *"At doses of 10 rem or less, statistical limitations make it difficult to evaluate cancer risk in humans."*

[1] BEIR VII Report, "Health Risks from Exposure to Low Levels of Ionizing Radiation." National Academies Press. 2006.

The following scientific, professional and governmental bodies support the concept of a threshold at about 5 to 10 rem above background, below which there would be no cancer risk from radiation exposure.

- The **Health Physics Society** states. *"The Health Physics Society recommends against quantitative estimation of health risks below an individual dose of 5 rem in one year or a lifetime dose of 10 rem above that received from natural msources. There is substantial and convincing scientific evidence for health risks following high-dose exposures. However, below 5–10 rem (which includes occupational and environmental exposures), risks of health effects are either too small to be observed or are nonexistent."* Health Physics Society Position Statement on "Radiation Risk in Perspective." August 2004.

- The **General Accountability Office** states, *"According to a consensus of scientists, there is a lack of conclusive evidence of low level radiation effects below total exposures of about 5,000 to 10,000 millirem."* GAO/RCED-00-152, Radiation Standards. Page 10. June 2000.

- The **American Nuclear Society** states, *"It is the position of the American Nuclear Society that there is insufficient scientific evidence to support the use of the Linear No Threshold Hypothesis in the projection of the health effects of low-level radiation."* Health Effects of Low-level Radiation. American Nuclear Society Position Statement No. 41. June 2001.

- Notwithstanding the pronouncement of BEIR VII, the **National Academy of Sciences** stated in the earlier BEIR V report, *"With few exceptions, however, [cancer] effects have been observed only at relatively high doses and high dose rates. Studies of populations, chronically exposed to low level radiation, such as those residing in regions of elevated natural background radiation [10 - 100 times average U.S. levels], have not shown consistent or conclusive evidence of an associated increase in the risk of cancer."* Health Effects of Low Levels of Ionizing Radiation. Committee on the Biological Effects of Ionizing Radiation (BEIR V). Page 5. National Academy of Sciences, 1990.