The Health Effects of Low-Dose Ionizing Radiation

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The exact contrary of what is generally believed is often the truth.
Jean de la Bruyere (1645-1696)

ABSTRACT

Evidence indicates an inverse relationship between chronic low-dose radiation levels and cancer incidence and/or mortality rates. Examples are drawn from: 1) state surveys for more than 200 million people in the United States; 2) state cancer hospitals for 200 million people in India; 3) 10,000 residents of Taipei who lived in cobalt-60 contaminated homes; 4) high-radiation areas of Ramsar, Iran; 5) 12 million person-years of exposed and carefully selected control nuclear workers; 6) almost 300,000 radon measurements of homes in the United States; and 7) non-smokers in high-radon areas of early Saxony, Germany. This evidence conforms to the hypothesis that adequate ionizing radiation protects against cancer and promotes health.

The Dose-Response Curve

The physiologic effects of whole body exposure to ionizing radiation (principally gamma radiation) are directly proportional to the logarithm of the dose. The resultant dose-response curve is a straight line. This powerful tool allows extrapolation for information beyond known values.

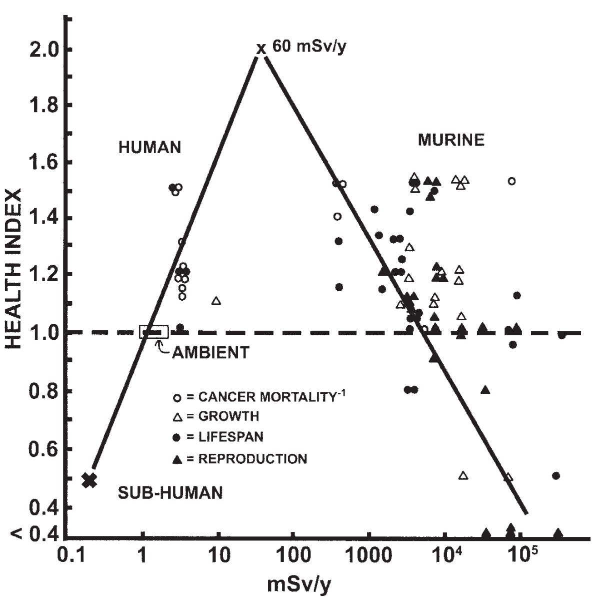

Figure 1. Complete Dose-response Curve for Ionizing Radiation in Mammals. These values were obtained using data from cancer mortality, reproduction, development, and average lifespan in humans and rodents.[2] Reprinted by permission of Inderscience Publications from *Int J Nuclear Law*.

Chronic low-dose exposure is defined to include exposures between ambient levels, about 2 mSv/y, and 8 Sv/y (8,000 mSv/y). When compared with controls living in ambient levels of ionizing radiation, murine data show a threshold of 8 Sv/y for radiation-induced harm as determined by four parameters (cancer mortality, reproductive competence, early development, and average lifespan).[1]

When total body exposures are plotted on a logarithmic scale against measures of health, the dose-response relationship is an (upper case) lambda (Λ) curve (an inverted "V"), shown in Figure 1.[2, p385] Bionegative effects observed in nonhuman species are shown beneath the dashed line representing a health index of 1.0: these occur both with radiation deficiency on the left and excess radiation on the right. The "subhuman species" used in experiments with lower than ambient levels of radiation—a radiation "deficiency"—include alga, paramecium, shrimp, barley, rat, and mouse. Biopositive effects, represented as a health index greater than 1.0, are above the dashed line. Human data are on the left side (above the dashed line), and rodent data on the right. Unfortunately, there are no data for the dose interval between these two sets. According to the Committee on Biological Effects of Ionizing Radiation (BEIR III), "experimental data from laboratory organisms must be used" in the absence of human data.[3] Collation of the data sets defines an optimum radiation level to be about 60 mSv/y. The murine line was drawn to provide a safe limit.

About 3,000 reports show the biopositive effects of low dose irradiation.[1, 4, 5] No significant evidence of harm has been found for whole-body exposures with low-dose irradiation in genetically normal mammals. The evidence reviewed here consistently shows decreased cancer mortality rates in humans following chronic exposures to low-dose irradiation. The positive effects include (a) increased immune competence (both cellular and chemical factors), (b) faster wound healing, (c) increased resistance to large doses of ionizing radiation, (d) increased DNA and cell repair systems, (e) increased reproduction, (f) decreased morbidity and mortality, and (g) increased average life span.

Chronic Irradiation Reduces Cancer Mortality

Both leukemia and solid tissue cancer mortality rates have been shown to decrease inversely with background gamma radiation in the United States.[1] In 1949, Kaplan noted that people in the Rocky Mountain states "had a considerably lower cancer mortality rate when compared with the average of the other states."[6] He also stated: "Both coastal areas were found to have higher cancer mortality rates than the average." More exact information about

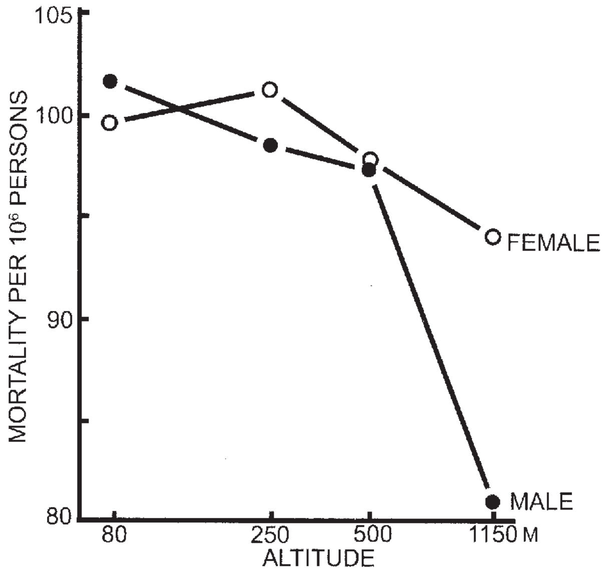

Figure 2a. Leukemia Mortality Rates Related to Cosmic and Earth Radiation.[7]

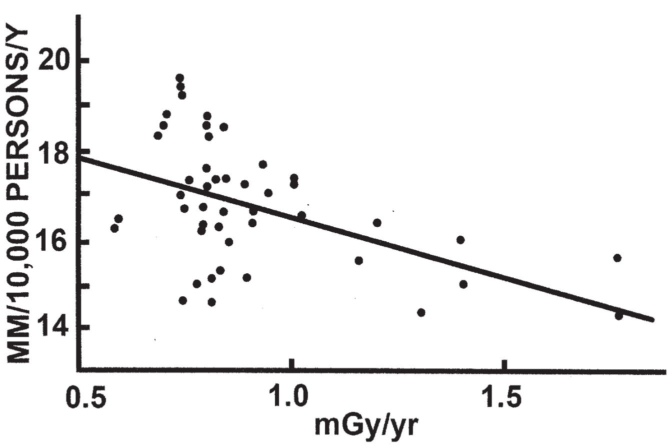

Figure 2b. Total Cancer Mortality Rates Decreased Inversely with Gamma Radiation in the 48 Contiguous U.S. States.[8] MM is malignant mortality. Reprinted by permission of Inderscience Publications from *Int J Low Radiation*.

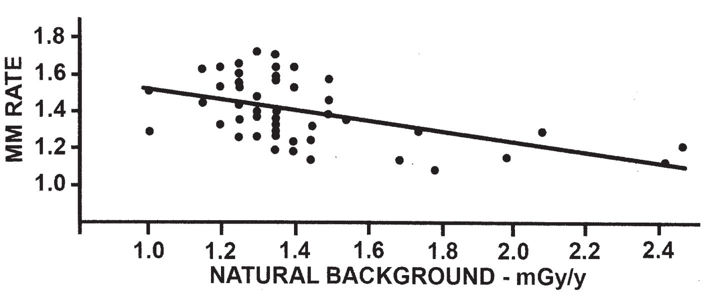

Figure 2c. Cancer Mortality Rates per Thousand Persons Compared with Gamma Radiation Levels for the 48 Contiguous U.S. States.[9]

gamma ray exposures was obtained with the same simple method, a radiometer held one meter above the ground.

In 1961, Craig and Seidman noted that increased altitude in 163 cities of the United States was associated with decreased leukemia and lymphoma mortality rates (Figure 2a).[7]

Since these data did not fit the current dogma, "all radiation is harmful," the newly formed (1971) Environmental Statement Project of Argonne National Laboratory undertook a survey to set the record straight. Its unanticipated results from cancer mortality rates for the white population in the 48 contiguous United States (Figure 2b) confirmed the earlier survey.[8] Extrapolation of the data suggests that cancer mortality might be negligible at about 7 mGy/y. People in the 12 states with the highest radiation levels had lower than average total cancer mortality rates ($P<0.01$). The authors stated: "We hope thus to indicate how it was possible for us to begin with the presumption that background radiation must be carcinogenic, only to be forced…to conclude that it was not." They concluded: "Whether age-adjusted or not, the data clearly showed an inverse correlation between background radiation and risk of cancer mortality from 56 types of cancer, especially the leukemias."[8]

In 1980, Cohen reported total cancer mortality rates were inversely related to background radiation for the United States population, which was then around 200 million (Figure 2c).[9]

In 1987, Nambi and associates reported that new cancer cases decreased in direct proportion with the increased background gamma radiation for the state hospitals of India (Figure 3).[10] Extrapolation of these data from about 200 million people suggests that increased background radiation would dramatically reduce cancer incidence.

In 1982-1983, several apartments in Taipei City, Taiwan, were built with structural steel contaminated with cobalt-60. Chen et al. noted the total cancer death rates for radiation-exposed adult occupants and controls in the city were comparable when the apartments were first occupied.[11] As both groups aged, the cancer mortality rate in the radiation-exposed group decreased while the cancer mortality rate of controls increased. The cancer mortality rate of those who had lived 9–20 years in these buildings was only 3% that of the general adult population. Chen et al. concluded: "The experience of these 10,000 persons suggests that long-term exposure to radiation, at a dose rate of the order of 50 mSv (5 rem) per year, greatly reduces cancer mortality.…"

The results found for gamma exposures also appear to hold for mixed radiation exposures. An important example of reduced cancer mortality following increased radiation (Figure 4) is a compilation of eight epidemiologic studies with 123,785 exposed nuclear workers and 199,395 carefully selected unexposed control workers from the same work sites.[12] Although some studies overlapped each other, the total cohort comprised 12 million person-years. Exposures were measured by film badges. Each study indicated that cancer mortality rates decreased with increased exposures. Using a weighted average exposure of 2 cSv, extrapolation of these data indicated an average body burden of 50 cSv would reduce cancer death rates to zero. When this dose was divided by the weighted average of 34 years exposure, the data suggest that 18 mSv/y would reduce cancer incidence so much that it would become a minor cause of death.

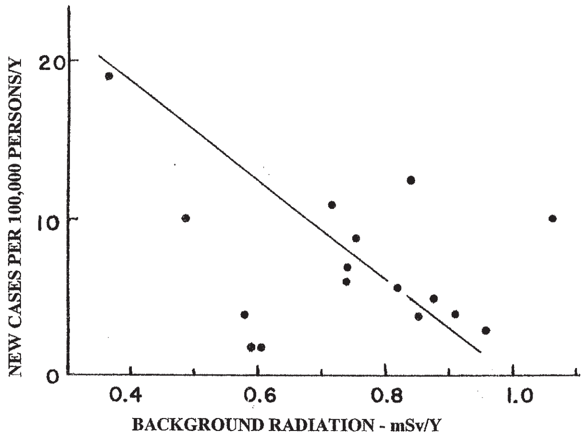

Figure 3. New Cancer Cases in the State Hospitals of India v. Background Gamma Radiation of Those States.[10] One state hospital, in Goa, with a very high incidence was omitted; this partially Portuguese population indulged in much tobacco and a special liquor. The line was drawn by inspection without mathematical manipulation. Reprinted by permission of Inderscience Publications from *Int J Low Radiation*.

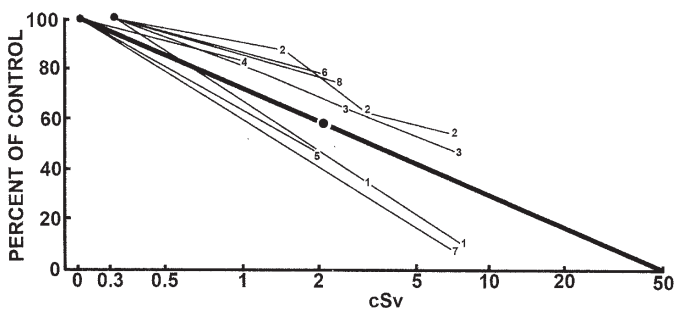

Figure 4. Dose-Response Data from Eight Studies of Cancer Mortality Rates in Radiation-exposed Nuclear Workers.[2] Multiple types of radiation were involved in each study. A weighted average for total cancer mortality rates at 2 cSv allows extrapolation (the heavy line) to zero cancer deaths. Data from the British (#1 and #2) and Canadian (#4 and #7) studies overlap. References for unexposed control and exposed workers (mostly white males) are respectively: 1) Kendall et al.[13] 2) Beral et al.[14] 3) Gilbert et al.[15] 4) Gribbon et al.[16] 5) Wing et al.[17] 6) Matanoski et al.[18] 7) Abbatt et al.[19] and 8) Wiggs et al.[20] Reprinted by permission of Inderscience Publications from *Int J Nuclear Law*.

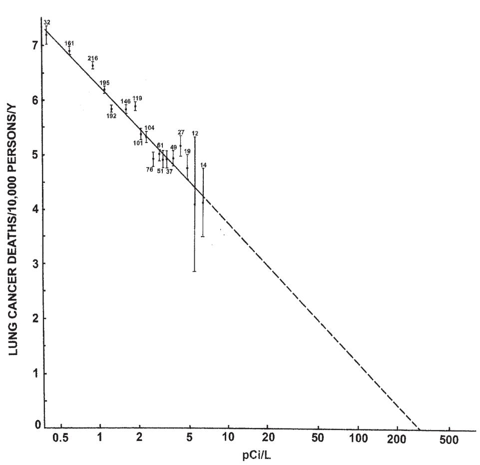

Figure 5 The Effect of Radon Concentrations on Lung Cancer Death Rates in Homes in the United States. The error bars represent one standard deviation of the mean. The data are from Cohen.[24] The number of counties represented by each datum is noted. The heavy line extrapolates the data to zero lung cancer deaths. Reprinted by permission of Inderscience Publications from *Int J Low Radiation*.

The value of 18 mSv/y was apparently validated by the experience of people in Ramsar, Iran, who have lived in homes with large amounts of ionizing radiation.[2] Although the mean effective dose is 6 mSv/y, some receive more than 300 mSv/y.[21] Mortazavi and Karam noted: "Interestingly, most local physicians in Ramsar report anecdotally there is no increase in the incidence rates of cancer or leukemia in their area…."[22] Monfared et al. stated: "However, the frequency of a few special diseases like cancer and cardiac disease in the HBR (high background radiation) residents was less than that in the area with ordinary background radiation (P= 0.011)."[23]

Radon Exposure

Two decades ago, Bernard L. Cohen noted an inverse relationship between U.S. home radon concentrations and lung cancer deaths.[24] His 272,000 individual measurements came from 1,730 counties, which include more than 90% of the U.S. population. Epidemiological correlations for 54 cofactors revealed no other valid correlations. Extrapolation of Cohen's data (Figure 5) suggests that 350 pCi/l of radon might eliminate lung cancer mortality. Continuous intake of 350 pCi/l of radon is equivalent to 400 mSv/y of total radiation. This optimum is well below the threshold of 8 Sv/y.

It appears that lung cancer protection by 350 pCi/l of radon is validated by data from mining communities in the eastern part of Germany. About 12% of the homes around Schneeberg have more than 400 pCi/l of radon. "Nevertheless, lung cancer remained extremely rare in the population before mass consumption of cigarettes started with the opening of Germany's first cigarette factory in Saxony in 1862."[25]

The excess lung cancer mortality rates of Erzgebirge miners was a myth based upon an invalid comparison: retired miners were compared with the rest of the population.[26] Lorenz cites three references indicating that there was no lung cancer in more than 700 miners in 1879.[27] Black lung disease was usual; however, anemia, congestion, infection, and silicosis caused most deaths.

Discussion

A large body of evidence shows that low-dose radiation has a hormetic effect; that is, small and large doses produce opposite effects. This can also be referred to as a biphasic dose-response curve. This is shown most clearly for cancer incidence. Studies of increased natural background radiation, occupational exposures, and radon in homes all give concordant results. The implications are far-reaching. Hattori noted: "If radiation hormesis exists, our daily activities in radiation management have been extremely erroneous."[28] Muckerheide and Rockwell have elaborated on this concept.[29]

Costly and stringent regulation to minimize radiation exposure is not only unnecessary; the evidence strongly suggests that it is actually harmful. The data presented support the hypothesis that ionizing radiation is an essential agent and that we live with a partial radiation deficiency that increases cancer incidence.[30] Moreover, optimal radiation exposure might curtail the excessive cancer incidence that we are now experiencing. As indicated in Figure 1, the optimum level for chronic irradiation appears to be about 60 mSv/y, 30 times our average exposure.[2] Biostatistician D. Hutcheson calculated that the elimination of cancer deaths would increase the average lifespan by 10 years (D. Hutcheson, personal communication, December 2007). One source for increased irradiation could be radioactive waste. Thus, nuclear waste that was considered a problem for the 20th century could become a solution for the 21st century.[31]

The basic concept may be tested in the future. Treatment rooms of several Japanese radiation hormesis clinics would expose occupants to about 90 mSv/y. Aside from any therapeutic value of low-dose irradiation for the patients, the staff receives about one-third of this dose. When compared with adequate controls, the staff should have notably increased health and average lifespan, if the concept of radiation hormesis is correct.

Conclusions

Evidence suggests that some of the more than 500,000 cancer deaths in the U.S. each year[30] could be prevented by increased exposure to ionizing radiation. It has not been possible to explore this possibility because of restrictions imposed by law and by national and international agencies. These restrictions are based on consistent misstatements by many radiation biologists and health physicists.[32]

Is it ethical for physicians to withhold a modality that might provide significant cancer prevention? Research into the hormetic effects of ionizing radiation should be pursued and encouraged, and physicians should not be hindered from applying existing evidence in making optimal irradiation available to patients who choose it.

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