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Resolving the Controversy over Beneficial Effects of Ionizing Radiation

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Abstract

In spite of the extensive research carried out during the past century, intense controversy continues over the health effects of low-level radiation. This controversy is largely due to political, social and economic issues among scientists and analysts in a variety of disciplines. These issues cloud objectivity and strengthen paradigms. Over the past ten years, in 14 universities and two research institutes, Japanese scientists have conducted exceptional research which clearly demonstrates beneficial effects of low-level radiation and cancer cures following therapy with low doses of radiation. Assessment, replication and extension of this work in North America could lead to greater appreciation of its significance. Cancer patients would demand such treatments, leading to universal acceptance of these bio-positive effects and reducing public fear of nuclear technology.

Keywords: nuclear radiation, public fear, cancer, low-dose, hormesis, beneficial effects, controversy, Japanese medical treatments

Introduction

What is the key to the golden age of nuclear technology that awaits us in the next millennium?[1] Is it not the resolution of this issue? Is it not the public awareness of the real effects of radiation on health, leading to a more positive attitude towards nuclear energy?

We must congratulate the World Council of Nuclear Workers for its initiative and leadership in taking on the challenge to examine this very important matter in this forum. This is quite appropriate because nuclear workers have a vital concern in the resolution of this on-going scientific controversy, which has greatly intensified over the past five years. On the one hand, they enjoy many interesting well-paying jobs, which provide tremendous benefits to humanity, but on the other hand, they routinely receive low doses of radiation in their occupation. Power plant workers live with their families near reactors and experience, in addition, the public concern about the possibility of a release of radioactivity.

Is it not true that most people believe that nuclear radiation is an important carcinogen? – that it also produces significant genetic effects? As a cause of death in Canada, cancer has risen to an incidence that exceeds 25 percent of the population. So cancer has become a great concern! People want to identify and avoid the causes, and they demand cures. The anti-nuclear movements are aware of these perceptions and fears, and they take advantage of them in their campaigns to advocate the phase-out of all nuclear technologies.

There have been cases where a court of law has accepted a nuclear worker's claim for compensation from his employer for becoming ill with cancer many years after exposure to low doses of radiation. These judgments were based on the common knowledge that radiation in any amount causes cancer. Will these cases set precedents for many more to follow? It is clearly important to resolve this matter soon.

What are the real effects of radiation? Ionizing radiation and radioactivity were discovered by Röentgen and Becquerel more than a century ago, and many scientists have studied these phenomena ever since. We have mountains of data about the actual effects of radiation on health. There is a consensus that a large, short-term dose causes burns and, in some of the cases, cancer occurs years later. However, as we know, there is a major disagreement about the effects of a low dose of radiation, received within a day or gradually over a long period of time. Many scientists believe, or assume, that the smallest doses of radiation still cause cancer, while others point out that the evidence shows that there are either negligible adverse effects or beneficial effects.

The controversy is due to major political, social and economic issues, affecting many scientists and analysts in a variety of disciplines. These issues cloud objective research and thinking, and increase resistance to changing established paradigms. So the disagreement will not be resolved simply by presenting more scientific evidence, as has been done many times over.

Considerable progress has been made in recent years in the field of molecular biology which is helping scientists understand the data and design new experiments to formulate and validate better models of cell behaviour. But the long-term effects of low doses of radiation will continue to be debated.

It is not very surprising that the Japanese, who suffered from the consequences of two nuclear bomb blasts, and now have a large nuclear power program, are world leaders in measuring and understanding the actual health effects of radiation, especially low doses of radiation. Their investigations have clearly shown that low doses of radiation are beneficial to health and that medical treatments with low-dose radiation can be used to cure diseases, including cancer. Unfortunately, the Japanese scientists are subject to the same political and social pressures that we experience in the west. So, how can this controversy be ended?

A promising way is to communicate the methodologies and results of the Japanese research to medical scientists in other countries and urge them to review, repeat and extend these studies. Once our own medical centres become familiar with these discoveries, patients with terminal diseases could be offered such therapies. The pressure from dying patients, seeking cancer cures, would lead to widespread acknowledgment of the beneficial effects of low-level radiation, helping to end the fear of all things nuclear.

Implementation of such a strategy is underway at the International Centre for Low Dose Radiation Research at the University of Ottawa in Canada, in cooperation with Japan's Central Research Institute of the Electrical Power Industry.

Early studies of the health effects of radium[2]

After the isolation of radium in 1898 by the Curies, physicians were intrigued by the potential effects of energetic heavy particles within the human body. This new form of energy deposition suggested that radium decay might have some therapeutic potential, and led to the first laboratory trials of radium in the United States. The Standard Chemical Company was formed in 1910 to handle radium production and sales. It included a biological laboratory to investigate medical uses of radium. The *Radium* journal was established in 1913, in which physicians could record the results of the treatment of many diseases through internal or external applications. Many patients were treated with radium in order to identify the medical ailments which radium can alleviate, e.g., arthritis, and the doses required. Doses up to 1,000 μCi were tolerated well.

The virtues of radium therapy were promoted until the late 1920s when the hazards of internal radium became apparent. The best known form of radium available to the public was radium water, e.g., 60 mL bottle of *Radithor* containing 2 μCi of radium. This form of therapy ended after the April 11, 1932 edition of *Time* magazine which publicized the death of celebrity E.M. Byers by "radium poisoning." He consumed 5,000 μCi of this product over several years.

Another early use of radium (starting in 1903) was the application of radium-luminous paint to watch and instrument dials. Symptoms of radium poisoning began to be observed in 1924, which was attributed to the painters' practice of pointing the brush with their lips. The condition was named "radium necrosis," e.g., jaw-bone necrosis (destruction). The radioactive elements formed fixed deposits, chiefly in the spleen, bones and liver. This appeared as a deterioration of the jaw and other bones, cancers and anemia leading to death. The 31 dial painting plants were closed by 1926. During the 16 years of luminous dial painting in the US, approximately 2000 dial workers had been involved.

R.D. Evans carried out extensive research on the radium dial painters and developed techniques to quantify and characterize their individual exposures. In 1941, he determined 0.1 μCi of radium to be the maximum permissible body burden, which included a safety factor of one or two orders of magnitude. In 1974, he identified a threshold and provided dose-response plots of cumulative (excess) tumor incidence versus cumulative (lifetime) skeletal dose.[3] He found tumor incidence to be 28 ± 6% at 1,000 to 50,000 cGy, and <u>zero</u> below 1,000 cGy. This threshold corresponds to a dose of 200 Sv (20,000 rem).

Experiments were conducted on the effects of radium on rats which showed that, per unit body weight, 150 times as much radium was required to produce particular chronic symptoms in the rat as in man. Evans concluded that "the proper subject for the study of man is man."[4]

Studies of human encounters with plutonium

Research on the health effects of plutonium inhaled and ingested by the Manhattan Project workers at Los Alamos started in 1952 to determine the delayed effects. Workers at Rocky Flats and the Mound Laboratory were also studied. The highest exposed workers, put in a group of 26, had effective doses ranging from 0.1 to 7.2 Sv. Although plutonium has been called "the most toxic substance known to man," this group has remained in surprisingly good health ever since. Dire predictions of catastrophic increases of lung cancers have not occurred. In fact, mortality has been significantly lower than the non-plutonium workers.[5] Studies of Russian plutonium-exposed workers are proceeding and are important because their exposures were much higher.

Studies on the Japanese bomb survivors and the LNT hypothesis

Studies of 86,572 bomb survivors revealed the long-term effects of the (short-term) exposure to be mainly 334 solid cancer deaths in excess of the 7244 cancer deaths expected.[6] The data at low dose was not statistically significant, so the risk was *inferred* and the excess deaths at low dose were *estimated* using a linear model.[7] The lowest DS86 dose at which there appears to be a statistically significant excess risk is 35 cSv (0.2-0.5 Sv). There are unresolved questions about the dosimetry which indicate that the neutron doses were at least five times greater than the gamma dose equivalent, suggesting that the initial T65D dosimetry should be used. Use of this dosimetry would put the lowest dose for a statistically significant excess risk of solid cancers above 1 Sv.[8, 9]

A fundamental scientific error was made when the linear fit to the cancer data, observed in the range of high doses, was extended outside this range into the low-dose range, where there is no statistically-valid cancer data, by assuming that the incidence of cancer is proportional to dose.[10, 11] (Figure 1) This assumption is convenient for nuclear regulators and safety analysts, and has been enshrined as the linear no-threshold (LNT) model and widely publicized. However, careful studies and experiments have not shown an increase in cancer following a low dose. There are even observations of decreased cancer.

Scientific evidence of beneficial effects following low doses of radiation

Beneficial effects were observed soon after the discovery of radiation, as was noted above, however T.D. Luckey carried out comprehensive studies and published two books on the phenomenon of radiation hormesis.[12, 13] He explained it as a particular case of hormesis – the stimulatory effect of a small dose of a stressing agent: physical, chemical or biological. His 1982 review article in the HPS Journal[14] resulted in an international symposium in

1985[15] and a large research program in Japan (see below) to determine whether radiation hormesis is really true.

Since then, there have been many studies on beneficial effects of low dose radiation. Annex B of the 1994 UNSCEAR report[16] reviews many of them as examples of "the adaptive response," in which organisms change after a small "conditioning" dose of radiation to better survive a subsequent massive "challenging" dose. The adaptive response is evidence of radiation-stimulated repair mechanisms in action. Is it not reasonable to expect systems, stimulated in this manner, also to repair damage caused by normal metabolic degradation?

Pollycove has reviewed much of the scientific evidence for radiation hormesis in several articles and presentations.[17, 18, 19, 20, 21]

Calabrese and Baldwin have pointed out that one of the major reasons why positive effects following low doses of chemicals are generally not observed, even though they occur, is that scientists have not been looking for them and have not designed their experiments to find them.[22, 23] This assessment likely holds true also for radiation hormesis.[24]

A classic test of the LNT theory of for inhaled radon decay products has been carried out. It proved that the LNT model is not valid.[25] Other considerations have been presented which demonstrate that the LNT model is wrong and gives the wrong predictions.[26] Nevertheless, many scientists and analysts continue to use this model because it is "conservative" (predicts more cancers than actually occur) and convenient for them.

The LNT-postulated increase in cancer due to low-dose exposure, if it were true, would be obscured below ~30 cGy by the statistical variation in the normal occurrence of fatal cancer in ~25 percent of the population, as shown in Figure 2. The recent regulatory recommendation[27] to <u>lower</u> the permissible dose limit for nuclear workers and the public has been challenged by the French Academy of Sciences.[28, 29]

The Health Physics Society issued a position paper in 1996 pointing out that "biological mechanisms including cellular repair of radiation injury reduce the likelihood of cancers and genetic effects." "Radiogenic health effects (primarily cancer) are observed in humans only at doses in excess of 10 rem delivered at high dose rates." It recommended that "estimates of risk should be limited to individuals receiving a dose of 5 rem in one year or a lifetime dose of a least 10 rem in addition to natural background. Below these doses, risk estimates should not be used ..."[30]

The press release following the Wingspread Conference read, "In a surprise move, leading United States and international scientific experts agreed in an historic accord that an increase in cancer has not been observed at radiation exposures below 10,000 mrem given to the whole body in a short time."[31]

It is important to note that much still remains to be learned about this phenomenon and the effects of radiation on people. For example, the ~1000 cases and three fatalities of thyroid cancer in children following the Chernobyl disaster is not well understood by scientists. The effects of radiation on children need further study.

Scientists have assumed that genetic effects, observed in plants, insects and animals, are also applicable to humans. This was also publicized widely, but there is no evidence to support this assumption.[32] However, 8-15 weeks after ovulation, it is well known that a short-term dose of 20 cSv or more to a fetus interferes with its rapidly-developing nervous system.[33, 34] Even though normal cell repair mechanisms work at a higher pace during rapid fetal development, they are not accustomed to coping adequately with the effect of a sudden high dose rate.

Just about everybody believes that exposing people to a very small dose of radiation will increase their likelihood of cancer and genetic effects. So we have great difficulty using nuclear technologies and transporting, storing and disposing radioactive wastes. Some environmental regulators[35] define a "contaminant" as "any solid, liquid, gas, odour, heat, sound, vibration, radiation or combination of any of them resulting directly or indirectly from human activities that may cause an adverse effect." A complex, expensive and time-consuming environmental assessment, based on the LNT hypothesis, is required before permission is granted to proceed with a project involving any nuclear application.

The US Department of Energy is funding $12 million of new research in 1999 on the "serious study of molecular and cellular responses to low dose radiation ... to provide us with real understanding on which to base intelligent standards for radiation protection."[36]

Beneficial effects observed in the Japanese research[37, 38]

As mentioned earlier, the revelation of Professor Luckey's work stimulated extensive research in Japan to corroborate the notion of radiation hormesis. However, Professor Sakamoto had been applying whole-body, low-dose irradiation as a therapy to suppress the cancer reappearing after conventional treatment, for ten years prior to this heightened interest. He reported on the success of his therapy on real patients. The therapy showed an enhancement of their immune systems and cures lasting more than ten years. For example, the survival rate of non-Hodgkin's lymphoma patients was increased by this therapy from ~50% to ~84%.[39]

The Central Research Institute of the Electric Power Industry (CRIEPI) organized a Hormesis Research Steering Committee, carried out preliminary studies which gave very interesting results, and then initiated an expanded program involving fourteen universities and two research institutes. Bio-positive effects were found which could be grouped as:

- rejuvenation of cells (increase of SOD and cell membrane permeability)
- moderation of psychological stress through stimulation of key enzymes
- suppression and therapy of adult diseases, such as diabetes and hypertension
- suppression of cancer through enhancement of the immune systems

- suppression of cancer and radio-adaptive response by activation of DNA repair and cell killing.

Cooperation between Japan and Canada

This exciting and very important research continues in Japan, but it has not been gaining global acceptance. On the encouragement of CRIEPI to duplicate the Japanese studies in Canada,[38] a program of cooperation is being established between CRIEPI and the International Centre for Low Dose Radiation Research at the University of Ottawa. This program is planned to include the participation of cancer treatment clinics in hospitals in Ottawa and Toronto.

Conclusions

The current pace of the evolution towards science-based regulation of nuclear technology may be too slow to prevent the phase-out of nuclear technology, being driven by political and anti-nuclear environmental movements. The nuclear workers are very important and credible participants in the resolution of this controversy, by virtue of the direct impact of radiation on their health and the public fear of radiation on their jobs. The recent massive public demonstrations of 35,000 nuclear workers in Bonn and 4,000 in Prague have shown that the workers can exert considerable influence in the public forum. Could they not also urge the scientists and regulators to use more scientific methods to quantify the actual benefits and risks of radiation at low and high doses?

But the real key to resolving the controversy are patients with cancer and other life-threatening diseases who could be cured by low dose radiation treatments (with negligible side-effects), if they were available. These people have an immediate life-or-death interest in the resolution of this controversy.

If western scientists would only urge the replication of the Japanese medical treatments in their local hospitals, the effectiveness of these low-dose treatments could be confirmed. If terminal patients were aware of these remedies, they would demand the treatments. This would soon lead to universal acknowledgment of the reality of radiation hormesis, and end the fear of low-level radiation and all things nuclear.

This conference provides an exceptional opportunity for nuclear workers to become more informed about this vital issue.

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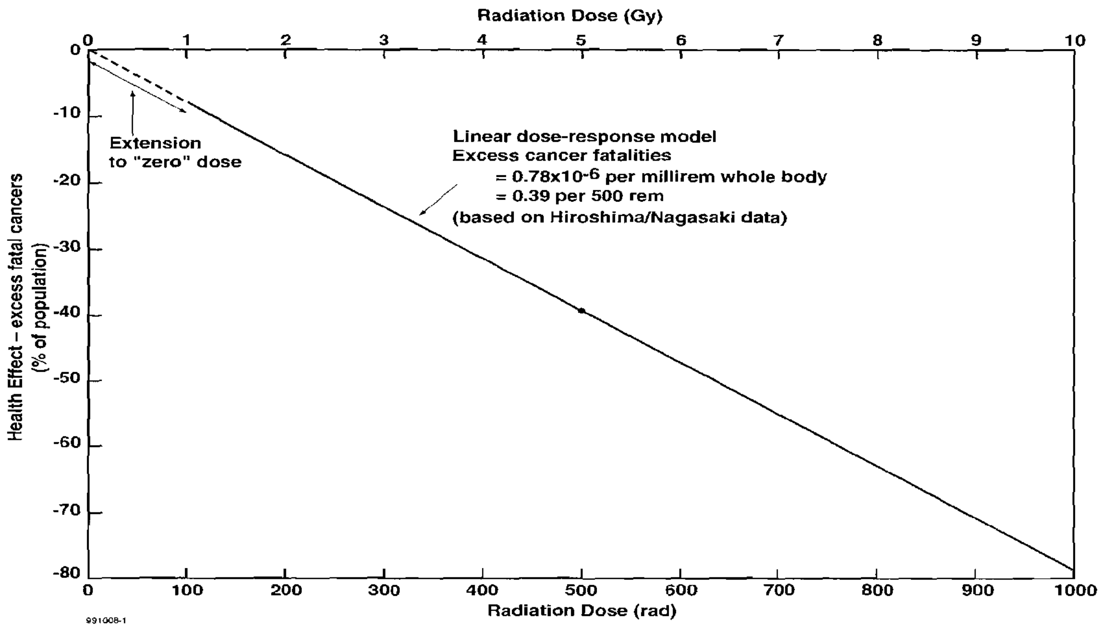

Figure 1. The linear dose-response model for radiation-induced cancer

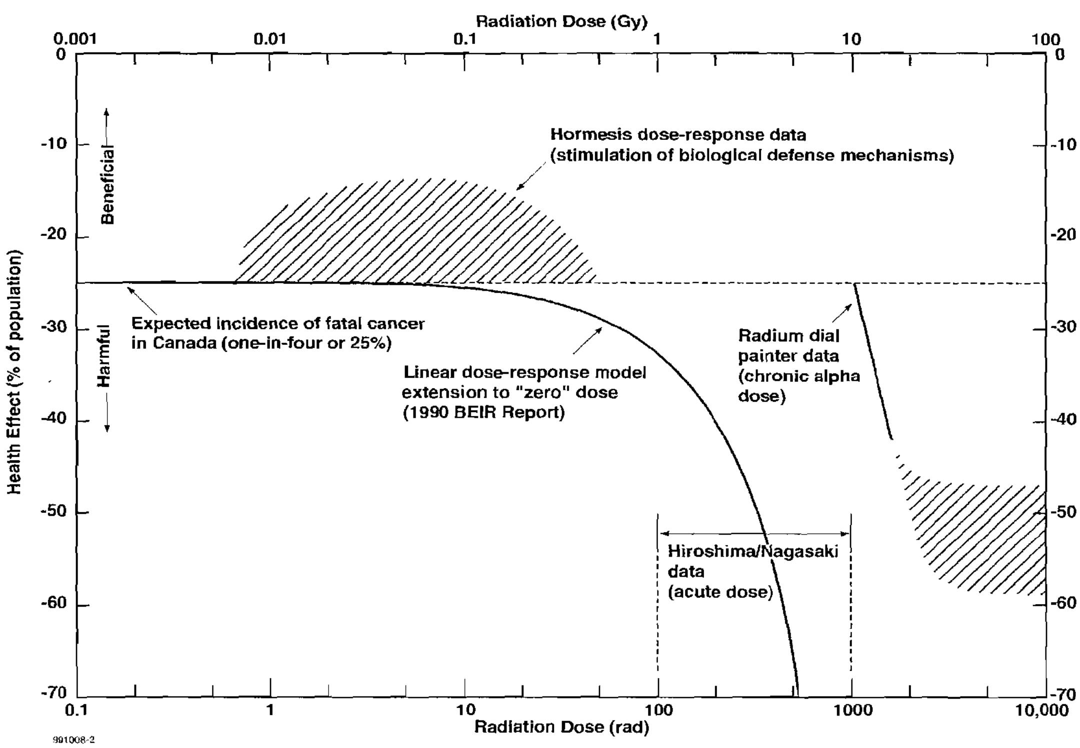

Figure 2. The linear model with radiation dose on a logarithmic scale