LOW DOSE RATE CHRONIC RADIATION IS EXTREMELY IMPORTANT TO HUMAN BEINGS

W. L. Chen\textsuperscript{a}, Y.C. Luan\textsuperscript{b}, M.C. Shieh\textsuperscript{b}, S.T. Chen\textsuperscript{b}, H. T. Kung\textsuperscript{b}, K. L Soong\textsuperscript{b}, Y. C. Yeh\textsuperscript{b}, T.S. Chou\textsuperscript{b}, W.C. Fang\textsuperscript{b}, S.L. Yao\textsuperscript{b}, C.J Pong\textsuperscript{b}, S.H. Mong\textsuperscript{c}, J.T. Wu\textsuperscript{c}, J.M. Wu\textsuperscript{c}, H.J. Jen\textsuperscript{c}, J. H. Chiu\textsuperscript{c}, W. P. Deng\textsuperscript{d}, M. F. Wu\textsuperscript{e}, M.L. Shen\textsuperscript{e}, C..P. Sun\textsuperscript{f}, Y.W. Yi\textsuperscript{g}

\textsuperscript{a}National Yang -Ming University, 155 Li-Nong St, Sec 2, Pei-tou, 112 Taipei, Taiwan, ROC
\textsuperscript{b}Nuclear Science & Technology Association, 8F, No 182 , Sec 2, Binsin Rd, Sindian City, Taiwan,, ROC
\textsuperscript{c}Nuclear Biological and Chemical Protection Society, 11F-5/110, Cheng-Tu Rd, Taipei ,Taiwan, ROC
\textsuperscript{d}Institute of Biological Material, Taipei Medical University, 250 Wu-Shing Street, Taipei, Taiwan, ROC.
\textsuperscript{e}National Taiwan University, Taipei City, Taiwan 10764, ROC
\textsuperscript{f}National Chiao-Tung University, Hsin-Chu City, Taiwan, ROC
\textsuperscript{g}National Tsnig-hua University, Hsin-Chu City, Taiwan, ROC

Abstract: Two events have revealed the human health effects of radiations: the first one was the acute radiation to the Japanese from the atomic bomb explosions in Hiroshima and Nagasaki, Japan; the second was the chronic radiation received at low dose rate by the residents in the Co-60 contaminated apartments in Taiwan. The acute radiation was most harmful to the Japanese, except at low doses. Even though the chronic radiation accumulated even to high doses to the Taiwan residents, they were not harmed; on the contrary, their spontaneous cancer deaths were reduced to only 2-3% of the general public’s. These health benefits of chronic radiation would be advantageous to workers in the peaceful uses of nuclear energy and in medical applications. In the case of a nuclear reactor accident, the acute radiation received by the workers could harm the workers, even kill them, but any released fission products dispersed to voluminous space and decayed to give only chronic radiation outside of the power plants could prevent cancer deaths that would otherwise occur.

1. Introduction

Radiation, including non-ionizing radiation, in the environment might be essential as air and water to the health and vitality of human beings. The health effects of acute radiation observed in two atomic explosions in August of 1945 were most harmful to the Japanese. Radiation started to be feared by people, became the main basis for anti-nuclear movements. The view that radiation is always harmful became the basis for radiation protection and regulation until today. Fortunately, the Taiwan event showed that the health effects of chronic radiation received in low dose rate (<1 mSv/hr), with doses even accumulated to high level, were beneficial to the irradiated residents observed, and their spontaneous cancer mortality rate was reduced to only 2–3 % of the rate in the general population. More fortunately, the chronic radiation is similar to the radiation received in the peaceful uses of nuclear energy and applications in medicine.

Therefore, chronic radiation is extremely important to humanity, people should always welcome it, and the conventional radiation protection policy and regulation originated from the atomic bomb explosions should be revised. If an accident occurs in a nuclear power plant, the release of highly concentrated fission products could give off high dose-rate radiation similar to acute radiation, which could harm and possibly kill workers; but when the fission products are dispersed into voluminous space and decay to give low dose rate chronic radiation outside of the power plant, it would be beneficial to the public, and could prevent a great number of cancer deaths. The chronic radiation of higher natural background regions and higher radon concentration in some locations in the world would also be beneficial to people. Results show that chronic radiation in dose rate <1 mSv/hr is always beneficial to humanity, although levels much greater than 1 mSv/hr need further study.
2. The harmful health effects of acute radiation

Estimates by military scientists of the damage from atomic explosions indicated that deterministic harm was caused first by blast, second by heat and last by radiation [1, 2]. The radiation from the atomic explosions might be divided into two types: first the initial radiation of gamma rays and neutrons emitted directly from the blast center exposed the Japanese people almost instantaneously; second the residual radiation of gamma, beta and alpha, emitted from fission products which were dispersed in the environment and might also have entered into human body and continuously emitted internal radiation. Most radiation to the Japanese people was the initial acute radiation from the explosion center; a much smaller exposure was due to residual radiation from fission products, which were mostly vaporized into gases and raised to the troposphere and drifted away to be global fallout, which could deliver little radiation to the Japanese.

The health effects of acute radiation vary greatly with the total doses received. The unit of acute radiation doses used in this paper is the effective dose equivalent of Sievert (Sv). The stochastic health effects of the acute radiation to the Japanese were mostly harmful, increasing the cancer mortality of survivors, and possibly also increasing the hereditary deformations of their offspring. The stochastic health effects of acute radiation had comprehensively studied by the US and Japan joint Radiation Effects Research Foundation (RERF) [3]. The study results had clearly showed that 86,572 survivors had 334 excess solid cancer deaths among 7244 spontaneous deaths, and 87 leukemia deaths among 162 spontaneous deaths. But the excess mortality of the survivors was observed mostly in higher doses range. About 90% of leukemia and 45% of solid cancers occurred in survivors who received doses greater than 2 Sv. The LNT model was developed based on RERF study results at higher radiation doses. When received doses were lower than 200 mSv, the increase of cancer mortality was not clearly observed and could not extrapolated from high doses or with modifying factors. The cohort of 42% of survivors who received doses <0.5 mSv, had less solid cancer deaths, and the cohort of 42% of survivors received doses in 0.5 mSv-100 mSv, had also less leukemia deaths observed than survivors receiving higher radiation doses. Only survivors who received high doses, >200 mSv, had an observable increase in the solid cancers and leukaemia. The leukemia mortality which increases rapidly in a short period is a good indicator for demonstrating the health effects of acute radiation; while the solid cancers is not, as only 334 excess solid cancer deaths occurred among 7244 spontaneous deaths in a long time. Dr Sohei Kondo asserted the low doses acute radiation might be harmless or even beneficial to the survivors [4]. The assumption in the LNT hypothesis preferred by ICRP that radiation is always harmful to people seems unreasonable. Lower dose acute radiation <200 mSv might be harmless and even beneficial to people. People’s fear of radiation, encouraged by anti-nuclear movements, is unreasonable.

3. The beneficial health effects of the chronic radiation

Many epidemiological studies show that populations in higher natural background radiation areas in the world [5, 6, 7], and nuclear energy workers of power plants or facilities in many countries [8] had lower cancer mortality; these facts had never been positively recognized by the international radiation regulatory communities, such as the ICRP, IAEA and UNSCEAR, etc.

Coincidentally, an out of control Co-60 incident occurred in Taiwan, where Co-60 was melted into steel bars used for construction of about 1700 apartments and exposed to about 10,000 residents in the apartments to radiation. The residents had no excess cancer mortality as would have been expected based on LNT; on the contrary their spontaneous cancer deaths sharply reduced to only 2~3% of the general population in 22 years. The first contaminated apartment was discovered in August of 1992, then one-by-one until today. This Co-60 contamination incident in Taiwan proved that chronic radiation has great beneficial health effects that could reduce cancer mortality of humanity, and might also reduce the hereditary diseases prevalence. The health effects of the chronic radiation was completely different to the health effects of acute radiation observed in the atomic bomb explosion in Japan.

The study of health effects of radiation usually uses epidemiological methods to investigate the harm caused, but the results of the chronic radiation event in Taiwan was found serendipitously to have the
reverse results. About 10,000 residents had lived in the apartments for at least 9 years, some up to 22 years, but the number of cancer deaths was greatly reduced. The average annual dose received by the residents in the first year 1983, was about 50 mSv/y, the highest was about 600 mSv/y. Their average total dose in 22 years was about 0.42 Sv, some received up to 6 Sv. The average dose is higher than the average doses received by the atomic bomb survivors, and also higher than the doses received by the Russian emergency workers in Chernobyl accident. If the LNT model is appropriate for evaluation of the health effects of the chronic radiation, such excessive doses of the residents would cause about 40 excess leukemia and 50 solid cancer deaths in 22 years, and their spontaneous cancer deaths would be 264, making the total deaths in 22 years expected to be 354. Actually their cancer deaths reduced to only 7 or 2.65% of the rate expected in the general population, as shown in Figure 1 which theoretically plotted in 1998 by Luan et al. The number of cancer deaths of the residents and predictions based on LNT are shown in Table 1.

![Figure 1](https://example.com/figure1.png)

*Figure 1 Chronic radiation could greatly reduces cancers*

**Table 1: The natural, predicted and observed results in 22 years**

<table>
<thead>
<tr>
<th>Natural (expected) cancer deaths</th>
<th>Natural (expected) hereditary defects</th>
<th>ICRP model predicted cancer deaths</th>
<th>ICRP model predicted hereditary defects</th>
<th>Observed cancer deaths</th>
<th>Observed hereditary defects</th>
</tr>
</thead>
<tbody>
<tr>
<td>264</td>
<td>46</td>
<td>314</td>
<td>67</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Includes 4-5 leukemia</td>
<td>All congenital diseases</td>
<td>264 natural 90 caused by radiation</td>
<td>46 natural 21 caused by radiation</td>
<td>2.65% of the general public cancer death rate</td>
<td>6.5% of the general public congenital disease rate</td>
</tr>
</tbody>
</table>

4. **Discussion and recommendation**
This paper has described the health effects of acute and chronic radiations. The acute radiation from atomic bombs and nuclear accident is harmful to people in high doses range, but low doses <200 mSv is harmless or even beneficial to people [4]. Chronic radiation is most important to human beings, at a dose rate around <1 mSv/hr is always beneficial to people, but dose rates higher than 1 mSv/hr need further studies. Mice experiments by Dr Shu-Zheng Liu [30] and Dr. R. E. J. Mitchel [31] at dose rate about 60 mSv/hr still showed beneficial effects. This shows that chronic radiation should never be feared. Any chronic radiation from the use of nuclear power would be very beneficial. The health effects of chronic radiation could be also used in prevention of cancers.

There is some uncertainty whether to include in this analysis the about 2000 students who received radiation from the contaminated classrooms of elementary and kindergarten, when they were the in the age 3 to 12 years, now 24 to 33 years, and two of whom died of leukemia. The Taiwan AEC did not consider the leukemia attributed by radiation, as their doses were too low. These students should not be listed in the resident cohort, as their age distribution and cancer mortality were not same as the residents. They should be listed in a separate cohort, and separately follow their health.

The cancer deaths of the residents and of the students, should be also discussed in other papers presented to the international conference and journals [9, 10, 11, 12, 13, 14], but they seemed to purposely avoid to mention of the cancer deaths, even two US authors knew the high doses and few cancer deaths [9, 14]. This paper has mainly studied the relationship between the doses and the reduced cancer deaths due to low dose race chronic radiation [15, 16, 17, 18, 19, 20, 21].

A theoretical dose-effects relationship illustrating the benefit of chronic radiation is shown in Figure 2. Chronic dose rates less than the natural background of 2.4 mSv/y might be harmful to people. Chronic radiation doses greater than 2.4 mSv/y would always be beneficial and reduce cancer mortality. Chronic doses close to 50 mSv/y might be most effective in immunity to cancer.

The recommendations of this paper are as follows:

1. Further study the mechanism of chronic radiation.
   Assess whether the mechanism of health effects of chronic radiation is related to stimulation of the immune system and whether the internal radiation from radioactive isotopes could also benefit people.

2. Revise radiation protection policy and regulation
   The conventional radiation protection policy and regulation, based on data from the atomic bomb explosion and animal experiments and assuming that any tiny radiation is harmful to people (the LNT model), should be revised earnestly based the beneficial health effects of chronic radiation observed from the Taiwan contamination incident.

3. Apply chronic radiation to prevention of cancers
   Cancer is the most miserable sickness of human beings and chronic radiation could be used to prevent cancer deaths. Elder volunteers could receive 50 mSv/y chronic radiation to prevent their cancers if the HPS and ANS issued statements that cancer deaths could be prevented without producing any other harms.

4. Apply chronic radiation for therapy of other sickness
   There were also many papers indicated chronic radiation could reduced other sicknesses of people [28, 29]. Japanese radiation scientist Dr. Kazuo Sakai et al of the Central Research Institute of the Electric power industries (CRIPI) experimented with mice had shown chronic radiation could also prevent the tumors, diabetics and autoimmune diseases (AIDS), and 5 papers had been published in the international journals [32, 33, 34, 35, 36]. Therefore the chronic radiation should be also studied for therapy of other sickness.

5. Address the beneficial health effects of chronic radiation to the entire world.
As health effects of chronic radiation are so important to humanity, the US Health Physics Society should recommend that major US nuclear organizations DOE and IAEA should cooperate with Taiwan radiation communities to confirm the beneficial effects of chronic radiation.

6. Recommend a new doses-effects relationship for low dose rate chronic radiation

The new dose effects relationship could show that when chronic doses less than the natural background of 2.4 mSv/y are harmful to people, and chronic radiation doses greater than 2.4 mSv/y are always beneficial because of reduced cancer mortality. The relationship recommended is in the Figure 2.

5. References


[17] Y.C. Luan et al, “The hormetic health effects of radiation observed in the incident of Co-60 contaminated apartments in Taiwan” the Non-linear Dose- Response Relationships in Biology, University of Mass. Amherst, MA


[22] NUREG-1103, “Contamination Mexican Steel Incident”, NRC, 1985


