“Fear of radiation” is frightening

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The world's two worst industrial disasters occurred in the early years of my career in radiation physics. The Bhopal gas tragedy was the worst industrial accident and occurred on the night of December 2–3, 1984 at the Union Carbide pesticide plant in Bhopal, India and killed 10,000 people on that one night. The worst ever nuclear accident occurred at the Chernobyl Nuclear Power Plant in Ukraine on 26 April 1986, which led to less than 60 fatalities within 3 months of the accident. These two catastrophic events helped me shape my perception of the risks associated with modern industrial processes.

While many have forgotten the Bhopal gas tragedy, the Chernobyl disaster is still fresh in our collective memory. Last year was the 25th anniversary of the Bhopal gas tragedy and I asked my medical radiation students if they had heard of this event. Not a single student out of the 80 in the class had

heard of or read about this event. However, more than a handful of students had heard or read about the Chernobyl disaster. The students were shocked to hear that for every one person killed in the immediate aftermath of Chernobyl one hundred more fatalities were recorded in Bhopal.

I often wonder why our perception of the risk associated with ionising radiation is so heavily skewed. Who is responsible for this public anxiety? Is it the media, politicians or scientists? I think the burden of responsibility falls equally on all three sections of society. If our perception of the risk is not balanced, we are predisposed to making incorrect judgments. Such decisions are invariably costly and often lead to exposure to the unknown and perhaps more significant risk elements.

After more than 100 years of research, the risk radiation poses to humans is still poorly understood at 'low dose' level. Most people regard a dose less than 100 mSv as low dose. Public fear of radiation began to develop after the dropping of the A-bombs on Japan during WW2. The fear has been propagated by the blatant lies of the anti-nuclear campaigners and was and is still supported by the mass media seeking sensationalist stories. The saying 'Never let a fact get in the way of a good story' unfortunately holds very true when applied to events involving ionising radiation. It is nearly impossible for a scientist to get anything in the mass media that contradicts the prevailing falsehoods.

My own experience illustrates that even professional radiation physicists are not spared from radiation phobia. On one occasion I was working near the door of a high dose rate (HDR) brachytherapy room, where the dose rate out of the shielding container is typically 5 μ Sv/h. My colleague, a physicist, insisted that I move away from that area as they considered the area to be characterized by a 'high radiation level'. I obliged, as at the time, it was easier than to explain why it was safe for me to work there. I was

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born in Kerala where the natural background radiation level is as high as 4 μGy per hour. I was continuously exposed at this dose rate until the age of 24 when I relocated to a different place. HDR treatment exposure has a typical duration of about 5 min and my presence for the duration of the patient treatment would have lead to an exposure of 0.3 μSv above natural background radiation. If I had attended 100 such procedures in a year my total dose would be 30 μSv . This small occupational radiation dose is well within fluctuations observed in the background radiation level often a result of sunspot activity and cosmic ray intensity. Furthermore this level of exposure represents less than 0.2% of the maximum annual dose limit prescribed for a radiation worker by the statutory radiation protection authority.

Current ionising radiation protection standards are based on the simple Linear-No-Threshold (LNT) hypothesis. The LNT hypothesis states that the dose–response relationship through all bands is linear and that there is no safe threshold level of exposure. The LNT hypothesis was developed on the basis of an extrapolation of our knowledge of pathology at high doses of radiation; e.g. high dose exposure to early radiation workers, impacts of exposure on the survivors of the Hiroshima and Nagasaki atom bomb. It is important to note that the LNT hypothesis is not based on any scientific data at low levels of radiation exposure. I therefore consider the adoption of this model for radiation protection to be based on illegitimate grounds.

To illustrate this point I would like to refer to the transcript of a conference held some 50 years ago. Colonel Pickering from the School of Aviation Medicine of Randolph Air Force Base, USA was presenting a paper on research conducted in his department in the Conference on Research in Radiobiology and Radiation Medicine, December 1 and 2, 1958—Washington, D. C. He made the following statements at the end of his discourse.

Continuing in the applied area, work has been going on using radiation and so-called other stresses that may be of importance in Air Force operations. One of these has been the investigation of low level radiation conducted by Dr. Carlson, at the University of Washington, wherein he has used about 8/10 r per day Cobalt-60 gamma radiation and studied animals at five degrees, 28°, and 35°, with an endpoint of radiation and its effect on metabolism.

Perhaps an interesting note with respect to these low levels of exposure, at the present time Dr. L. Carlson's exposed animals are outliving his control animals. I understand other individuals are finding this to be true in certain of the low levels of exposure. As a matter of fact the contract was extended to wait for the radiated animal to die.

Dr. Lauriston Taylor: I am interested in the remarks you made at the last, Dr. Pickering, about the longer survival of slightly irradiated animals compared with some of the controls. This keeps bobbing up. Is it being looked at systematically? Do you believe your results?

Colonel Pickering: I believe Dr. Carlson's results, yes sir. May I say just this – I am sure there are others who have opinions on this, but there are several experiments of which I am aware where, as you say, it has bobbed up continually. One in particular which Dr. Gerstner in our own laboratory conducted, a bit different from this. Namely, if one administered one large dose of radiation and measures the survival, and then complements this experiment by administering a small dose to a second group of animals followed by a second large dose, it takes a larger dose to produce the same mortality than in the first experiment. I am certain that this has been demonstrated by Dr. Lautit, and I am sure Col. Hartgering has some words on this. I do not know other than our own small attempt whether this is being systematically followed.

These scientists were discussing the phenomenon we know today as adaptive response or hormesis. Hormesis is a dose–response relationship characterised by low-dose stimulation and high-dose inhibition. This phenomenon is broadly applicable for a range of toxic agents including chemical, biological and radiation. This is exemplified by the risks and benefits of exposure to ultraviolet radiation; too much exposure leads to the development of melanomas and other serious medical problems, however sub-optimal exposure inhibits the synthesis of Vitamin D in the body, which can also lead to health impacts such as osteoporosis.

Hence, many radiobiologists today question the validity of the LNT model at low dose. At the twelfth international congress of the International Radiation Protection Association, which took place in Buenos Aires, in 2008, Professor Christian Streffer presented the Sievert Lecture entitled '*Radiological Protection: Challenges and Fascinations of Biological Research*'. Prof. Streffer admits the limitations faced by epidemiological studies in providing low dose radiation effects information. In the lecture he said:

The data generally show fluctuations around the linear dose response below doses of about 100 mSv. This can be explained by two possibilities:

- (1) No cancers are induced after exposure to such low radiation doses.
- (2) Cancers are induced after these low doses but the effect is so small that it is hidden by fluctuations in spontaneous cancer rates.

The congress, however, decided to stay with the LNT hypothesis for want of more evidence.

Radiation protection regulations based on the LNT model coupled with the general anxiety regarding radiation hazards created by the mass media have led to a prevailing public attitude that all radiation is harmful, no matter how small the dose. Accordingly we adopted the ‘ALARA’ principle and have taken a very conservative approach to radiation protection. We use this conservative approach when designing and building radiotherapy bunkers, diagnostic X-ray rooms and other industrial radiation producing installations that generally exceed the requirements of the current radiation protection regulatory framework. As a result occupational exposure to radiation is practically at a noise level of background radiation to almost all radiation workers.

The application of the LNT model has come at a huge financial cost to our community with no demonstrable epidemiological benefits. Billions of dollars have been spent around the world to meet (and often exceed) very conservative radiation safety standards. There are many regions where natural background radiation far exceeds present radiation protection standards, in some cases these background levels are 50–200 times higher. For example: Guarapari in Brazil, Ramsar in Iran and Kerala in India have a very high background radiation. Furthermore various epidemiological studies have indicated that high natural radiation in these areas is not harmful to the inhabitants. The LNT model, at low dose levels, has little or no foundation in science; yet almost all regulatory bodies formulate their rules based on the assumptions therein. The weak scientific foundation upon which we have built our radiation protection standards and our lack of commitment to finding a better dose–response model has led to an exacerbation of public anxiety.

A few years ago, the US Department of Energy (DOE) began investigating the affects of low dose radiation. A number of new phenomena like the radio-adaptive response and the radiation-induced bystander response were uncovered. Preliminary evidence confirms that low levels of radiation exposure are not as harmful as the LNT hypothesis would lead us to believe. At low doses, DNA repair mechanisms are stimulated and these findings may assist with developing evidence-based approaches to modifying our radiation protection regulations. I was fortunate to be part of the low dose research study at Flinders University, Flinders Medical Centre and the Royal Adelaide Hospital under the leadership of Professor Pam Sykes funded by the Low Dose Radiation Research Program, Biological and Environmental Research (BER), U.S. Department of Energy where we studied the effects of a wide range of whole-body X-ray doses on chromosomal changes in mice. The non-linear results obtained in that study supported a hormetic dose response [1].

Blind faith in the LNT model has a negative influence on how we allocate our limited healthcare resources. Investing large sums of capital mitigating overestimated risks does not benefit the community; and in many instances has an adverse effect by reducing focus on more pertinent public health endpoints.

Reference

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