Life and Nuclear Radiation: Chernobyl and Fukushima in Perspective

*Wade Allison**

An increased use of nuclear power is now accepted as inevitable by many people, but not without some unease, and the accidents at Chernobyl and Fukushima as described in the media bring little reassurance. So how dangerous is radiation exposure, for instance to those living within the influence of such accidents?

During the Cold War with its threat of a nuclear holocaust, fear of radiation was an effective weapon deployed by both sides, and the resulting collateral damage to civilian morale persuaded many to avoid any contact with radiation, even to opt for a nuclear-free society. Many marched, demonstrated and voted accordingly. Governments, whilst maintaining their Cold War stance, tried to calm domestic concern, and international and national committees drew up recommendations designed to ensure that, apart from its use in medicine, any radiation dose would be close to levels found in the natural environment – the acronym was ALARA: As Low As Reasonably Achievable.

Without explanatory education these regulations provide rather ineffective reassurance, and this was particularly true as many early national nuclear programmes also involved military objectives with a degree of secrecy, which inhibited popular understanding. In addition, at that time it was not possible to give firm scientific assurance because the effect of nuclear radiation on living cells and organisms was not well understood and long-term data were lacking. Further, the global dangers of burning fossil fuels were not appreciated and it was reasonable to opt for coal and gas to generate electricity instead of a major nuclear expansion. So the cautious ALARA approach to radiation safety seemed sensible enough.

Caution may be appropriate when a new technology first appears but then, as experience builds and designs are optimised, progressive relaxation may be considered. The use of high magnetic fields in MRI is an example; as the dangers have been understood, fields have been increased by ten times with great benefit to research and public health. However, the opposite has happened in radiation safety – in 1951 three milli-sieverts per week was the recommended maximum while today it is one milli-sievert per year, a 150-fold reduction.[1] Was this justified?

Recently much has changed and now the biology of the effect of radiation on living cells is understood well enough, at least in principle. It paints a picture of replacement, repair and immune responses at the cellular level, which usually protect against permanent radiation damage. If the radiation dose is acute and intense (typically more than 4,000 milli-sievert within a day or so) these protective mechanisms may be overwhelmed with fatal results (Acute Radiation Syndrome, ARS) as experienced by 28 workers at Chernobyl. Lesser acute doses of more than 100 millisievert may give rise to cancer in later years, although that is infrequent compared with "normal" cancer. These findings come principally from the 50-year records of the survivors of Hiroshima and Nagasaki.[2] Other data show the importance of the period over which a dose is received. Thus experience with radiotherapy shows that tissue and organs adjacent to a tumour under treatment have a good survival rate even after a very high dose (in excess of 20,000 milli-sievert, five times a fatal acute dose) provided it is spread out over a few weeks – and many members of the public are live witnesses to this. In fact the repair of radiation damage is essential to the success of a radiotherapy treatment. There are also large studies of the effect of chronic radiation doses, such as the incidence of lung cancer among those who have lived their lives at home or at work inhaling an enhanced concentration of radioactive radon that escapes from rocks in some regions. Rather surprisingly, with the exception of those who also smoke, there is no clear evidence that such a radiation exposure is harmful.[3] Another large study based on the health records of

* Prof. Wade Allison, Keble College, Oxford University, Oxford.

1 103 ICRP Publication (2007), pp. 35–40, available on the Internet at <http://www.icrp.org/> (last accessed on 21 July 2011).

2 Preston *et al.* (2004), available on the Internet at <http://www.bioone.org/doi/abs/10.1667/RR3232> (last accessed on 21 July 2011).

3 WHO (2006), available on the Internet at <http://www.who.int/mediacentre/factsheets/fs291/en/index.html> (last accessed on 21 July 2011).

all UK radiation workers shows that for them the chance of death from cancer before age 85 is 15 % less than for other comparable groups in the same population.[4] The truth is that nuclear radiation is far less dangerous than usually feared – perhaps a thousand times less, as I have suggested in my book *Radiation and Reason.*[5]

The lack of public information and over-cautious radiation regulations, mis-interpreted as danger levels, caused widespread despair and misery at Chernobyl[6] where the enforced evacuation at short notice of local agricultural population to distant and unfamiliar accommodation was responsible for serious social damage; the consequences of this dislocation have been emphasised in recent reports.[7] The psychological effects were also felt far away; for example, the number of abortions in Greece increased by nearly 2,000 because of the accident.[8] At Fukushima also there has been damage to families and communities on top of that caused by the tsunami. The level (20 milli-sievert per year) at which evacuation has been required is too low and large numbers of people have been evacuated needlessly. The criterion for such invasive socio-economic surgery should be set high, perhaps up to 100 milli-sievert per month.[9] This is still some 200 times smaller than the monthly dose received by patients on a course of cancer therapy.[10]

Major industrial accidents such as the chemical accident at Bhopal (1984), the Gulf oil spill (2010) and the Seveso dioxin release (1976) leave a serious environmental legacy. Usually there are significant fatalities and prolonged enquiries into the human failure, proper management and safety provision. Nuclear accidents are also treated in this way, but there were no deaths at Windscale (1957) or Three Mile Island (1979) and none are likely at Fukushima (2011), where the cause was an earthquake followed by a tsunami that killed 25,000. Even at Chernobyl (1986) the number of known deaths was less than fifty.[11]

So what happened in these accidents? There were notably few fatalities and no risk of a nuclear explosion but the reactors destroyed themselves through excess heat which caused physical rupture and chemical explosions. At Fukushima the reactors shut down when the earthquake struck so that all fission ceased but heat was still produced by radioactive decay, initially at 7 % of full power and falling to ½ % within a day. Without enough cooling this "decay heat" caused the partial melt down of fuel and several reactors released radioactive material, much of it iodine and caesium which are volatile – further details are still becoming available. The iodine-131 radioactivity halves every eight days so that by 20 May its activity had dropped by a factor 400. The activity of caesium-137 persists for 30 years but no health consequences could be attributed to its presence at Chernobyl where it was released in larger quantities. And what of the health of the workers? After six weeks 30 had received a dose reported to be between 100 and 250 milli-sievert.[12] To put this in perspective, at Chernobyl 55 workers received doses between 2,000 and 4,000 milli-sievert, of whom only one died of ARS – so none of those at Fukushima is likely to die.

So what should we make of this story? Evidently concerns for human health based on ALARA are out of proportion by a wide margin. The principal threat to health comes, not from radiation, but from fear, uncertainty and enforced evacuation – at Fukushima as at Chernobyl. Yet again, official caution about radiation has damaged many lives and generated socio-economic cost, misery, recrimination and loss of trust in authorities.

Where should we go from here? We need better public education and realistic safety standards. Currently these are set by the International Committee for Radiological Protection (ICRP) "*based on (i) the current understanding of the science of radiation exposures and effects and (ii) value judgements. These*

4 Muirhead *et al.* (2009), available on the Internet at <http:///www.nature.com/bjc/journal/v100/n1/full/6604825a.html> (last accessed on 21 July 2011).

5 Allison (2009), available on the Internet at <http://www.radiationandreason.com ISBN 9780956275615> (last accessed on 21 July 2011).

6 UNSCEAR (2011), available on the Internet at <http://www.unscear.org/docs/reports/2008/11-80076_Report_2008_Annex_D.pdf> (last accessed on 21 July 2011).

7 IAEA (2006), pp. 7, 13, 19, 20, available on the Internet at <http://www.iaea.org/Publications/Booklets/Chernobyl/chernobyl.pdf> (last accessed on 21 July 2011).

8 Trichopoulos *et al.* (2007), available on the Internet at <http://www.bmj.com/content/295/6606/1100.extract> (last accessed on 21 July 2011).

9 Allison (2011), available on the Internet at <http://www.bbc.co.uk/news/world-12860842> (last accessed on 21 July 2011).

10 Royal College of Radiologists (2006), available on the Internet at <http://rcr.ac.uk/docs/oncology/pdf/Dose-Fractionation_Final.pdf> (last accessed on 21 July 2011).

11 UNSCEAR (2011), *supra* note 6.

12 World Nuclear News (2011), available on the Internet at <http://www.world-nuclear-news.org /RS_Recovery_and_rubble_at_Fukushima_2704111.html> (last accessed on 21 July 2011).

value judgements take into account societal expectations, ethics, and experience".[13] In the past ICRP has followed opinion rather than leading it, a mistaken approach given the state of popular understanding derived from the primitive picture left by last century's political propaganda. Accordingly, ICRP should now show some leadership (or leave it to others to do so); safety levels should be revised in the light of modern radiobiology with programmes of public re-education. The levels should be as high as is relatively safe (AHARS) rather than as low as is reasonably achievable (ALARA). In a world of other dangers – earthquakes, global warming, economic collapse, shortages of power, food and water – the pursuit of the lowest possible radiation levels is in nobody's best interest.

13 ICRP home page, available on the Internet at <http://www.icrp.org/> (last accessed on 21 July 2011).