EDITORIAL

Chernobyl and Fukushima—where are we now?

To cite this article: Richard Wakeford 2016 J. Radiol. Prot. 36 E1

View the article online for updates and enhancements.

Related content
- The silver anniversary of the Chernobyl accident. Where are we now? Richard Wakeford
- A geographical study of thyroid cancer incidence in north-west England following the Windscale nuclear reactor fire of 1957 Richard J O McNally, Richard Wakeford, Peter W James et al.
- A double diamond anniversary—Kyshtym and Windscale: the nuclear accidents of 1957 Richard Wakeford

Recent citations
- Japanese Food Data Challenge the Claimed Link between Fukushima's Releases and Recently Observed Thyroid Cancer Increase in Japan Georg Steinhauser et al
- A double diamond anniversary—Kyshtym and Windscale: the nuclear accidents of 1957 Richard Wakeford
Editorial

Chernobyl and Fukushima—where are we now?

This year, 2016, marks two special events: the 30th anniversary of the explosion that destroyed the Unit 4 reactor at the Chernobyl nuclear power station in northern Ukraine [1], and the 5th anniversary of the tsunami that caused loss of cooling and consequent melting of fuel in three recently operating reactors at the Fukushima Dai-ichi nuclear power station on the east coast of Japan [2]. These two major nuclear accidents released large quantities of radioactive materials into the environment, and the scale of these releases can be judged by their being the only two events that have achieved Level 7 (‘major accident’, the highest level) on the International Nuclear and Radiological Event Scale (INES) of the International Atomic Energy Agency (IAEA) [3].

At Chernobyl [1], immediately following the explosion, radiation exposures of some plant and emergency response workers were so high that 134 suffered from acute radiation syndrome, and 28 died within a few months of exposure. Evacuation of the population from the areas around Chernobyl most affected by radioactive contamination was delayed, but the worst consequences flowed from children in those parts of the former USSR that experienced the heaviest fallout continuing to drink milk highly contaminated with radioactive iodine (which concentrates in the thyroid gland) so that tens of thousands received large thyroid doses in excess of 1 Gy. Just four years later, the first sign of excess thyroid cancers resulting from these high exposures became apparent and within twenty years several thousand additional cases of thyroid cancer had occurred among those exposed as children in heavily contaminated areas of Ukraine, Belarus and Russia. Fortunately, owing to the success of treatment of thyroid cancer, only 15 cases proved fatal by 2005 [1]. Thyroid doses outside the areas of the former USSR badly affected by fallout from Chernobyl were much lower and excess thyroid cancer cases have not been detected [1]. It will be important to continue to track the health of those individuals heavily exposed to radioiodine as children because current radiation-induced thyroid cancer risk models predict that the excess risk continues into later life as a proportion of the background risk of thyroid cancer [4], which increases with attained age, so we may have seen only the tip of the iceberg as far as additional cases of thyroid cancer is concerned.

As for other health effects in the general population resulting from radiation exposure, there have been some reports of excess cases of a variety of health effects, but the interpretation of these is far from straightforward. Doses to other tissues, largely from external exposure to gamma radiation from Cs-134 and Cs-137 deposited in the environment, were generally much less than those to the thyroid—for the ~115 000 evacuees, the average effective dose (excluding the thyroid dose) was 13 mSv, while for the ~6 400 000 people living in areas with moderate levels of contamination the average effective dose for 1986–2005 was 9 mSv [1]—so statistically discernible effects were not to be expected; but following the health of those groups of people most exposed, particularly at a young age, is desirable. More importantly, perhaps, the Chernobyl accident occurred just a few years before the break-up of the USSR, and the socioeconomic turmoil that this dissolution produced was not good (to say the least) for the epidemiological investigation of the health impact of Chernobyl. Record keeping suffered, but it is clear that the socioeconomic disruption of the 1990s (and into the 2000s)
had profound effects upon health, as can be appreciated by the roller-coaster mortality rates in Russia for that period [5, 6]. Some commentators have suggested that the initial rise in mortality rates in Russia in the early-1990s was due to radioactive fallout from Chernobyl [7], but it is clear that this was a countrywide phenomenon [5], and that the far east of Russia was just as affected as European Russia (if not more so) even though the far east was hardly touched by Chernobyl fallout. At present, any effect of radiation exposure from Chernobyl in the general population, other than the clear signal of thyroid cancer, is equivocal.

In excess of half a million recovery workers (‘liquidators’) were brought in to clean up the Chernobyl site and immediately surrounding area after the accident, and these workers present another opportunity to investigate protracted exposures to radiation, especially the majority of the liquidators who were working during 1986 and 1987; for all liquidators during 1986–1991, the average external dose was 117 mGy, but for workers employed during 1986 and 1987, the average doses were 146 mGy and 96 mGy, respectively [1]. Again, the fragmentation of the USSR has provided problems for follow up of liquidators, who have become dispersed throughout the former USSR, and although registries of Chernobyl liquidators have been established to record health effects, the different recording practices of the registries, together with the potential for more medical attention being paid to (possibly the more highly exposed) recovery workers than to the general population, has led to difficulties in interpretation. Given the number of people and the doses involved, it is clearly worthwhile continuing to study the Chernobyl liquidators, and there are indications of excess adverse health effects that could be linked to radiation exposure: leukaemia, some solid cancers (including thyroid cancer), cardiovascular diseases and eye cataracts. However, the logistics of these studies are complex, particularly now after the recent troubles in Ukraine, and dependable data are required to draw confident inferences from the investigations.

Although not as large as the radioactive releases from Chernobyl, the discharges of radio-nuclides from Fukushima Dai-ichi were still substantial [2]. Fortunately, a greater part of the radioactive materials released to atmosphere was blown out over the Pacific Ocean, but a few days after the start of the accident a plume of material was carried to the north-west causing significant contamination of the terrestrial environment (mainly from Cs-134, Cs-137 and I-131) out to around 40 km from the damaged reactors. An area within 20 km of Fukushima Dai-ichi had been evacuated before this major contamination event had occurred, and sheltering and food restrictions were established in the affected areas beyond the 20 km radius. Measurements of radiation from children’s thyroids, albeit limited in number given the disruption caused by the earthquake and tsunami, indicate that the protection measures prevented the high levels of exposure to radioiodine that occurred after Chernobyl [2].

Although the conditions facing the workers dealing with the emergency on-site at Fukushima Dai-ichi were challenging, necessitating the evacuation of personnel on occasions, early health effects from high doses were avoided, although 12 workers are assessed to have received thyroid doses in the range 2 to 12 Gy from the inhalation of I-131 [2] and the health of these workers will have to be monitored over their lifetimes. For the remaining ~25 000 workers present at Fukushima Dai-ichi between March 2011 and October 2012, effective doses were kept below 250 mSv with ~170 workers receiving cumulative doses exceeding 100 mSv; the average effective dose was ~12.5 mSv [2]. It is unlikely, given the numbers of workers involved and their doses, that health effects due to these radiation exposures at Fukushima Dai-ichi will be detected, but the plant and recovery workers will be the subject of an epidemiological study.

Following the large excess of thyroid cancer cases among those who had been exposed at a young age to high levels of radioiodine from the Chernobyl accident, the principal concern in monitoring the health of the general population around Fukushima Dai-ichi is whether
an excess of thyroid cancer incidence will be detectable. Given the assessed and measured thyroid doses involved, this seems unlikely [2]. Nonetheless, a large survey of the health of residents of Fukushima Prefecture in its entirety has been initiated, including an ultrasound screening programme examining the thyroids of ~300,000 individuals who were <19 years of age at the time of the accident, and during October 2011 to March 2014, 113 confirmed or suspected thyroid cancers were detected [8]. This observed number of cases is some tens of times greater than would be expected from Japanese national rates, and has led to the alarming suggestion that we are seeing the start of a large excess of thyroid cancer cases attributable to radiation exposure following the Fukushima accident [9].

An explanation of the thyroid cancer survey findings in terms of radiation exposure is implausible for a number of reasons [8, 10]. First, the Chernobyl thyroid cancer excess became apparent 4–5 years after the accident, whereas the Fukushima survey found cases at a uniform rate during the period within 3 years of exposure [8]. Second, the assessed thyroid doses are far too low to produce this number of excess thyroid cancers this quickly. Third, the number of cases discovered by ultrasound screening cannot be compared to that obtained when, in general, no such screening has taken place, because smaller tumours will be found by ultrasonography and it is known that this has a dramatic effect upon the ability to detect thyroid cancers [11, 12]. Fourth, there is no statistically discernible difference between the rates of occurrence of cases in areas with differing levels of contamination [13]. Fifth, in stark contrast to the excess thyroid cancers found among those exposed to radioiodine in the heavily contaminated areas around Chernobyl, the thyroid cancers in Fukushima Prefecture did not occur among those who were infants or young children at the time of the accident, as illustrated in figure 1.

The wild claim [9] that the thyroid cancers found in Fukushima Prefecture by the ultrasound screening programme are the start of a big excess of cases attributable to radiation exposure from the Fukushima Dai-ichi accident is just not credible.

One major impact on health caused by the Chernobyl and Fukushima accidents is the adverse psychological effects produced by evacuation, displacement and anxiety about...
radiation exposure and the consequent risk of cancer and other diseases, especially among the parents of young children [14, 15]. This is not a direct effect of exposure to radiation, but it is nonetheless of considerable importance in assessing the overall impact on health of the accidents. Indeed, it may be that it is the psychosocial consequences of large-scale accidents (and not necessarily just nuclear ones) that impose the greatest burden upon society and its medical resources [16, 17].

Around Chernobyl, a large area of a few 1000 km² (the ‘Chernobyl Exclusion Zone’) continues to remain evacuated with (human) access restricted. Iodine-131 (half-life, 8 d) has long decayed, and Cs-134 (half-life, 2 years) has almost all gone, so the main remaining problem is contamination by Cs-137 (half-life, 30 years), although half of the original release of this radionuclide has now decayed. The zone offers the opportunity of ‘natural experiments’ to study subjects such as the transfer of radionuclides to animals in the wild [18], although it would appear that wildlife is flourishing in the absence of humans [19]. In Fukushima, it is gamma radiation ‘groundshine’ from deposited Cs-137 (and to a lesser extent, Cs-134) that poses the biggest obstacle to the return of evacuees to their homes. Extensive remediation measures (such as topsoil removal and pressure hosing of buildings) have been conducted, and return of people to less contaminated areas has been possible; but there are areas out to 40 km to the north–west of Fukushima Dai-ichi where the dose accumulated over a year remains above the 20 mSv criterion set by the Japanese Government for the exclusion order to be lifted, and some areas where the annual dose exceeds 50 mSv. Realistically, the comprehensive return of evacuees to such heavily contaminated areas is unlikely to be possible in the near future.

What, then, have we learnt so far from the experiences of the Chernobyl and Fukushima accidents? For sure, confirmation that high whole-body doses received over a brief period will produce acute radiation syndrome and death if the doses are sufficiently high, and that high doses to the thyroids of children will increase the risk of thyroid cancer. Also, that unless the effect is clear (as with thyroid cancer among those exposed as children), obtaining reliable results from epidemiological studies of populations is challenging in countries where accurate and uniform tracing of individuals, and diagnosis and recording of diseases, is uncertain. However, an effect that is substantial but not directly related to radiation exposure is the psychosocial impact of accidents, not just nuclear accidents, and this may be a neglected area of research that requires attention [16, 17].

Finally, both the Chernobyl and Fukushima accidents resulted not from some unexpected novel phenomena, but from a failure to properly appreciate the reality of the risk of a major accident: at Chernobyl, an irresponsible experiment was performed on an inherently unstable design of reactor, and at Fukushima, insufficient attention was paid to defence in depth so that equipment failed that should have remained operational when the tsunami struck. These matters were known beforehand, but in neither instance were they acted upon. Familiarity with everyday operations and complacency about rare abnormal events are dangerous adversaries to safe behaviour. That is why effective internal governance and external regulation of companies that run hazardous installations is essential to avoid major accidents [20]. That may be one of the most important lessons to be learnt from Chernobyl and Fukushima.

References


[16] Hasegawa A et al 2015 Health effects of radiation and other health problems in the aftermath of nuclear accidents, with an emphasis on Fukushima Lancet 386 479–88


[18] Beresford N A, Gaschak S, Maksimenko A and Wood M D 2016 The transfer of $^{137}$Cs, Pu isotopes and $^{90}$Sr to bird, bat and ground-dwelling small mammal species within the Chernobyl exclusion zone J. Environ. Radioact. 153 231–6


Richard Wakeford
Editor-in-Chief, Centre for Occupational and Environmental Health, Institute of Population Health, The University of Manchester, Ellen Wilkinson Building, Oxford Road, Manchester, M13 9PL, UK
E-mail: Richard.Wakeford@manchester.ac.uk