



Health risk assessment

from the nuclear accident
after the 2011 Great East Japan
Earthquake and Tsunami

based on a preliminary dose estimation



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8. Summary and conclusions

This report presents the results of a HRA of the Fukushima Daiichi NPP accident for the general population and for workers dealing with the emergency. The assessed health risks include cancer and non-cancer effects of exposure to radiation, encompassing both stochastic and deterministic health effects.

8.1 Health risk assessment in the general population

Health risks in the general population were assessed in different geographical locations inside and outside Japan, for both sexes and three age-at-exposure groups: 1-year-olds (infants), 10-year-olds (children) and 20-year-olds (young adults). These age groups were considered suitable to permit the characterization of risks for younger and more sensitive populations.

Based on the doses estimated to be substantially below threshold levels, deterministic effects (i.e. tissue reactions) are not expected. For this reason, no increase in the incidence of spontaneous abortions, miscarriages, perinatal mortality, congenital malformations, developmental abnormalities or cognitive impairment is expected as a result of *in utero* radiation exposure.

A risk of radiation-induced hereditary effects has not been definitively demonstrated in human populations. Based on animal data, international scientific bodies consider that any risk of hereditary effects for the offspring of those who were exposed before they have conceived children would be much lower than the additional lifetime risk of cancer for the exposed individual him- or herself (about one order of magnitude lower).

The present results suggest that the increases in the incidence of human disease attributable to the additional radiation exposure from the Fukushima Daiichi NPP accident are likely to remain below detectable levels.

The predicted magnitude of cancer risks was assessed for leukaemia, thyroid cancer, female breast cancer and all solid cancers combined. The risks were calculated over a lifetime and over the 15 years following the accident. The lifetime attributable risks (LAR) were quantitatively estimated only in the most affected parts of Fukushima prefecture. For all other locations in Japan and around the world, the radiation-related cancer risks were estimated to be much lower than the usual fluctuation in the baseline cancer risks.

The results show the largest additional cancer risks among those exposed in infancy (leukaemia in males and solid cancers in females). Given the exposure to radioactive iodine, during the early phase of the emergency, the lifetime attributable risk of thyroid cancer was specifically assessed. The results show the greatest risk among girls exposed as infants in the most affected area in Fukushima prefecture, although the excess absolute risk is small, because of the low baseline risk of thyroid cancer, it represents a comparatively high relative increase in the lifetime risk of up to around 70% (as an upper

bound). The high relative risk of childhood thyroid cancer becomes more evident when risks are calculated over the first 15 years after the accident for those exposed as infants, because the baseline thyroid cancer risk in early life is very low. Monitoring children's health is therefore warranted.

The risk of leukaemia as a result of radiation exposure from the accident was assessed to be greatest in males exposed as infants in geographical locations with the highest exposure, slightly above 5% over baseline risk as an upper bound. A similar result is found for breast cancer in girls exposed as infants. For all solid cancers, a maximum relative increase of about 4% was estimated.

8.2 Health risk assessment in emergency workers

To date, the Fukushima Daiichi NPP accident has not resulted in acute radiation effects among workers. None of the seven reported deaths among workers is attributable to radiation exposure¹. Thyroid dysfunction was reported in three workers as a result of repeated self-administration of stable potassium iodide for thyroid blocking against radioactive iodine. This effect was transient and thyroid function returned to normal once the administrations were stopped.

The potential health consequences of exposure to radiation of the emergency workers have been assessed assuming four scenarios that describe different exposure patterns. Scenario 1 represents around two thirds of the emergency workers with quite low doses to all tissues. Scenario 2 contains about one third of the emergency workforce who received moderate thyroid doses and lower doses to other tissues. Scenarios 3 and 4 represent upper bounds for external and internal exposure respectively. Scenario 3 concerns less than 1% of workers who received higher, more homogeneous tissue doses (including thyroid doses). Scenario 4 relates to those few workers who received high thyroid doses as a result of inhalation of radioactive iodine and lower doses to other tissues.

Because tissue doses received were below threshold doses, no deterministic effects of radiation are expected in the workers, apart from possible thyroid disorders in those few workers who inhaled significant quantities of radioactive iodine.

Cancer risks were calculated for workers aged 20 years, 40 years and 60 years. The estimated risks were consistently lower for workers exposed at an older age. Relevant findings are summarized below. For around two thirds of the emergency workers (Scenario 1), all calculated risks are of similar magnitude as the normal fluctuations in the baseline cancer risks. For about one third of the workers (Scenario 2), the relative increase over background for thyroid cancer is estimated to be up to 20% for the youngest workers. For less than 1% of workers (Scenario 3), the relative increase over background for leukaemia and thyroid cancer is as high as 28% in the youngest workers. For those few emergency workers who received very high doses to the thyroid (Scenario 4), a notable risk of thyroid cancer is estimated, especially for young workers.

1. The causes of these deaths have been reported as disaster-related (two cases), heart attack (three cases), sepsis (one case) and leukaemia (one case for which the time of the onset was shorter than the minimum latency period for radiation-induced leukaemia).

There may be an increased risk of long-term circulatory disease among workers with the highest doses (Scenarios 3 and 4), which is likely to be substantially smaller than any additional cancer risk.

The considerations made above for heritable risks in the general population (section 8.1) are also applicable to workers.

8.3 Final considerations

This HRA was drawn up to give an indication of the health implications of the Fukushima NPP accident for the identification of needs and priorities for public health actions. The estimates presented in the report must be regarded as indicative of the magnitude of the health risks based on best judgment rather than as precise predictions.

The estimation of radiation risks, at doses below which increases in cancer incidence have been readily observed in epidemiological studies, involves a number of uncertainties. The main sources of uncertainty in this HRA were discussed in chapter 6. Owing to the preliminary nature of the dose estimation and the time frame for the HRA Expert Group to complete its work, a fully quantitative assessment of the uncertainties associated with the LAR central estimates was not performed.

Although substantial information on radiation risks is available, further evidence would be highly desirable. This accident highlights the need for continuing and improving low-dose and low-dose-rate radiation research.

To avoid any underestimation of risks, the HRA Expert Group adopted the LNT model as the most reasonable approximation of the relation between low-dose radiation exposure and cancer risks and made the prudent choice of not applying a dose and dose rate effectiveness factor (DDREF). Because this HRA is based on a LNT model and the risk quantity adopted (LAR) is proportional to the dose, more refined risk estimations can be provided in the future if a more detailed dose assessment becomes available.

The HRA Expert Group considers the risk estimates robust on the basis of existing knowledge and information at the time of this assessment. The input data and risk models used are considered to be the most appropriate at present. An effort was made to avoid any underestimation of risks when adopting assumptions; hence, any possible bias is likely directed toward overestimation of health risks.

This HRA is not intended to provide estimates of disease burden in the population or cases of excess disease resulting from radiation exposure. This report uses preliminary dose estimates based on environmental and food monitoring data for the calculation of lifetime attributable risks. This makes no assumption of how many persons were exposed according to the different exposure scenarios, for which distributions of individual dose estimates are needed. In addition to the environmental and food monitoring data, an evaluation of the population dose distribution requires the knowledge of the behaviour of persons, e.g. how much time they spent in the differently exposed areas. Moreover, population figures by sex, age and area were not considered for this report, especially in light of the expected substantial migration and movement in the months following the accident. Reliable numbers would be needed for the estimation of population doses and associated risks. Provided these become available, such assessment could be performed

in future studies, such as the upcoming 2-year UNSCEAR study and the on-going survey conducted in Fukushima prefecture to determine the whereabouts of the residents.

It is important to note that this is a report on radiation health risks and that it does not refer to radiation-induced health effects. While radiation risks can be estimated prospectively, radiation-induced health effects are assessed retrospectively and this requires a long-term follow-up of the exposed population. Surveillance of health and monitoring of disease occurrence is required for empirical assessment of the health consequences of the accident and quantification of health outcomes resulting from it.

The Fukushima Health Management Survey is expected to contribute to future health effect assessments. Population health surveillance will permit the identification of additional needs for the delivery of health care. In addition, as part of the occupational health programmes, a special protocol for medical follow-up of emergency workers is being adopted. These initiatives are also relevant for the mitigation of the psychosocial impact of this accident and the prevention of adverse mental health consequences, which are considered to be of major significance.