the HRA Expert Group to assess thyroid cancer risk (i.e. the hybrid model mixing 50% ERR and 50% EAR) results in higher risk estimates than the pure relative risk model approach (i.e. 100% ERR). This can be illustrated by comparing the cumulative attributable risks over the first 15 years after the accident (AR_{15}) presented in Annex J. As seen in Table 43, the AR_{15} is estimated to be 3 in 10 000 for female infants in the most affected Group 1 location using the hybrid risk-transfer approach, while using the 100% ERR approach the AR_{15} value is 1 in 10 000. In choosing a hybrid model for thyroid cancer risk-transfer instead of the 100% ERR model adopted by other international bodies such as ICRP (*12*), BEIR VII (*87*) and EPA (88), the HRA Expert Group took into account the extrapolation of LSS results to shorter times after exposure based on information from Chernobyl (see Annex E section E.3). It was also considered that the pure application of the ERR to calculate the LAR for thyroid cancer in this HRA report might have involved more uncertainties, particularly because of the very low baseline incidence rates at young ages[2].

Thyroid cancer risks in workers deserve particular consideration in the context of the models applied. Scenario 4 assumes the highest effective dose (700 mSv) with the radioiodine inhalation pathway being the major contributor, resulting in a very high thyroid dose (>10 Sv). This scenario, which could be considered as an upper bound, represents a few (< 0.01%) of the emergency workers. The assessment of cancer risks at such high thyroid doses is associated with high uncertainties because, as discussed in section 3.4, a flattening of the dose-response for thyroid cancer has been observed at high doses (*6,24,107,120*). Therefore, the actual risks are probably not higher than, and may well be lower than those indicated by the calculated LAR values.

6.2.4 Extrapolation of data from moderate doses to low doses

To date, neither radiobiological nor epidemiological research has provided a definitive answer to the question of whether or not the use of a factor to extrapolate epidemiological data from moderate doses to low doses is warranted. The HRA Expert Group based the risk calculations on models derived from the atomic bomb survivors' cohort without applying any factor for low dose or low dose rate. Correspondingly, a linear dose-response model is used for solid cancer, and a linear-quadratic dose-response model is used for leukaemia. As leukaemia models are linear-quadratic there is no need to apply any DDREF. With respect to solid cancers, the experts chose not to apply a factor, based on the evidence cited in section 3.6. LAR values are proportional to ERR and the concept of LAR is based on linear dose-responses: therefore, any number could be taken into account for DDREF if warranted in the future and could be applied directly to the LAR values presented in this report.

6.3 Specific considerations

6.3.1 Occupational radiation safety

The annual limit of effective dose for occupational exposures in normal situations established in the International Radiation Basic Safety Standards (BSS) (*121*) is 20 mSv

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[2] The thyroid cancer incidence data for Japan show zero incidence rates for some of the youngest age groups, suggesting that a risk-transfer approach not purely based on a 100% ERR transfer would be more appropriate for this population.

per year averaged over five consecutive years (i.e. 100 mSv in 5 years), and 50 mSv in any single year. As described in section 4.2 less than 5% of the workers exceeded the radiation dose limit for a single year under the normal working conditions classified in the BSS as "planned exposure situations".

Dose limits do not apply to emergency exposure situations. However, it has been internationally agreed that no emergency worker should exceed the annual limit of effective dose for occupational exposures referred to above other than in exceptional circumstances, for which guidance values are provided. All reasonable efforts shall be made to keep doses for emergency workers below 500 mSv for lifesaving interventions, actions to prevent severe deterministic effects or catastrophic conditions that could affect people and the environment.

Before the Fukushima Daiichi NPP accident, Japan had established 100 mSv as a guidance value for emergency workers. This value was revised to 250 mSv on 14 March 2011 (i.e. 50% of the BSS guidance value referred to above). This new regulation was applicable only to emergency workers responding to this particular accident. Data provided by TEPCO indicate that, by the end of January 2012, around 1% of the emergency workers had received more than 100 mSv and 0.03% of the workers exceeded the guidance value of 250 mSv.

6.3.2 Health burden

It is important to note that the present HRA estimates relate to cancer incidence rather than cancer mortality. For consideration of the health burden, an approach to account for disease severity can be considered. For instance, the ICRP 103 model-weighting approach (*12*) quantifies the harmful effect of radiation exposure, taking into account the radiation detriment related to the disease severity (lethality of the disease and years of life lost). For example, non-melanoma skin cancer (NMSC) is rarely lethal and surgical treatment is highly effective. Therefore NMSC does not have the same implications for health burden compared with other solid cancers such as pancreatic cancer, where curative treatment is rarely possible. In contrast to pancreatic cancer, treatment strategies for thyroid cancer are very effective and therefore mortality is very low. This consideration about the improvement of cancer cure rates is also applicable to leukaemia and breast cancer. When assessing and analyzing risk of all solid cancers it should be kept in mind that all solid cancers include various diseases that may have very different health burdens.

6.3.3 Prenatal exposure and carcinogenic risks

Since the first reports that *in utero* radiation was associated with an increased risk of leukaemia and solid cancers during childhood were published in the late 1950s, this issue has been debated. The estimated excess absolute risk (EAR) for childhood cancer due to prenatal exposure derived from case-control studies is around 0.06 per Gy for all cancers and about 0.025 per Gy for leukaemia (*122*), although the evidence from cohort studies is equivocal (*123*). Few studies have addressed the potential risk of adult cancer after *in utero* exposure. An increased risk of adult-onset solid cancers was observed in atomic bomb survivors exposed *in utero*, and risks were lower than risk among those exposed early in life. Many survivors of the LSS atomic bomb survivors cohort who were exposed *in utero* are now in the period of life when the baseline incidence of adulthood cancer markedly rises, so more data can be expected in the future.

There is evidence-based international consensus that the lifetime risk of cancer following exposure *in utero* does not differ greatly from that following exposure in infancy, nor does the risk of childhood leukaemia following exposure *in utero* differ greatly from that following exposure in infancy. On these bases, it can be considered that the lifetime attributable risks for leukaemia and solid cancers after *in utero* exposure do not differ significantly from the LAR values calculated for 1-year-old infants. As mentioned in section 2.2.1, this criterion was adopted by the HRA expert group for the present assessment.

Although consensus effectively exists on increases in the lifetime risk of cancer and the risk of childhood leukaemia following in utero exposure to radiation, there remains some controversy about the risk of child onset cancers other than leukaemia. Following postnatal radiation exposures at early ages, there is no clear evidence of an increased risk of solid cancers during childhood or adolescence from exposures in the low or moderate dose range, although some types of cancer are seen at high doses. Thyroid cancer, which is not a typical childhood cancer, is an exception, because firm evidence exists for increased risk in individuals exposed in childhood during the Chernobyl accident. In contrast, neither the Chernobyl study (*124*) nor the atomic bomb study (*125*) showed a statistically significant increase of thyroid cancer risk after *in utero* exposure, probably due to low statistical power. Whatever the explanation for this apparent difference between *in utero* and postnatal exposures, childhood cancers make up a relatively small component of cancer risk over a lifetime.

6.3.4 Assessment of all solid cancer risks

This HRA considers the risk of all solid cancers combined, which includes the risk of thyroid and breast cancer. No model to calculate the risk for all other solid cancer excluding breast and thyroid cancer risks is available from the LSS data.

The assessment of the risk of all solid cancers combined is intended to provide, together with the assessment of the risk of leukaemia, an overall indication of the lifetime risk of cancer and this was the reason why it was included in the present HRA. In the LSS, the risk of all solid cancers combined uses a dose to tissues based on the colon organ dose as a surrogate for the averaged whole-body dose.

In circumstances where the tissue doses are highly heterogeneous, such as with thyroid exposure to radioactive iodine, this approach can lead to underestimation of cancer risks in specific tissues. When an intake of radioactive iodine occurs, the resulting dose is predominantly to the thyroid, leading to a thyroid dose that is greater than the colon dose, so that the risk of all solid cancers combined will not, under these circumstances, fully account for the risk of thyroid cancer. In contrast, the risk of thyroid cancer assessed as a specific cancer site is based on the thyroid dose and therefore does take account of the tissue dose distribution resulting from the intake of radioactive iodine.

6.3.5 Iodine status and thyroid disease

It is well-known that iodine status influences the avidity of the thyroid gland to concentrate radioactive iodine. Whether, in addition, iodine status can modify the radiation effect in terms of cancer risk is not clear. In view of pre-existing iodine deficiency in the areas affected by the Chernobyl fallout, several studies addressed this issue. A case control study used environmental indicators to assess the stable iodine intake at the time of exposure in the contaminated regions of Belarus and Russia (*177*). Thyroid cancer risk was modified by both soil iodine content and iodine consumption in the years after the accident for prevention of iodine deficiency. Consumption of stable iodine was associated with a reduction in the radiation-induced thyroid cancer risk to approximately one third. Correspondingly, the risk related to radiation was three fold in the areas with the lowest relative to the highest amount of soil iodine content. Some indication of a higher thyroid cancer risk for areas with lower iodine intake (assessed as excretion, though with a narrow range of variation) was also reported from the Bryansk region in Russia (*126*), though a cohort study in Belarus did not find an association of the background level of stable iodine intake with thyroid cancer risk (*127*).

In contrast to the region of Chernobyl, Japan has a diet with one of the highest iodine contents (e.g. sea fish, shellfish and seaweed), although not all diets in Japan are rich in iodine (*128,129*). A positive association between seaweed consumption and the risk of thyroid cancer (especially for papillary carcinoma) in postmenopausal women in Japan was recently reported (*130*). Existing scientific evidence does not support any quantitative estimation of this potential source of uncertainty in the assessment of thyroid cancer risks. However, this factor has been minimized in the present assessment because it is based on risk models derived from a Japanese population (the LSS cohort).

6.4 Summary of key choices

Table 18 summarizes the key choices made in this HRA and indicates areas where conservative approaches have been adopted.

Table 18. Summary of key choices in the health risk assessment

Selection of input data	
Exposure data	Dose estimates for the general population were taken from the WHO Preliminary Dose Estimation Report, where efforts were made to prevent underestimation of doses (*3*). Some of the conservative assumptions that may have resulted in dose overestimation are: ■ that relocation in the "deliberate evacuation area" took place at four months (though some inhabitants of this area were subjected to relocation earlier than this); ■ that consumers only ate food produced in the area where monitoring was implemented (i.e., that those living in Fukushima ate only food produced in Fukushima, though this was not always the case); ■ that all the food monitored was on the market, although the data set included the results of food samples collected for monitoring purposes, which were not allowed on the market.
Lifetime dose	A ratio of lifetime dose to first-year dose (of two) was selected based on i) experience from Chernobyl (ratio of three), (ii) consideration of differences such as a lower proportion of the long-lived 137Cs in Fukushima than in Chernobyl, and iii) information about ongoing and planned protective measures and remedial actions in Japan. Additional remedial actions can further reduce the calculated ratio of lifetime to first-year dose (section 4.1.4).
Health statistics data	The 6-year difference between available cancer incidence data (2004) and cancer mortality data (2010) was assumed not to introduce significant bias. No alternative data sets were available when starting the collection of input data for the risk models*. (section 5.1)
Incidence vs. mortality data for cancer	The major health risk indicator used in this HRA was cancer incidence rather than cancer mortality. Many cancers have a high chance to cure, a chance that is increasing with time. From a public health perspective, incidence maximizes relevance to populations with different health systems, while mortality is affected by the strength of health systems, screening programs, and access to early treatment (section 3.4).
Adjusted survival curves vs. survival curves	This HRA selected "cancer-free" survival (adjusted survival curve) rather than overall survival as more suitable for the calculation of LAR and LBR of cancer related to this radiation event (Annex D).
International classification of diseases (ICD)	There was incomplete concordance of ICD codes between LSS data and Japan health statistics data for breast and all solid cancers, but this did not substantially affect the results. (section 5.1.3; Annex E, sections E1 to E4).
Healthy worker effect (HWE)	The health statistics and demographic data used in the present HRA for the emergency workers were the same as in the general population. In general the mortality rates for workers tend to be lower than for the general population (HWE), and this choice might overestimate all-cause mortality risk in workers (Annex D). The health statistics and demographic data used in this HRA for the emergency workers were the same as in the general population. In general, the mortality rates for workers tend to be lower than for the general population (HWE) and this choice might overestimate all-cause mortality risk in workers (Annex D). No alternative data were available.
Assumed exposure scenarios for workers	The assumed exposure scenarios 1 and 2 are considered to be representative of about 99% of the emergency workforce, while scenarios 3 and 4 represent upper bounds of external and internal exposure respectively, representing less than 1 % of the workers. (section 4.2.4). In particular, scenario 4 would be only applicable to <0.01% of the workforce (i.e. a few workers) who received the highest effective dose, with a very high thyroid dose due to inhalation of radioactive iodine.

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* Cancer incidence data from 2006 became available later, showing a trend to higher incidence rates for female breast cancer and thyroid cancer compared to the 2004 rates (for age ranges of 45-80 years and 25-55 years respectively). For all solid cancers and leukaemia the rates just show random variation. This may result in higher LAR estimates for thyroid cancer in adults if they are calculated based on the 2006 rates. However this would not affect the lifetime fractional risk (LFR) estimates.

Selection of models and approaches	
Non-threshold models	For the low-dose radiation exposures estimated from the Fukushima-Daiichi accident, the best approach was considered to be the use of a linear non-threshold (LNT) model for solid cancers, and a linear-quadratic non-threshold model for leukaemia (Annex E).
Dose and dose rate effectiveness factor (DDREF)	Epidemiology does not provide support for the use of a DDREF for extrapolating risks from high or moderate to low doses.
Selection of cancer sites	Leukaemia, thyroid cancer and female breast cancer were modelled separately from other cancers because of the known radiosensitivity of these tissues and the demonstrated dependence of their risk on the age-at-exposure. Moreover, thyroid cancer is especially relevant to this HRA because of the release of radioactive iodine from the Fukushima Daiichi NPP. In addition, to provide an overall assessment of cancer this HRA used the "all solid cancer" risk model (not subtracting for breast and thyroid, as no such model is available from the LSS data) (section 2.2.1).
Latency periods	Minimum latency period was applied based on the ones reported in the literature (i.e. 2 years for leukaemia, 3 for thyroid cancer; 5 for breast cancer and all solid cancer). For breast cancer, the youngest age of disease onset of age 20 years is supported by epidemiological evidence, including populations with childhood radiation exposure (section 3.3.2).
Selected age at exposure	The three age groups considered for this HRA (i.e. infants aged 1 year, children aged 10 years, and adults aged 20 years) were selected to ensure representation of the youngest, most radiosensitive members of the population. The Japanese population has long been among the oldest in the world. Therefore, the choice of a 20 year age-at-exposure to represent an adult population, as well as the selection of a 1-year-old to represent all children under age 10, represents the most conservative scenarios.
Adopted risk quantity	The lifetime attributable risk (LAR) was selected as a simple quantity to quantify risk. At the low doses estimated from this accident, it is equivalent to the more complex risk of exposure-induced death (REID).
Models based on atomic bomb survivors vs. a nuclear accident	Despite the differences between types of exposure from the atomic bomb (largely external exposure) and nuclear accidents (internal and external exposure), LSS models were used in this study because they provide the largest body of epidemiological data on cancer and non-cancer radiation risks. Calculations of risk for thyroid cancer took data from the Chernobyl accident into consideration (Annex E, section E.3).
Transfer weights for each cancer sites	Overall, the choices of the transfer weights were either consistent with the published literature or were more conservative. The influence of the choice of the transfer weights on the LAR results can be seen in figures 23-25 (section 6.2.2). In general this choice did not substantially affect the LAR results.
Thyroid cancer risk at high doses	Epidemiological data suggest a flattening of the dose-response for thyroid cancer risk at very high doses. Therefore, thyroid cancer risks estimated for workers in scenario 4 in the present HRA may be overestimated.
Workers' sex and age-at-exposure	As only a few female workers were involved in the early response and their doses were very low, using males to represent all workers is a realistic choice. The selected ages-at-exposure (20, 40, 60) are judged sufficient to represent the workforce. Only 10% of the workforce was younger than 29 years at the time of the accident, while almost 40% were over 50 years old (Table 7 section 4.2.3). Taking into account that cancer risks are lower at older age-at-exposure, the workers' HRA provides conservative risk estimates (section 6.1.1). This is particularly relevant for thyroid cancer because epidemiological data indicate that the risk decreases significantly with increasing age-at-exposure, with little risk apparent after age 20 years (section 2.2.1).

7. Public health considerations

The Fukushima Daiichi NPP accident took place in the context of a natural disaster that caused catastrophic loss of life and massive loss of property. Owing to this unique association of an earthquake followed by a tsunami that caused a nuclear accident, this event is referred to as a "combined disaster" (*133*). An overview of the public health issues related to the disaster has been published by the WHO Western Pacific Regional Office (*134*). The health risks assessed in the present report focus on those effects potentially related to the radiation exposure resulting from the Fukushima Daiichi NPP, mainly cancer and some non-cancer outcomes. However, it should be kept in mind that WHO defines "health" as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (*135*). Other non-radiation-related health impacts of this combined disaster are discussed in this chapter, including mental health and psychosocial consequences.

7.1 Public health response during the emergency phase of the Fukushima Daiichi NPP accident

As the lead health agency within the United Nations, WHO is responsible for the international public health response in emergencies. The early response of WHO to this combined disaster included the assessment of and response to evolving health concerns related to mental health and the psychosocial impact of the disaster; prevalence of communicable diseases (e.g. acute diarrhoea, respiratory diseases, measles and other vaccine-preventable diseases); non-communicable diseases (NCDs) and priority-setting for chronically and critically ill patients who had to be evacuated (e.g. patients on dialysis, insulin-dependent patients, those on post-transplant critical care, or with lung, cardiovascular, and other NCDs).

For public health response in radiation emergencies, WHO relies on specialized technical networks, such as the Radiation Emergency Medical Preparedness and Assistance Network (REMPAN), which includes more than 40 medical and research institutions worldwide that support WHO's work on preparedness and response to radiation emergencies. The importance of global collaboration and coordination of emergency preparedness for timely and efficient emergency response was one of the lessons learned from the Fukushima accident that complements the knowledge gained after the Chernobyl accident (*136*).

The existing arrangements for the coordinated actions of international organizations (*2*) proved efficient during the response to the Fukushima Daiichi NPP accident. International organizations demonstrated a strong commitment to addressing issues related to health, food, drinking water, environment, trade, travel and nuclear safety. As discussed in section 1.1, short-term emergency public health actions were taken in Japan and around the world to manage and reduce the consequences of the accident. These actions, which in Japan included evacuation, sheltering, and food and drinking water monitoring, were consistent with the internationally recommended criteria for emergency interventions (*137*). In many countries around the world, governments considered measures to protect their citizens with a primary concern for those residing in or visiting the most affected regions of Japan in the days and weeks after the earthquake.

The safety of the food supply was of concern early on and extensive monitoring was put in place in Japan as well as in other countries. The FAO/WHO International Food Safety Authorities Network (INFOSAN) was instrumental in providing technical briefing notes related to food safety aspects and regular updates on food monitoring results to Member States.

7.2 Public health challenges in the recovery phase of the radiation emergency

The recovery phase after a radiological emergency is considered a different type of exposure situation under the current international system of radiological protection, with some specific radiation safety requirements that differ from those applied under emergency situations (*121*) (see Box 8). As a general principle, the introduction of countermeasures should bring the maximum net benefit to the population. All the risks and benefits resulting from a particular measure should therefore be considered in reaching a decision, and this includes both radiological and non-radiological risks (*138*). This is particularly challenging during the emergency response phase, characterized by strategies driven mainly by urgency and predominantly centralized decisions. The transition period between the emergency and the recovery phases is characterized by a change towards more decentralized strategies aimed at improving living conditions, protecting people with the highest exposures and reducing radiation exposure to "as low as reasonably achievable" (the ALARA principle) (*12,96,139*).

The Government of Japan, municipal authorities and residents implemented a number of remedial actions to lower radiation exposure (*100*). Environmental monitoring, including monitoring of food and drinking water, is continuing. In April 2012, the limits for radioactivity in food and drinking-water were reduced in Japan to levels that are consistent

Box 8. Categories of exposure and exposure situations

People may be exposed to radiation as members of the general population (public exposures), as a result of their work (occupational exposures) or for medical purposes (medical exposures). These are the three categories of exposure considered in the international system of radiological protection (*12*). Exposure to radiation can occur under any of the following three types of exposure situations:

- planned exposure situations arising from any planned activity that results in an exposure to radiation (e.g. a patient undergoing a radiological medical procedure);
- emergency exposure situations arising from an accident, a malicious act, or any other unexpected event (e.g. public or occupational exposures during a nuclear emergency);
- existing exposure situations which already exist when a decision on the need for control has to be taken (e.g. radon exposure in dwellings, prolonged exposures after an emergency).

with a maximum annual dose of 1 mSv (*140*). Decontamination and remedial actions are ongoing. The most efficient remediation options need to be considered, to ensure that benefits outweigh the hazards to the environment and people's well-being, recognizing that radioactive contamination is just one component in a complex mix of (often interacting) factors that demand careful attention. With this in mind, priority-setting for remedial actions will help identify target locations where people are expected to stay for prolonged periods (e.g. playgrounds, schools). The results presented in this report support the importance of prioritization with respect to the most sensitive populations (e.g. infants, children, pregnant women), for whom such remedial actions would have the highest impact in terms of reducing long-term risks.

The results of this HRA indicate that the health effects of radiation exposure resulting from the Fukushima Daiichi NPP accident inside and outside Japan are likely to be less ominous than the socioeconomic impact. This particularly applies to residents of Fukushima prefecture. A key issue during the current recovery phase is effective policy- and decision-making for the restoration of a normalcy.

During and after emergencies, public health risk management is supported by scientific evidence, taking into account ethical and social values, socioeconomic factors, and public perceptions and expectations of society. In the case of the Fukushima Daiichi NPP accident, public perceptions and the expectations of stakeholders – e.g. residents, consumers, producers, farmers, manufacturers – are particularly related to radiation safety, levels of risk that are tolerable and degrees of protection that are necessary. It is important to take into account perceptions and expectations when stakeholders are informed about available options and as they are encouraged to undertake self-help protective actions (*96*).

Social interventions aimed at building community strengths, capabilities and self-reliance can help large numbers of people to preserve a sense of social solidarity, to improve the quality of community life. The engagement of the affected population in developing and implementing protective and remedial actions (such as "self-help actions") can reduce people's feelings of vulnerability. Making use of existing mechanisms to promote personal and societal cohesion increases the effectiveness of the radiation protection interventions and may also contribute to recovering and improving mental health (*96,141*). Community-centered interventions that facilitate the involvement of stakeholders from Fukushima and neighbouring prefectures can help individuals express their own needs and to participate in the selection of suitable protective and remedial actions by making informed choices.

As of November 2012, many residents are still unable to return to their homes, and for some there is uncertainty about when – or whether – they will ever be able to go back to their homes and communities. Their engagement in the implementation of remedial actions and recovery plans will help them rebuild their lives.

Risk communication is a key component of the risk analysis process, and is linked closely to risk assessment and risk management. Proactive risk communication, coupled with public involvement in the remedial process, is critical to the success of any remedial activity. Addressing public health concerns is a major communication challenge. The building blocks of an effective risk communication strategy are trust, transparency, ethics, technical accuracy, values, credibility and expression of caring. Different types of messages may be more – or less – suitable for different audiences (e.g. the general public, policy-makers, decision-makers, the mass media). Fears and perceptions need to be addressed – even if they are not commensurate with the actual risks. It is of utmost importance to prevent reactions that themselves carry risk (such as self-administration of potassium iodide), to allay unnecessary fears (such as avoidance of breastfeeding because of health fears), and to promote healthy coping mechanisms (such as social solidarity).

7.3 Long-term follow-up of populations following radiation emergencies

Programmes for medical monitoring of populations after radiation emergencies are intended to address two different target populations:

- persons who have developed clinical conditions requiring medical assistance during the emergency (e.g. acute radiation syndrome, local radiation injuries);
- asymptomatic persons known (or presumed) to have been exposed to low doses of radiation.

No clinical conditions have been identified after the Fukushima NPP accident for the general population, nor for workers. The current HRA, in particular related to specific cancer risks, identifies the aspects of most concern and helps target follow-up actions with respect to cancer types, age groups and geographic location.

Medical follow-up of asymptomatic persons involved in a radiation emergency poses major concerns regarding the identification of populations at higher risk and whether screening for disease in the "at-risk" population produces more benefits than potential harm. The goal is to detect disease as early as possible, with the assumption that earlier diagnosis will result in reduced morbidity and mortality. In addition, health monitoring and surveillance can provide reassurance in response to the population's concerns about health risks (*96,141*).

Several factors can help ensure that such screening is beneficial:

- Disease risk should be identified in the most vulnerable population or population subgroups (e.g. children, pregnant women).
- An accurate practical screening tool should be available.
- Early detection of the disease must lead to improved survival.
- Effective treatment of the disease should be available.
- The benefits of the screening must be greater than any potential harm (individual and public health dimensions).

A thyroid ultrasound screening programme is currently being conducted in Fukushima prefecture (see Box 9). It is important to ensure that this programme includes a representative sampling of residents, selected from geographical areas with different levels of radionuclide ground deposition over the whole prefecture. The screening should be conducted without knowledge of the specific exposure situation of the person (if at all possible). This ultrasound screening for thyroid disease is likely to lead to an increase