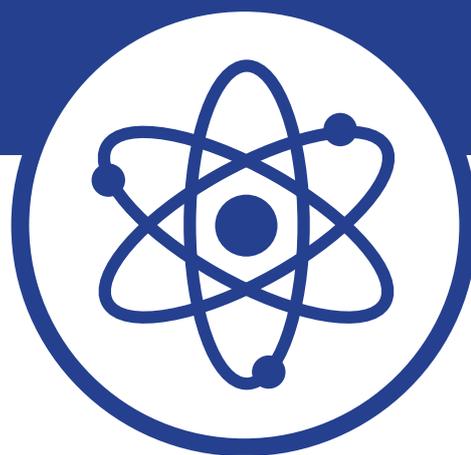


# Recommendations and procedures for preparedness and health surveillance of populations affected by a radiation accident





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## 1. Background

The EU-OPERRA SHAMISEN project started in December 2015, with the goal of producing a set of recommendations that would contribute to health surveillance and related communication with affected populations after nuclear accidents. Experience suggested that this was an area that had not been sufficiently addressed in current accident response planning in many European countries. It was also recognised that an update of emergency preparedness in this area was needed for a number of reasons. These include the fact that existing recommendations had a technical focus, with less attention paid to social, ethical, psychological issues and that the information tended to be directed towards the decisions made by experts rather than for support of affected populations<sup>1</sup>. Finally, there have been a number of changes in legal and ethical requirements for health surveillance and epidemiological studies (e.g., related to data protection) that need consideration.

## 2. Introduction to the Current Document

The current recommendations are based on reviews, carried out within the SHAMISEN project, of guidelines in existence at the time of the Chernobyl and Fukushima accidents and of the actions which were taken, highlighting successes and limitations. The review includes case studies and lessons learnt from previous nuclear accidents, and summaries are provided as an Annex to the present document. The recommendations aim at improving health and living conditions of potentially affected populations. They cover health surveillance, epidemiological studies, dose reconstruction, evacuation and training of health personnel and other actors involved in liaising with affected populations.

The recommendations are divided into general principles that apply across all phases of an accident, and three sets of specific recommendations for emergency and accident preparedness, the early and intermediate phase and the long-term recovery phase (Figure 1). According to the ICRP, the early and intermediate phases comprise the emergency response, whereas the long-term phase is associated with the recovery of the affected areas and the long-term rehabilitation of living conditions of the population. The exact demarcation between the phases will be dependent on the specific accident, and for large nuclear accidents affecting large areas, different phases could affect different geographic areas at the same time. In addition, recommendations have been colour-coded<sup>2</sup> according to topic.

<sup>1</sup>In a broad context, the affected population is defined as: “those whose health and well-being was/is at risk of detrimental effects due to the consequences of a nuclear accident”. This could include indirect effects to those outside designated contaminated areas, for example, persons whose livelihoods and well-being were affected by loss in consumer trust. Alternatively, the definition could be restricted to only those persons actually exposed to an increase in radiation dose such as: “persons who live, work or stay in the areas contaminated by a nuclear accident”.

<sup>2</sup>The colour scheme of the recommendations is as follows: Evacuation, Health surveillance, Epidemiology, Dose assessment, Communication and Training



**Figure 1** – The different phases of an accident

<b>Preparedness</b>	<b>Early and Intermediate</b>	<b>Long-term Recovery</b>
Continuous cycle of planning, organizing, training, exercising, equipping, evaluating and taking corrective action.	<b>Emergency response:</b> coordination and management of resources. <b>Early:</b> initial phase of radiation hazard resulting in an emergency exposure situation. <b>Intermediate:</b> radiation level is no longer increasing.	<b>Activities of populations: adjust to the prevailing radiation situation.</b> <b>Focus:</b> recovery of the affected areas and long-term rehabilitation of living conditions of the populations.

A number of national and international organizations have, or are working on, strategies for nuclear emergency preparedness and health surveillance (e.g., IAEA 2015a; WHO-REMPAN 2017). ICRP is updating its guidance on accident management (ICRP 109, 2008) and ICRP 111 2009) and has a report on the Ethical Foundations of the System of Radiological Protection out for consultation (see ICRP, 2016 and [www.icrp.org](http://www.icrp.org)). Recognising these activities, as well as the considerable international expertise and experience that is available, the recommendations are intended to be disseminated to radiation protection authorities, medical experts, affected populations and other scientific and non-expert audiences. It is hoped that they can contribute to the ongoing international developments in this area.

## General

<b>R1.</b> The fundamental ethical principle of doing more good than harm should be central to accident management
<b>R2.</b> Recognise the difference between health/medical surveillance and epidemiology
<b>R7. Build a radiation protection culture</b>
<b>R6.</b> Adapt dosimetry and individual exposure monitoring to the situation
<b>R3.</b> Encourage a health surveillance strategy that targets the overall well-being of populations
<b>R4.</b> Ensure that health surveillance respects the autonomy and dignity of affected populations
<b>R5.</b> Review, and if needed improve, existing health monitoring systems for epidemiological surveillance



Preparedness	Early and Intermediate	Long-term
<p><b>R9.</b> Plan sheltering, evacuation and stable iodine distribution protocols</p>	<p><b>R15.</b> Optimize timing and support for sheltering and evacuation</p>	<p><b>R22.</b> Have plans for lifting of evacuation orders as soon as possible</p>
<p><b>R8.</b> Establish early response and communication protocols</p> <p><b>R10.</b> Prepare and facilitate training and education material and resources</p> <p><b>R13.</b> Foster participation of stakeholders and communities in emergency and health surveillance planning</p>	<p><b>R14.</b> Ensure prompt sharing of accurate and reliable information</p>	<p><b>R21.</b> Build networks of experts - local facilitators - population</p> <p><b>R23.</b> Consider the preferences of people living in affected areas</p> <p><b>R28.</b> Foster long-term participation of affected populations and communities</p>
<p><b>R12.</b> Prepare action frameworks focused on dose assessment for workers and populations</p>	<p><b>R17.</b> Collect and store all radiation-related dosimetry data</p> <p><b>R18.</b> Provide support to populations who wish to make their own measurements</p>	<p><b>R19.</b> Continue dose assessment for workers and affected population</p> <p><b>R20.</b> Continue dose measurement support to populations</p>
	<p><b>R16.</b> Create a common roster of affected populations</p>	<p><b>R24.</b> Expand support of populations to take into account economic and social upheavals</p> <p><b>R25.</b> Launch systematic health screening based on appropriate justification and design</p>
<p><b>R11.</b> Prepare frameworks and checklists for epidemiological protocols</p>	<p><b>R16.</b> Create a common roster of affected populations</p>	<p><b>R26.</b> Clarify objectives and expected results of epidemiological studies</p> <p><b>R27.</b> Ensure long-term sustainability of follow-up of populations at risk</p>

Evacuation

Communication and Training

Dosimetry

Health surveillance

Epidemiology



# General recommendations



# R1

**The fundamental ethical principle of doing more good than harm should be central to accident management.**

## WHY

Management of radiological accidents raises a number of ethical issues. A central question, and one that has been raised after both Chernobyl and Fukushima, is whether or not the response to the accident has caused more good than harm. Although the majority of radiation protection actions, including health surveillance, are directed towards reducing the impacts of exposure to ionizing radiation, most of these carry with them a multitude of direct and indirect consequences (Oughton, 2016), including the inefficient use of health services (Vale and Albani, 2017), which can have a large impact on the welfare of affected and unaffected populations. Ethical considerations are also important for the design and implementation of health surveillance and epidemiological studies.

## HOW

SHAMISEN recognizes the need for a holistic approach to accident management and health surveillance if the aim of **doing more good than harm** is to be realized. This aim is not straightforward, and is complicated by different values, perceptions and uncertainties about outcomes (Table 1). Nevertheless, addressing ethical issues can help ensure that the assumptions, potential conflicts and reasons behind eventual decisions are as transparent as possible. This would include **being balanced in the way uncertainties are addressed** when evaluating outcomes. For example, being overly conservative about potential doses and radiation health effects (i.e., selecting the highest possible dose ranges rather than best possible estimates), yet underestimating the societal and health consequences of evacuation or other protective measures, is not likely to result in optimal decisions for the affected populations.

## WHO

All players involved in emergency preparedness, dose assessment, evacuation, health surveillance, and communication; this includes authorities, academic and other research institutes, NGOs, etc.

# R2

**Recognise the difference between health/medical surveillance and epidemiology, and their different objectives and data needs.**

## WHY

Health surveillance following radiation accidents has been hampered by a lack of clarity about the difference between medical surveillance, health surveillance, health screening and epidemiology. This has caused confusion and misunderstanding in communication about the goals and expected outcomes of health surveillance, among affected populations, scientists and authorities.

## HOW

The **objectives of health/medical surveillance** are to evaluate whether **individuals** affected by an accident suffer from some **health condition**. This involves contact with, and follow-up of, affected individuals through medical check-ups, questionnaire surveys, etc. and is a basis for providing support and treatment as required. Health conditions can encompass both somatic effects from the radiation exposure, as well as psychological and stress related illness.

In contrast, the **objectives of post-accident epidemiology studies** are 1) to evaluate whether the radiation exposure/accident has impacted **disease rate/risk** through “epidemiological surveillance”, using **population** hospital/health-insurance **registries**; and 2), if possible, to improve our knowledge on **effects of radiation**, using analytical epidemiological approaches. These studies could also consider the wider social and economic impacts of the accident and methods taken to alleviate its consequences.

While some health/medical surveillance programmes can provide a roster for epidemiological studies, it may be incomplete, and careful checking of its representativeness and of the information collected is needed before using it for an epidemiological study. It is important to be transparent about the objectives and expected outcomes of all programmes and studies so that they are clear to the population. This is also needed for ethical approval.

## WHO

Health agencies, health professionals, academic and other research organisations.



## R3

**Encourage a health surveillance strategy that targets the overall well-being of populations and not only addresses radiation effects, but also psychosocial and socio-economic impacts induced by the consequences of a nuclear accident.**

### WHY

According to the WHO, “Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO, 1948). One of the most important lessons learnt from previous accidents is that the negative consequences and potential benefits of health surveillance go beyond the direct impacts of radiation exposure. These include psychosocial and health impacts caused by stress and anxiety, or by emergency evacuation, as well as socio-economic, cultural and other societal impacts, such as access to community areas, or safeguarding traditional practices and lifestyles. The long-lasting societal and economical disturbances can also be linked to a range of lifestyle-related diseases among the exposed populations. Failure to capture the full impacts of surveillance means that an efficient surveillance strategy cannot be readily identified.

### HOW

A **multidisciplinary approach** to health surveillance is needed to identify, measure, assess and alleviate psychosocial and other indirect health impacts of socio-economic and social upheavals of the consequences of the accident (*see also R24*). It should include the participation of psychologists, mental health specialists, sociologists, health economists, radiation protection experts, epidemiologists, general physicians and other stakeholders able to take into account the **concerns and expectations of local populations**. Since the revitalisation of community welfare is a particularly important consideration, and often challenged by mistrust of authorities, the participation of **local health practitioners and actors** should be especially encouraged.

### WHO

Health authorities, medical professionals, academic and other research centres, local citizens.



## R4

**Ensure that health surveillance respects the autonomy and dignity of affected populations, and is sensitive to any inequity in the distribution of risks and impacts.**

### WHY

The ethical values of dignity and autonomy are most commonly linked to questions about the self-determination and choice of affected populations, while respect for the ethical values of fairness and justice stress the importance of addressing the way in which risks, costs and benefits are distributed.

### HOW

Actions that can **help people gain control over their lives** and situation can strengthen dignity and respect autonomy. Examples include provision of monitoring equipment (e.g., WBC<sup>3</sup>, dosimeters or food monitoring), provision of information that can help the populations make their own decisions and actions, and engaging populations in decision-making concerning the implementation and lifting of radiological protection countermeasures. **Respect for dignity** is also important to consider. This includes **the nature of the personal data** collected (particularly regarding lifestyle and health), how it is stored (including how it can be accessed and by whom and dissociation of personal identifiers), how it is used and how results are disseminated (any results presented other than to the person itself should be anonymized). For health surveillance, this means paying attention to the expectations and expected benefits and costs of the surveillance for the participants, and underlines the importance of including populations in study design. Being sensitive to the distribution of risks and benefits would include a **particular concern and responsibility for children**, and acknowledging and attempting to redress - the inequities that can arise from the impacts of the accidents, both in the short and long-term due to ill health and disruption to social environment and education. (*Further examples of these aspects are given below in R9, R15, R18, R22-25, see also ST1 and ST2 summaries – Annex 1*).

### WHO

Health authorities, medical professionals, academic or non-academic research centres, local citizens.

<sup>3</sup>WBC: whole body counting



## R5

**Review existing health monitoring systems with particular emphasis on cancer registries and, where needed, improve or establish new ones for epidemiological surveillance. Disease registries must be expanded through better harmonization and linkage within and between countries. All aspects related to data protection and ethical rules need to be addressed and resolved.**

### WHY

Health systems and health monitoring systems vary widely from one European country to another, and even within countries (WHO, 2015). Moreover, health monitoring systems cannot always provide data on disease incidence at the local or even regional level or at a sufficiently precise diagnostic level (e.g. disease subtype). This can be due to lack of validated data, difficulties in producing a harmonized diagnostic definition and/or inability to link between existing databases within and between countries. Although many disease registries exist at the regional or national level in different European countries, an overview of the completeness of the monitoring systems and data availability, as well as of the possibility to link these registries to other routinely collected data on use of health and social services across Europe is needed.

### HOW

Analyse the **health monitoring system** in each European country:

- Review disease registries, describing in particular their coverage, exhaustiveness, recorded diseases and diagnostic level;
- Review availability of surrogate health databases and their reliability for health monitoring **and the use of other health and social service records** (e.g. health insurance, hospital discharge, other national observatories, etc.);
- Review data protection and ethical rules in each country;
- Identify the difficulties of **linking databases within and between countries**;
- Identify important **gaps in health monitoring systems** and social care records in each country.

Where gaps or limitations are identified, improve or establish new health monitoring databases, **preferably disease registries**, to provide information for: i) general health surveillance and characterization of disease frequency; ii) epidemiology, for the general population and for workers; iii) **evaluation of the effectiveness and cost-effectiveness** of possible surveillance strategies. Whilst respecting the ethical guidelines and ensuring personal data protection, propose improvements to **allow linkage of databases** for the establishment of an efficient European health monitoring system in case of disaster.

### WHO

Health authorities, academic and other research centres, ethics committees.



## R6

**Adapt dosimetry and individual exposure monitoring to the exposure pathways, the phase of the accident, the general situation and the different concerns and needs of people and society, and where needed, improve or establish new approaches of dose assessment.**

### WHY

Dose assessment is a critical issue in radiation protection of individuals, from workers in charge of responding to the accident to the general populations living within the surrounding area. Evaluation of doses after a nuclear or radiological accident is crucial for many purposes, including implementing prompt medical assistance, radiation protection countermeasures and later health surveillance and epidemiology programs. It is essential to note that the dosimetry system used must be appropriate to pathways of exposure and dose ranges and that dosimetric concerns in the early and intermediate phases are different from those in following phases (Tables 2 and 3).

### HOW

During the **early phase**, the initial evaluation of the radiological consequences of an accident should be based on potential releases and used to inform decisions about emergency phase countermeasures (sheltering, evacuation, iodine thyroid blocking). Once individual and/or environmental data are available, in the **intermediate phase**, dose assessment should focus: 1) for workers, on identifying those who need medical attention and ensuring appropriate radiation protection; and 2) for populations, on supporting decisions about concerted countermeasures (for example, extension of the evacuation), long term health surveillance and communication. **During the long term and recovery phases**, the assessment and reconstruction of doses of the affected individuals should address: i) the needs of individuals and society, including communication about the exposure situations; ii) development and possible adaptation of appropriate health surveillance programs and associated social care; and iii) where appropriate, supporting epidemiologic studies to evaluate the possible health impact on those affected.

Note that the type and quality of **data collected in the early phase** are of crucial importance (in particular thyroid *in vivo* measurements of short-lived radionuclides such as <sup>131</sup>I), since this will provide essential information for the implementation of health surveillance programmes and epidemiological studies.

### WHO

Radiation protection authorities, nuclear companies, academic and other research centres.



## R7

**Build a radiation protection culture between radiation protection experts, healthcare workers, professionals and the general public.**

### WHY

Radiation protection culture is defined as the understanding and know-how that is essential for a population to interpret monitoring results and, on that basis, be able to make informed decisions related to protective actions against existing or potential exposures to radioactivity (CODIRPA, 2012, p.83). This recognises that radiation protection is not only a matter of science, but also a question of values and judgement, and needs the participation of experts, professionals and publics. Past nuclear accidents and studies in the literature have revealed that there is a lack of trained radiation protection experts worldwide, that healthcare workers are not sufficiently trained to deal with direct and indirect radiation effects, and that the general population is not informed (or is misinformed) about the risks of ionising radiation, especially at low doses.

### HOW

We need to **recognize the crucial role of radiation protection experts and healthcare professionals**, and provide them with training courses, training material, and information sessions adapted to their professional requirements. For non-healthcare stakeholders and populations, basic information on ionising radiation needs to be ready and available, and necessary **communication channels** (mass media, social media, websites, local seminars by experts and local translators, etc.) need to be developed and maintained. Official authority representatives and media contacts should better apprehend the uncertainty related to any emergency situation, as well as the need for rapid, transparent and coherent information in order to avoid misinformation and unnecessary anxiety.

This should include information on protective measures and ways in which populations can reduce exposure in day-to-day life. These actions are to be prepared before, implemented during the early phase and reinforced along the long-term recovery phase of an accident.

### WHO

Radiation protection authorities and experts, civil protection authorities, local health departments, hospitals, teachers and media contacts.



# Preparedness Phase





## R8

**Establish early response and communication protocols with responsibilities and roles clearly laid out. Engage relevant stakeholders in the establishment of these protocols, and prepare the necessary material and channels to communicate with the public (including social media).**

### WHY

The immediate response following a nuclear accident needs to be rapid, coordinated and, to the degree possible, evidence-based. Past nuclear accidents (e.g. (Prezelj et al, 2016)) and a number of reports (e.g. (Dalnoki-Veress et al, 2014)) have highlighted gaps in the adequacy of training, awareness of the chain of command and transfer of information during a radiological emergency, as well a lack of clear and coherent communication strategies. These hinder optimum accident management procedures and can lead to mistakes and wrong decisions by authorities, particularly during the immediate aftermath of an accident. They also generate mistrust and “information voids” that can be quickly filled by misinformation (see R14).

### HOW

Nuclear accident preparedness protocols must include strategies on crisis communication (on the actual event occurring or occurred) and risk communication (on the possible short and long-term health consequences of the accident) that identify in advance who will be providing information to the decision-makers, how this flow of information to and from local and national authorities will be coordinated, and what channels will be used to communicate such information to the public. This means **defining responsibilities** and **identifying spokespeople** for nuclear power plants and local and national authorities. Risk communication training and protocols will necessitate the **establishment of liaisons with different stakeholders**, such as identified radiation protection experts and scientists who can foresee potential effects, as well as NGOs and community leaders who can explain the local situation. Experts must be trained to acknowledge and convey possible **differences in opinion as well as the uncertainty** associated to any emergency situation. Communication strategies also imply the **establishment of communication channels in advance**, including the identification of key journalists and the preparation of online information (e.g. websites) and social media channels (e.g. Twitter) (Perko et al 2016). Along this line, authorities should elaborate a national plan for preparedness and management of post-nuclear accident situations that includes special recommendations on communication with an emphasis on adequate and credible crisis communication, trust-based relations with media, the incorporation of online communication, and the creation of dialogue spaces.

### WHO

National and local authorities, operators, radiation protection experts, NGOs, community leaders, journalists.



## R9

**Plan sheltering, evacuation and stable iodine distribution protocols, including prioritisation of vulnerable populations (e.g. children and pregnant women), and appropriate balancing of life-protection actions against the potential health impacts of evacuation, particularly for patients and nursing home residents.**

### WHY

Sheltering and evacuation can be effective radiation protection actions for residents in the emergency phase. Without a plan, however, evacuation can lead to confusion, increased incidence of road traffic casualties and injuries. Hospitalised patients and the elderly at nursing care facilities can suffer serious life-threatening conditions due to deterioration of underlying medical problems. Traffic jams can prolong evacuation time, resulting in increased rather than reduced radiation doses. Evacuation can also have long-term consequences both for the individuals affected, but also for the wider economy and society in general (see *R15*).

It is well-documented that children and adolescents exposed to radioiodine after Chernobyl had a sizeable dose-related increase in thyroid cancer, greatest among those who were youngest at exposure, and that stable iodine deficiency may have increased the risk. Despite this, there was great confusion as to whether residents needed stable iodine tablets in Fukushima.

### HOW

- Plans need to **identify populations** that are vulnerable to radiation (pregnant women, children), those requiring special care (patients, nursing home residents, persons with disability), and those with unique needs (prison inmates, etc.), **and disseminate information about personal protection to residents** (i.e., how to protect themselves from external and internal exposure). Sheltering facilities with suitable structures and available living resources (water, food, power, etc.) should be designated, and plans for evacuation should consider the evacuation route, means of transportation and destination taking into consideration the special needs of different groups of evacuees (patients, nursing home residents, etc.)
- If long-term sheltering is chosen, specific plans for hospitals or nursing care facilities should be made, taking into consideration reduction of hospital staff and suitability of facilities (i.e., effective air-conditioning), and securing supportive staff and supplies to maintain the basic functioning of the facilities.
- Plans for iodine thyroid blocking need to include depositories, distribution methods, criteria for administration and persons responsible for administration in case of accident. Consider iodine supplementation programmes for children as a public health policy in iodine deficient areas.

### WHO

Radiation protection, civil protection and health authorities, hospitals.



## R10

**Prepare and facilitate training and education material and resources adapted to healthcare and other professionals, as well as other stakeholders.**

### WHY

One of the main lessons learned from previous accidents is that information needs to be adapted to the persons' demands and needs. Educating medical students, doctors and teachers is a key action in this process. A number of training programmes in radiation protection exist in Europe (Table 4), though assessments have shown a significant need for post-graduate training, with a particular demand for radiation protection experts (Skipperud et al, 2011). The post-graduate programmes recently developed by Japan are an example to follow (Table 4). Further, though refresher short courses on nuclear preparedness and response are offered by organisations such as REMPAN, NERIS, REAC/TS (Table 5) for radiation protection experts, the availability of pre-accident training for primary healthcare and other responders is very low. Moreover, non-health professionals such as teachers and community leaders are not sufficiently informed about the direct and indirect effects of radiation. Specific education and training programmes, material and resources need to be anticipated and developed before any accident occurs.

### HOW

**Radiation protection preparedness should be promoted**, by providing skills and knowledge adapted to healthcare workers and other professionals (practitioners, nurses, teachers) and other stakeholders (local authorities, NGOs, journalists, teachers). For **health workers**, a brief document with information and recommendations on dosimetry, health surveillance, evacuation decisions, thyroid screening, risks of over diagnosis and anxiety needs to be prepared, with an emphasis on well-being. Information material should also be prepared by and for **a broad range of stakeholders** (local public health authorities, NGOs, journalists) to increase radiation knowledge among populations, without raising unnecessary concerns. This material will serve to provide rapid basic information in case of an accident. A noteworthy example is the 2016 workshop organized by the World Federation of Science Journalists with the European Nuclear Education Network to strengthen European journalists' competences in nuclear safety (WFSJ, 2016).

### WHO

Radiation protection authorities, public health authorities, hospitals, schools, journalist associations.



## R11

**Prepare frameworks and checklists for epidemiological protocols, questionnaires and consent forms for individual dosimetric and health monitoring, and appropriate databases through local, national and international coordination, ensuring ethics approvals.**

### WHY

Lessons learned from previous accidents indicate that implementation of post-accidental epidemiologic studies is very difficult, in particular because of the lack of pre-existing organisational framework, material or protocol, hence the need to start preparations from scratch.

### HOW

A framework and checklists should be prepared in advance, to be adapted to the specificities of an accident, which, in Europe, would likely affect several countries. This would include:

- **Questionnaires and associated consent forms** for the collection and use of individual dosimetric and health data, translated into different languages;
- **Checklists for epidemiological protocols**, with particular emphasis on diseases associated with radiation exposure (thyroid cancer, leukaemia, etc.) and indirect health consequences (psychological disorders, health impact of evacuation, etc.) linked to economic or social difficulties faced by the affected population;
- **A priori criteria for the definition of study populations** based on evacuation, definition of post-accidental exposure zones and clean-up worker status;
- **Identification of the actors to be involved** in post-accidental epidemiologic and public health studies, defining roles, actions and responsibilities of each institute or administration;
- **Procedures developed jointly** by radiation protection specialists (emergency measurements), public health/or disaster managers (rosters), dosimetrists, epidemiologists and other researchers **to allow collection and conservation of important data**, also considering feasibility of biobanking for future epidemiological studies;
- Possible pitfalls in data access and sharing related to **ethical and data protection aspects**;
- **Coordination** of the creation of databases locally, nationally and internationally to ensure the ability to link between various databases within and between countries.

### WHO

Health authorities, academic and other research centres.



## R12

**Prepare action frameworks focused on dose assessment for workers and populations, with the objectives of: 1) monitoring as many individuals as possible, in particular among critical groups; and 2) collecting and maintaining the results and other relevant data for future needs.**

### WHY

The importance of developing a plan to perform large scale measurements and recording of appropriate quality individual doses has been recognized previously. However, experience has demonstrated that the capacity and calibration of techniques for *in vivo* (especially thyroid) and *in vitro* activity measurements were often inadequate. Due to difficult conditions, worker dosimeters can be mislaid or malfunction. In general, lack of coordination and harmonization of dosimetry systems, procedures and record keeping is a main area for improvement.

### HOW

A system of **procedures and tools for dose assessment based on individual measurements** should be developed in advance. This should include data to be collected that can be useful for future needs, including dose reconstruction, health surveillance, epidemiology and public health. Plans need to be realistic in terms of resources and should **aim to foster coordination, harmonization** of dosimetry and of record keeping procedures.

**With respect to measurements and dose assessment**, this can be achieved by: 1) **preparation of guidelines**, with a **focus on critical groups** (those potentially most exposed and most vulnerable); 2) plans for rapid *in vivo* and *in vitro* activity measurements with adequate capacity and proper calibration (especially for children); 3) **mobilization of the *in vivo* and/or *in vitro* measurement instruments** (sharing equipment as needed between organisations and countries), including improved **standardization of protocols** for shared resources; 4) preparation of procedures and tools for dose assessment based on measured *in vivo* and/or *in vitro* activities; 5) transportation of biological or inert samples in case *in vitro* measurement onsite is not possible and preparation of procedures for sample taking and shipment; 6) **predistribution of dosimeters** capable of recording wide ranges of dose-rates to selected groups of residents (e.g. teachers, doctors) in the form of “emergency boxes”; 7) **use of GPS in measurement** equipment to map position, time and movements; 8) **safe storage of back-up or additional worker dosimeters** in case of lack of operability or loss, and planning for dosimeter sharing between organisations (e.g. hospitals) in case of need; 9) establishment of **minimum performance criteria** of new technologies for self-made measurements and harmonization of official and non-official measurement networks; and 10) drafting of **procedures for the management of large amount of data** (“big data”).

**With respect to data storage**, a strategy is needed for: the collection and recording of dosimetry results and personal behaviour data in standardised databases and for linkage between the different databases; and for the preparation of simple brief e-questionnaires (with paper copies in case of electricity shortage) about personal behaviour for workers and population, to be completed at time of dosimetric screening, with data useful to assess and better reconstruct doses retrospectively.

### WHO

Radiation protection and health authorities, nuclear, academic and research organisations.



## R13

**Foster participation of stakeholders and communities by engaging them in emergency preparedness, including planning for socio-economic health surveillance and, where appropriate, epidemiology.**

### WHY

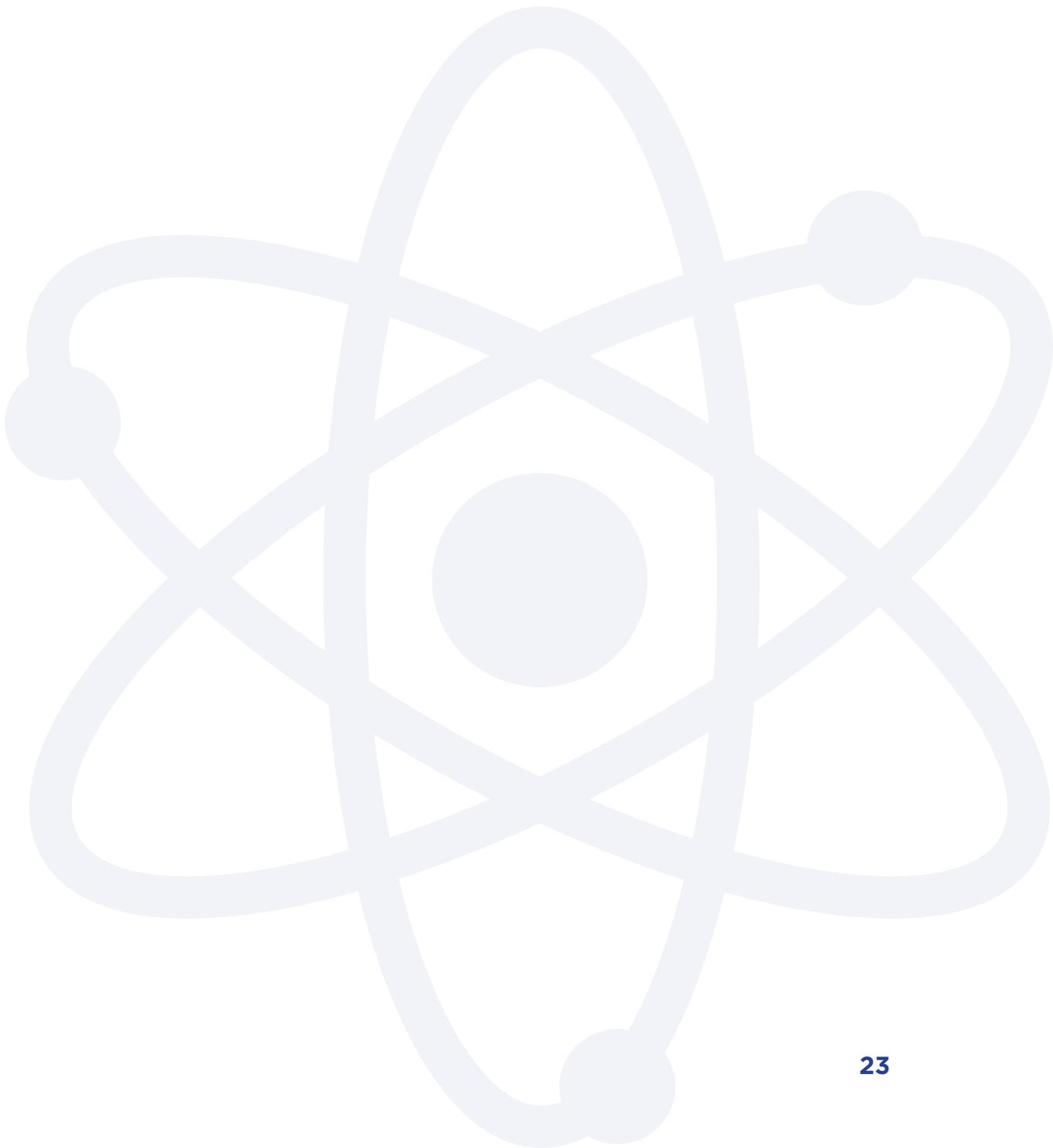
The importance of stakeholder engagement is recognized across many areas of radiation protection, accident management and emergency preparedness (e.g. ICRP 109, 2009) and ICRP 111, 2009); IAEA, 2015a). Public engagement can be advocated by the fact that populations have a right to participate in decisions that impact on their lives, and is also supported by growing evidence that this leads to more effective and efficient risk management and health surveillance, and can improve public understanding of the consequences of nuclear accidents (see *ST1 and ST2 summary reports*). Involving a variety of different stakeholders in emergency preparedness (i.e., during “peace time”), helps to establish valuable contacts and a common understanding of issues and responsibilities.

### HOW

Stakeholder engagement approaches range from only informing, to consulting, involving, collaborating with or even placing final decision-making in the hands of the public (Table 6). In the context of radiation emergencies, effective engagement should **involve as wide a range of stakeholders as possible during the preparedness phase** (i.e. by improving their knowledge on the consequences and management of nuclear accidents, see *R7*), with the intention of continuing to involve populations and other relevant stakeholders in early, intermediate and recovery phases. Stakeholder panels are common in many European countries within emergency preparedness (see papers in (Liland et al, 2016 ), and include a range of experts, representatives of national and local authorities, public health practitioners and NGOs. Although the actual involvement of local populations and communities can be limited in the preparedness phase, a **framework for involvement of the public in the post- accident phase** has to be prepared and adapted to the national specificities at this stage. Furthermore, experts should be prepared on how to include the population in post-accident health surveillance and epidemiological studies (see *R28*).

### WHO

Radiation protection and health authorities, national and local authorities, public health practitioners, epidemiologists, radiation protection experts, key local NGOs and citizens' organisations.





# Early and Intermediate Phase





## R14

**Ensure prompt sharing of accurate and reliable information (e.g., plant conditions, radiation dose, radiation protection actions) between nuclear plant representatives, authorities, experts and the population.**

### WHY

As previous public health emergencies showed, it is easier to scare than to reassure. The absence of timely, coherent and responsive official information leads to an “information void” quickly filled by misinformation (a recent study found that, during the Zika virus outbreak, the most popular social media health stories were the least accurate (Sharma et al 2017)). In the two months after Fukushima, the communication process in Europe was characterized by the dispersion of information sources and partially subjective and conflicting media reporting (Prezelj et al, 2016). Despite little increase of background radiation in areas outside evacuation zones, all areas of Fukushima prefecture suffered due to a substantial drop in tourism, produce supply cuts, and misinformation (IAEA, 2015b). However, a study showed that almost 70% of tweets after the accident were synthesis-derivative (i.e. containing third-party information) based on highly credible sources. The proximity to the crisis also seemed to increase the tendency to share information from credible sources (Thomson, 2012). The benefits of online information offer the public a unique opportunity to learn about nuclear power, which may outweigh the costs associated with “internet cacophony” (Pierpoint, 2011).

### HOW

The communication strategies defined in the preparedness phase (*R8*) should be implemented to: i) **ensure prompt sharing of accurate and reliable information** between nuclear plant representatives, radioprotection experts and local and national authorities to make evidence-based decisions; ii) **provide rapid, credible and consistent information to the public** using several sources (Wray et al, 2008; Perko, 2014) (e.g. specialized journalists, general press, official websites and social online networks). The use of an **official hashtag** may serve as a collaborative filter against false rumours, as was observed for the #fukushima hashtag (Thomson, 2012). Messages need to reference the seriousness of the accident, the possibility of radiation exposure, the health risk, costs and benefits of the recommended course of action and if an individual can take the recommended actions. They should make clear where consensus exists between specialists, but be open to discussion about limits of scientific knowledge and uncertainties linked to any emergency situation. The overall strategy must keep public risk perception in mind, and be integrated into policy making and implementation during the recovery phase (Sato, 2016). Creating a relationship of mutual trust is the most important element in conveying this message to the public (Ng & Lean, 2012; Rubin et al, 2012). In this sense, **potential local facilitators** (see *R21*) **should be identified** during this phase.

### WHO

Local/national authorities, nuclear plant operators, radioprotection experts, journalists.



## R15

**Optimize the timing and support for sheltering and evacuation to reduce radiation exposure, avoid negative health effects arising from evacuation or relocation, and provide the necessary medical and psychological assistance.**

### WHY

Rapid implementations of the sheltering and evacuation plans outlined in *R7* are required to avoid confusion, inadvertent radiation exposure or life-threatening consequences for patients and the elderly. In addition to the logistical problems of carrying out public evacuation, other major issues include insufficient information being provided to populations on radiation doses, protective actions, expected length of evacuation, and transportation.

### HOW

Decisions about whether and when to evacuate should be based on the best possible assessment of total health risks by balancing radiation and other risks. **Sheltering and personal protection measures should always come first**, particularly in areas within reach of the radioactive plume, but where doses are not expected to warrant evacuation. Before implementing evacuation, arrangements need to identify and ensure **appropriate evacuation routes**, and arrange transportation and other supporting measures. The simultaneous evacuation of large populations should be avoided, e.g., by proceeding with block-by-block evacuation in a stepwise manner. Sheltering advice needs to be accompanied by instructions for how to achieve this efficiently (i.e., sufficient resources for food, water, power, etc. – see *R9*), and combined with other protective measures including iodine thyroid blocking for children. Health authorities need to ensure **continuation of care for patients or nursing home residents** during sheltering or evacuation. This would include provision of information and psychological support to populations.

### WHO

Radiation protection, civil protection and health authorities, hospitals.



## R16

**Create a common roster, collecting minimum prerequisite information from affected populations to allow efficient medical and health follow-up and facilitate future epidemiological studies, where feasible, to be shared between relevant organizations with appropriate pre-obtained ethics approvals.**

### WHY

The main limitations of previous post-accidental health surveillance and epidemiologic studies were the difficulty of clearly defining and reaching the affected populations and the lack of minimal individual information. The creation of a roster of persons affected by a nuclear accident during the emergency phase is a major element for the success of post-accidental health surveillance and epidemiology. Several countries (e.g. France, Italy, the Netherlands, the UK and the USA) have identified this as an essential issue for public health and epidemiologic studies post-disaster.

### HOW

All persons affected by a nuclear accident should, if they give consent, be **registered in a roster**, immediately after the accident or later, with special attention for those evacuated and/or monitored. Registration would involve signing an informed consent form allowing collection of identifying information and **contact details** (addresses, email, telephone number) and linkage to population-based and other **health and dose registries** for follow-up. Collection of information related to sheltering, stable iodine supplementation and individual dose assessment could also be included, to allow reconstruction of early exposure doses.

Ideally, all information would be gathered in a **pre-formatted database** that can be shared and completed by different team/organisations involved in the management of the various phases of the accident. Such a database (Behbod et al, 2017) would be created in advance, in **close collaboration with dosimetrists and public health practitioners** (see R17, R18), and adaptable to the specificities of the accident (see R11). The actual roster should be maintained in the post accidental phase as a basis for medical and health surveillance and possible epidemiological and public health studies.

### WHO

Radiation protection, civil protection and health authorities, representatives of the state at local level, academic and other researchers.

<sup>3</sup>WBC: whole body counting



## R17

**Collect and store all radiation-related dosimetry data (both for workers and for the public) to ensure traceability of all measurements, even those that do not appear relevant from an immediate radiation protection viewpoint, since these may be crucial for accurate dose reconstruction at a later date.**

### WHY

Past accidents showed that data, particularly collected in the early phase, may be easily lost. Once lost, they cannot be retrieved, or, if they are, their completeness and reliability is unknown, thus creating major uncertainty in reconstructed radiation doses.

### HOW

Despite the difficult conditions in the emergency situation of the early and intermediate phases, all efforts should be made **not to lose any data** potentially useful for later dose assessments. The type and quality of data collected in the early phase are of crucial importance and can reduce the sources of uncertainties in the assessed and reconstructed doses. All radiation-related data should be recorded/stored, both for workers and for the public, even those that do not appear critical in this phase due to other priorities (e.g. decontamination), but which may be of importance for an accurate dose reconstruction in the future (Table 2).

Relevant data include: thyroid *in vivo* measurements for short-lived radionuclides such as <sup>131</sup>I, since this can provide valuable information for the implementation of future health surveillance programmes and epidemiological studies; individual measurements (*in vivo* and *in vitro*) and personal behaviour and health status information with a link to nominative data (when subjects consent); surface contamination, environmental dose-rates. Consider the feasibility of biological sample (blood, urine and/or other biological fluids) collection.

### WHO

Emergency management persons: nuclear companies/operators, civil protection, radiation protection authorities, academic and other researchers, local authorities.



## R18

**Provide support to populations who wish to make their own measurements, recommending reliable equipment and resources (e.g., apps, social media, information centres) that can contribute to the characterisation of population exposure and its evolution.**

### WHY

It is recognised that self-made measurements (e.g. of radionuclides in foodstuff, contamination of the environment, individual doses) can serve a number of purposes, beyond dose reconstruction and surveillance. Such measurements create opportunities for providing information to individuals, and can empower them to take an active role in their own radiation protection decisions and regain control over their lives. Experiences after the Chernobyl and Fukushima accidents have clearly shown that dosimetry and radiation measurement can help people to better apprehend and manage the situation, especially if they are trained and given the tools to make the measurements by themselves (see R20). It also facilitates understanding of individual exposure and provides information on dose and contamination distribution in the population.

### HOW

Although there may not be time for extensive training for measurements in the early phase, access to validated apps and to mobile and easy-to-use dosimetry devices could be provided rapidly. The **development of such new technologies**, with the **support and advice of RP experts**, should be encouraged; if not, populations will undoubtedly make use of existing unreliable apps and devices available widely on the internet. Data sharing among affected communities, as well as on social media and the internet (crowdsourcing), is inevitable and may raise concerns about privacy, and scientific quality. Radiation protection institutes need to invest in this field and provide tools that could help a better understanding and interpretation of **web-published measurement results**, as well as help reduce the uncertainty in self-made measurements by ensuring that the tools comply with minimum performance criteria. At **the local level, the support of expert facilitators** would be helpful (see R20, 21). Populations outside the affected areas are also likely to require reassurance that their doses do not exceed the normal background levels. Although there is still much work to be done in the area, such support can help ensure that affected populations have confidence in the information provided by radiation protection authorities and technical experts.

### WHO

Radiation protection authorities, emergency preparedness authorities, technical experts and facilitators, NGOs.



# Recovery phase





## R19

**Continue dose assessment for workers and affected population as, in this phase, dosimetry and monitoring can be useful for increasing radiological protection knowledge and culture, reassurance, helping people manage their own exposure and supporting epidemiology.**

### WHY

In this phase, dosimetry is particularly important for supporting epidemiology and health surveillance programmes and for continuing to support the development of a radiological protection culture in the population (see R18 and 20).

### HOW

More detailed dose assessment and refinement of doses received in the early/intermediate phases should be pursued to **adapt health surveillance, inform populations and support epidemiological studies**. **Group doses** will be adequate for epidemiological surveillance through ecological studies (time trends and comparisons across groups with different dose levels), whereas analytical epidemiological studies, aimed at assessing risks, require reliable individual or **individualized doses** (and related uncertainty) for each cohort or case-control study participant. If epidemiological studies observe an unexpected increase of an effect, then there may be a need to validate and confirm the assessed doses. **Residual exposure** still present in this phase should be monitored and if new radiation exposure pathways are identified, the dose assessment should be adapted accordingly. However, it must be kept in mind that people may be reluctant to be monitored for a long period of their life and may feel stigmatised. **Long-term individual dosimetric surveillance can only be envisaged on a voluntary basis** (see R8) and the duration of the assessment programme should be established, also considering economic factors. **Local populations should be engaged in the design of monitoring programmes** taking into account their willingness to participate in such assessments.

### WHO

Academic and other researchers, radiation protection authorities, local authorities.



## R20

**Continue dose measurement support to populations by providing access to equipment such as personal dosimeters and mobile applications, food measurements and whole body counting, together with adequate expert counselling resources to support these measures.**

### WHY

Access to equipment such as personal dosimeters, food measurement and WBC can increase the control which affected populations have on their life/situation (*ST2*). This also helps in understanding the potential impacts of the accident and promotes dialogue between the public and experts (Miyazaki et al, 2014; Hayano et al, 2015; Miyazaki & Hayano, 2016; Naito et al, 2016). Involving affected populations in measurements and providing them or local communities with the means to carry these out can continue to facilitate “self-help” remediation measures such as exposure and dietary control.

### HOW

During the recovery phase, it should be possible to provide the population with access to equipment that will **increase their involvement in radiation dose and activity measurements**. Such measurements should be done with the supervision of technical experts and could be different from the measurements performed by people during the early phase (R18). While providing equipment is relatively straightforward, the **responsible authorities still need to consider how to communicate results** and implications to the populations, and provide not only technical support but also resources such as training of local experts and communicators (*see R21*). A **transition of responsibilities from central authorities to local authorities** and stakeholders might be encouraged and supported depending on the accident and country situation. Since measurements provide important opportunities for dialogue within the community and between experts and the public, **sufficient resources need to be assigned for counselling support**. There is also a need to consider the balance between the reassurance and empowerment that these measures can provide, and the possibility that they enhance stress and concerns by reminding people about the problem. These actions should be **provided on an entirely voluntary basis**, without putting undue/unnecessary pressure on populations to participate. The duration of these measures should take into account the cost and benefits of the various choices and related economic factors. Especially for WBC, the results should be communicated to the examined person as soon as possible, bearing in mind that errors in dose estimation can lead to distrust towards the experts.

### WHO

Radiation protection authorities, technical experts and facilitators, local population.



## R21

**Build networks of experts – local facilitators – population to assist with the dissemination of scientific information and facilitate two-way communication through the creation of dialogue spaces where affected people can voice their needs and worries and receive practical advice on everyday life.**

### WHY

In the different settings analysed, similar issues were found: mistrust of experts and authorities, lack of communication on health issues, and strong demand for counselling and advice on behaviour and practices that minimise risks. The case studies also highlighted the importance of listening to populations to identify their needs and improve their well-being, taking into account the specificities of the local situation. As previous assessments underline (Nisbet & Chen, 2015), the late-stage recovery phase is necessarily community focused and therefore driven by a broad range of stakeholders.

### HOW

In order to assist with the healing process of the affected communities, sound, reliable scientific information should continue to be disseminated via institutional and local stakeholders to the radiation-affected communities via two-way communication and dialogue. The key role of **local facilitators** and interpreters (nurses, teachers, local doctors, **leaders of local NGOs**), **ideally identified during the early and intermediate phase (R14)**, should be recognized in this process as a liaison between the national and local levels, providing the capacity to **listen, relay and balance** the scientific expertise with local concerns and context. Examples are face-to-face risk communication (particularly by nurses and other healthcare workers) and the creation of **dialogue spaces** where affected families can voice their needs and worries, receive advice on practical behaviour and identify means of improving their situation. Results of epidemiological studies when available should also be discussed with stakeholders.

### WHO

Local authorities in coordination with radioprotection experts, community leaders, nurses, local doctors, teachers.



## R22

**Have plans for lifting of evacuation orders as soon as possible to minimize the adverse effects of evacuation on physical and mental health of evacuees, and communities.**

### WHY

The Fukushima and Chernobyl accident revealed severe health problems caused by long-term relocation, such as mental health problems and life-style related diseases (diabetes, alcoholism, hypertension, increased body weight, etc.). The greatest difficulties were experienced by evacuee families who were separated, lost their homes and work and moved to unfamiliar places. In addition, complex psycho-social issues arose, including disagreements in families and in society about the potential health consequences of the accidents. Furthermore, evacuation causes significant social and economic costs.

### HOW

Although the criteria for lifting evacuation should be decided as soon as possible, appropriate support needs to be supplied to populations if long-term evacuation or relocation is likely. **Temporary return**, with appropriate protective actions, should be taken into consideration to enable populations to take care of belongings or pets left at home, and deal with security and cleaning of houses. While the **criteria for lifting evacuation** should be based on an assessment of radiation exposure doses in the evacuated areas, the actual decision should be made through **consultation with stakeholders**. Such decisions should be based not only on radiological criteria, but also on **social, cultural and economic aspects**. This requires elaboration of a framework to engage local stakeholders in assessing the evolution of the radiological situation and in deciding about the possible future of the evacuated areas. A common assessment of the situation can help reduce uncertainties in evacuated populations and support their decisions about their future (*see also R23*).

### WHO

Radiation protection authorities and experts, and local stakeholders; central government.



## R23

**Consider the preferences of people living in affected areas when deciding whether mitigation actions should be revised, lifted or extended according to the evolution of the situation (e.g. individual dose monitoring, decontamination of living places, psychosocial assistance, foodstuff surveillance).**

### WHY

Living in an affected area, with uncertainties about radiation levels and potential health consequences, raises a lot of questions and worries. Experiences in Belarus, Norway and Japan show that lifting remediation or mitigation actions without consultation of affected people can cause a strong sense of abandonment and provoke psychosocial effects. For example, lack of stakeholder involvement can delay or even reduce the willingness of people to return to, or to stay in, affected territories. Changing or removing mitigation actions can also increase the anxiety and worries of those who had decided to return or to stay, since those decisions might have been contingent on the fact that these measures had been put in place.

### HOW

The criteria for lifting remediation and mitigation actions (e.g. individual dose monitoring, decontamination of living places, psychosocial assistance, foodstuff surveillance) should be decided based on the **evolution of the situation, the willingness of the affected population and the availability of resources to provide the necessary support**. The decision should be made in agreement with stakeholders (see R22), and the affected populations should be supported until they have enough information to decide and manage themselves their day-to-day life and envisage their future.

### WHO

Local affected people, community leaders, facilitators, local and national authorities.



## R24

**Expand support for affected populations to take into account social and economic upheavals caused by the accident on infrastructures and community welfare.**

### WHY

Socioeconomic impacts of Chernobyl and Fukushima include the loss of livelihoods, disruption of industry as workers are evacuated, and of transport and energy infrastructure, loss of market sales of agricultural produce (including loss of consumer trust in non-contaminated produce) and demographic changes (IAEA, 2015b). These, and other lifestyle changes, can have knock-on health effects in the affected populations as well as in those not directly affected by the accident. For many evacuated people, decisions to return to their homes after lifting of evacuation are influenced as much by the availability of infrastructures (schools, shops, medical care, job opportunities) as by radiological aspects.

### HOW

Addressing **the consequences of the social and economic upheavals on infrastructures and community welfare** should include compensation policies, support for infrastructure revitalisation, as well as a holistic assessment of the cost-benefit aspects of remediation actions. Problems with compensation were experienced after both Chernobyl and Fukushima, and it is important that **compensation policies** are elaborated and that these and other **support are adapted over time**. The terms and conditions to receive compensation and support, and their evolution need to be defined and discussed with inhabitants of the affected area (e.g. local economic and environmental players, evacuees, returnees) **to avoid any negative effect on well-being**. Implementation of cost benefit analyses of remediation actions, changes to policies, **evaluation of evaluation of revitalisation and recovery initiatives is recommended**, considering **public concerns and priorities**.

### WHO

Local authorities, economic and environmental players, community leaders, evacuees and returnees.

<sup>3</sup>WBC: whole body counting



## R25

**Launch systematic health screening based on appropriate justification and design.**

**Do not recommend systematic thyroid cancer screening, but make it available (with appropriate counselling) to those who request it.**

### WHY

In case of future nuclear accidents, it is important that countries have pre-existing high quality registry of diseases, particularly cancer. Without appropriate baseline rates, epidemiological surveillance cannot evaluate the possible impact of the accident on disease trends.

Even when good quality disease registries are available, it is important to note that the apparent incidence of some occult or dormant diseases, in particular thyroid cancer, may greatly increase, not because of the radiation but because of the sudden attention paid to the disease by well-meaning physicians. This has been seen clearly in the case of Fukushima where high technology ultrasound screening has led to the detection of very large numbers of thyroid nodules and cysts, and large numbers of potential cancer cases which may have never had any clinical manifestation or consequence on health (over-diagnosis). Given the good prognosis and slow evolution of the majority of thyroid cancers, screening will not only provide little benefit to the patient, but will cause considerable distress and anxiety in the population (Normile 2016), as well as negative consequences of unnecessary treatment (i.e. mostly surgery and lifetime medication).

### HOW

Systematic screening should only be envisaged when it will do more good than harm (WHO, 1970). For any type of health screening, the criteria for making such decisions will depend on a number of factors, including the availability of disease-specific registries and natural history of disease, the size of the affected population. Good communication about the potential harms and benefits of screening with the affected populations is essential to allow them to make their own informed decisions. Since dose is only one of many criteria influencing screening decisions, it is not reasonable to identify an absolute dose level at which screening would or would not be recommended.

Given the challenge and adverse effects noted above, **thyroid cancer screening should be proposed, on a voluntary basis**, for those who wish to be monitored, as long as it is accompanied with appropriate information and support. A screening programme based on a clinical examination including thyroid palpation could be envisaged, in which **only suspicious cases are referred to ultrasound**. Furthermore, it is necessary to take into account factors other than screening which could play a role on incidence variations (e.g. iodine deficiency).

### WHO

Health authorities, academic and other researchers, medical practitioners.



## R26

**Clarify objectives and expected results of epidemiological studies, justifying the design and methods and explaining the limitations.**

### WHY

A large number of studies have been conducted after the Chernobyl and Fukushima accidents. Nevertheless, relatively few studies have been informative – and results have sometimes been controversial – due to methodological limitations, including unclear objectives, inadequate study designs, lack of reliable exposure estimates and limited statistical power (*see ST1 summary*).

### HOW

There are two main reasons to conduct epidemiological studies: 1) as a **surveillance tool** to evaluate objectively the frequency of diseases (**descriptive/ecological studies**) and how this may change following an accident; and 2) where and when feasible, **to increase our knowledge about the health effects** of a nuclear accident, not limited to radiation-induced effects (**analytical/etiological studies and risk modelling**).

As methodological approaches for these two types of studies differ, it is important to **clarify the objective** of the study at the outset. This includes the definition of the most suitable study population (residents, workers, evacuees) and of the main health outcomes of interest (e.g. leukaemia, cancer, birth defects, circulatory diseases, lens opacities, thyroid diseases). Depending on the outcome and objective, consideration needs to be given to the **major limitations and pitfalls** (quality of individual dose estimates and **associated uncertainties**; confounding or modifying factors such as iodine deficiency or smoking behaviour; selection bias, recall bias, screening bias, etc.) which may affect the study results and how they can be addressed. **Decisions about launching analytical epidemiology studies, should be based on their feasibility and pertinence.** It is important to evaluate *a priori* the **ability of a study to achieve its goals** (i.e., minimal detectable excess for objective 1, and power to demonstrate a significant trend in risk for objective 2), and to ensure that the **study period and duration** are appropriate for the outcome of interest (radiation induced chronic diseases may take decades to appear).

Epidemiological studies should be carried out with respect for maintaining confidentiality and dignity of study participants; and study objectives and following findings should be communicated in a clear understandable language to all concerned. Epidemiological studies could also be useful to inform on the cost-effectiveness of surveillance strategies by providing details of their outcomes achieved and the use of health and social services.

### WHO

Epidemiologists, health economic researchers and health agencies (including international collaborations).



## R27

**Ensure long-term sustainability of follow-up of populations at risk for comprehensive ascertainment of potential health consequences of nuclear accident.**

### WHY

Lifespan studies of affected populations (e.g. the atomic bomb survivors in Japan) have provided an important opportunity to comprehensively study the consequences of exposure over time, particularly because many important diseases, both cancer and non-cancer, have long latent periods. The creation of sustainable epidemiological and health surveillance infrastructures can prevent interruption or discontinuation of follow-up and the consequent challenges in searching and tracing affected individuals and loss of information (CO-CHER, 2016). Long-term surveillance programmes also provide affected populations important information on the evolution of their health, allowing them to adapt their protection accordingly and contributing to improve their long-term well-being. The information provided is essential to plan efficient health surveillance programmes and services.

### HOW

A sustainable follow-up should be established to provide an comprehensive assessment of the long-term health consequences and of the use of health and social services after a nuclear accident. To be useful, it should be set-up in **consultation with affected populations**, taking into account their exposure levels. As any accident in Europe is likely to affect neighbouring countries, **collaboration between countries** is essential to ensure complete coverage of exposed population follow-up programmes. Maintenance of long-term follow-up including health monitoring of the affected populations could be challenged by political, financial and social limitations. Steps to **ensure follow-up** include:

- Support of infrastructures (databases, rosters, collections of biosamples) including maintenance of qualified staff to conduct the long-term follow-up;
- Fostering a dialogue between scientists, public health representatives, decision-makers, local stakeholders and population representatives about the study findings and concerns of the affected population;
- Envisaging possible modifications in a follow-up protocol/procedure, as needed, based on the follow-up experience.

### WHO

Epidemiologists, health economic researchers and health agencies (including international collaborations).



## R28

**Foster long-term participation of affected populations and communities by engaging them in decision-making, particularly with regard to health surveillance, with the aim of improving the relevance, efficiency and acceptability of the interventions and maintaining radiation protection awareness.**

### WHY

The main arguments for the involvement of affected populations and communities in decision-making and accident management are similar to those given in R13: the right to participate in decisions that impact on their lives, and the attainment of more effective risk management and health surveillance (see *ST1 and ST2 summaries*). Stakeholder engagement in radiation protection has been discussed for many years, and the importance of supporting the public in “self-help” countermeasures is widely recognised (see also *R18 and 20*). Involving affected populations in health surveillance and epidemiology is a more recent notion, albeit one that is acquiring increasing support (see *ST2 reports*). The intention is that participation will improve the public’s comprehension of the relevance and limits of health surveillance and epidemiology, increasing participation compliance, acceptability and credibility of the results.

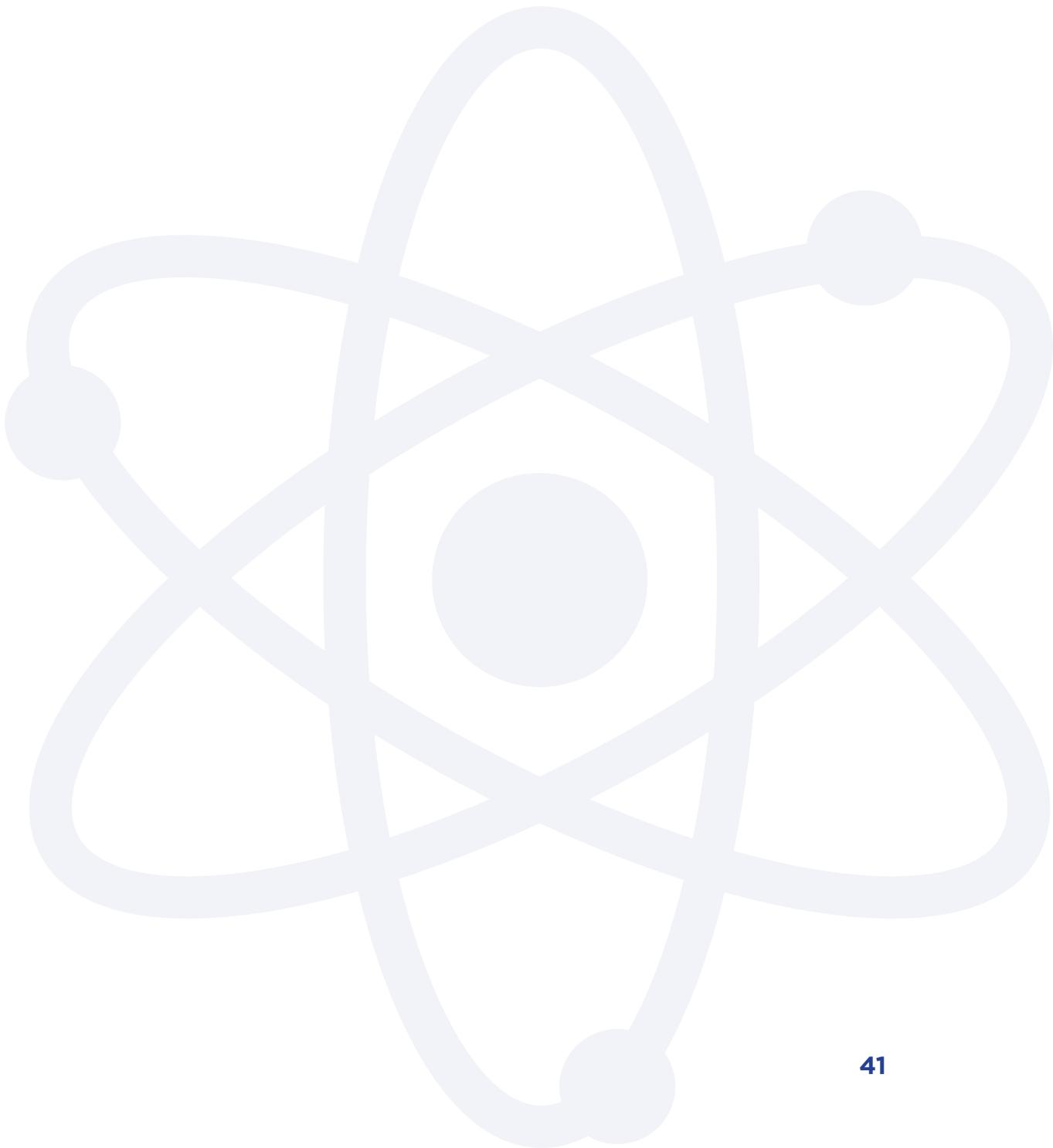
### HOW

In the recovery phase, stakeholder engagement can cover a range of aspects including dosimetric, health surveillance and epidemiology. This includes involvement of the public in the **collection and assessment of exposure and health data (including the conduct of “citizen science”)**, their engagement in the **planning and design of health surveillance** and epidemiological studies, and/or **participation in the decision and implementation of remediation activities**. In all cases, it should be stressed that **successful stakeholder engagement needs resources** from authorities and experts, including development of dialogue skills, and **should not be seen as a reason to abandon support** to affected populations.

The involvement of study subjects in design of surveillance and epidemiology could raise challenges with objectivity, but these are outweighed by the benefits if correctly frameworked, for example in ensuring that health surveillance actually addresses those issues of concern to the public. In addition, **epidemiologists can benefit from the populations’ expertise** (e.g. on modalities of exposure) and everybody can benefit from **avoiding costly and non-informative epidemiological studies**.

### WHO

Epidemiologists, health economic researchers, local stakeholders, affected communities.



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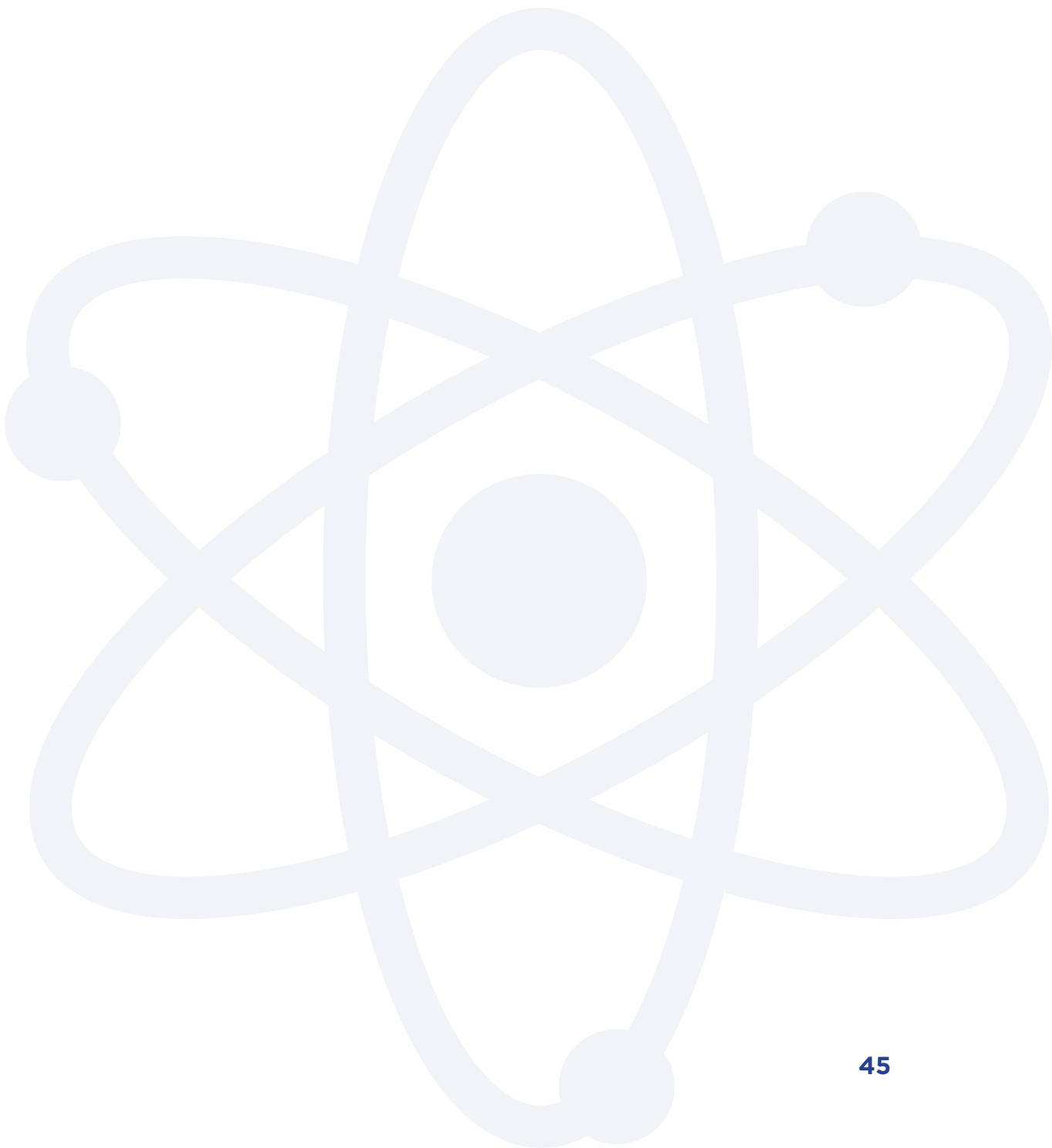
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**Table 1.** – Ethical Challenges in Health Surveillance and Accident Management (after values adapted from ICRP’s Ethical Foundations of the System of Radiological Protection, [www.icrp.org](http://www.icrp.org))

Ethical Value				
	Well-being	Dignity/Autonomy	Justice/Equity	Prudence
<b>Health Surveillance for the benefit of affected populations</b>	Addressing direct and indirect health effects	Loss of control over lives bought about by the accident and mitigation actions.	Vulnerability of children to radiation; of the elderly to disruption and evacuation, etc.	Not being over-conservative in dose estimates [i.e., not assuming the highest possible rather than best estimate]
	Economic consequences (direct through loss of livelihood or sales; indirect through loss of consumer trust, etc.)	Provision of measurement tools and equipment to help empower populations [self-help actions]	Differences in compensation strategy (e.g. between radiation and tsunami affected populations)	Balancing uncertainties when assessing different outcomes
	Cultural and Societal impacts (e.g., loss of access to traditional sites)	Stakeholder participation in decisions that affect their own lives	Perceptions of discrimination or stigmatisation	Not underestimating the potential for societal, economic and cultural impacts.
<b>Screening (and thyroid screening)</b>	Ensuring that screening results in reduction in disease incidence or severity. Addressing problems with over-diagnosis, false positives etc.	Voluntarism and free informed consent of participants. Participation of affected populations in screening study design.	Recognising different risks, perceptions and needs of different populations (including children and parents).	Care with communication of results. If reassurance is a key objective of screening, make sure the programme has a chance of achieving it.
<b>Epidemiology and data registries</b>	The importance of improved data and disease registries, including sharing information between countries	Respect for privacy and free informed consent of participants. Stakeholder participation in, and benefit from, the study in question.	Information on factors influencing risk distribution between populations and critical groups	Preparedness in establishing data and disease registries.



**Table 2.** – Classification of methods of dose assessment used in this report

Dose assessment to a critical group of population or to a representative worker	Individual or individualized dose assessment for a real person (public or worker)
<p><b>Calculation of doses by:</b></p> <ul style="list-style-type: none"> <li>- route-of-exposure models and intake models for each important exposure pathway</li> <li>- activity concentrations in the environment [such as measured levels of radionuclides in the environment, in tap water and in foodstuffs, estimated amounts of radioactive material released, atmospheric dispersion and deposition patterns]</li> <li>- the habits of local people, e.g., the amount of locally grown food eaten, amount of time spent on beaches</li> </ul> <p><i>These methods provide the dose to a critical group of population or to representative individuals in a general population – not associated to a specific individual</i></p>	<p><b>Individual assessed dose:</b></p> <p><b>Measurement methods for dose:</b></p> <ul style="list-style-type: none"> <li>• personal dosimeters [passive luminescent dosimeters, electric/active dosimeters, pocket/pencil ion chamber]</li> <li>• Clinical/biological dosimetry</li> </ul> <p><b>Direct measurement methods for radionuclides intake:</b></p> <ul style="list-style-type: none"> <li>• whole body counting</li> <li>• organ counting [such as thyroid or lung monitoring]</li> </ul> <p><b>Indirect measurement methods for radionuclides intake:</b></p> <ul style="list-style-type: none"> <li>• biological samples [e.g. excreta]</li> <li>• physical samples [e.g. sampling of the breathing zone with air filters]</li> </ul> <p><i>These methods provide the dose estimated for a specific real person</i></p>

**Table 3.** – Use of dosimetry in the accident phases for workers, evacuees and residents of affected areas.

	Phase	Emergency workers	Evacuees	Residents of affected areas
		1	2	3
<b>A</b>	Initial	Make sure that dosimetry system matches pathways and dose ranges, all emergency staff has appropriate dosimeters	Rule out overexposure [radiological triage]	Calm public concerns
<b>B</b>	Intermediate	Secure collection and retention of dosimetric monitoring data	Collect data needed for individualization of dose estimates	Establish monitoring program for validation of the dosimetric models on representative/critical groups of population
<b>C</b>	Long term/ recovery	Stakeholder participation in decisions that affect their own lives Return to normal operation of dosimetric practices	Perceptions of discrimination or stigmatisation Perform estimation of individual, group specific and collective doses	Not underestimating the potential for societal, economic and cultural impacts. Characterize exposures of public ['dosimetric passportization']



**Table 4.** – Major academic courses on radiation protection and emergency response, in Japan and Europe

Type of courses	Topic	University	Target population	Website information
Master degree Medical Science course	Disaster and Radiation Medical Sciences	Joint Graduate School Fukushima Medical University/ Nagasaki University	Train professionals to engage in various disaster responses, includes medical responses and activities and crisis/risk communication	<a href="https://www.fmu.ac.jp/univ/en/graduate/joint_major.html">https://www.fmu.ac.jp/univ/en/graduate/joint_major.html</a>
Master degree Nursing course	Disaster and Radiation Medical Sciences	Joint Graduate School Fukushima Medical University/ Nagasaki University	Train nurses, public health nurses and midwives in radiation disaster medicine, including radiation risk communication	<a href="https://www.fmu.ac.jp/univ/en/graduate/joint_major.html">https://www.fmu.ac.jp/univ/en/graduate/joint_major.html</a>
PhD Phoenix program	Radiation Disaster Medicine course	Hiroshima University	Train medical, dental, pharmaceutical, veterinary and masters graduates to protect lives from radiation disaster, including psychological effects of radiation contamination	<a href="https://www.hiroshima-u.ac.jp/en/phoenixlp/about/purpose">https://www.hiroshima-u.ac.jp/en/phoenixlp/about/purpose</a>
PhD Phoenix program	Radioactivity Environmental Protection course	Hiroshima University	Train science bachelors and masters to protect the environment from radioactivity, including decontamination and disposal of radioactive waste	<a href="https://www.hiroshima-u.ac.jp/en/phoenixlp/about/purpose">https://www.hiroshima-u.ac.jp/en/phoenixlp/about/purpose</a>
PhD Phoenix program	Radioactivity Social Recovery course	Hiroshima University	Train science bachelors and masters to protect children and society from radioactivity, including child rearing under stress of radiation contamination	<a href="https://www.hiroshima-u.ac.jp/en/phoenixlp/about/purpose">https://www.hiroshima-u.ac.jp/en/phoenixlp/about/purpose</a>
European Master [M2]	Radiation Protection [EMRP]	Joseph Fourier University [Grenoble]/ Institut national des sciences et techniques nucléaires [INSTN]-CEA, France	Students with a first master's degree [M1] in physics, health engineering, environment, etc.	<a href="http://www-instn.cea.fr/formations/diplomes-et-titres/liste-des-diplomes-et-titres/m2-radioprotection-european-master-in-radiation-protection-emrp,29.html">http://www-instn.cea.fr/formations/diplomes-et-titres/liste-des-diplomes-et-titres/m2-radioprotection-european-master-in-radiation-protection-emrp,29.html</a>
International Master course	Chemical, Biological, Radiological, Nuclear and Explosive [CBRNe] Protection	Tor Vergata University, Rome	1st Level Course for First Responders 2nd Level Course for Advisors	<a href="http://www.mastercbrn.com/">http://www.mastercbrn.com/</a>
Master degree	Radiation Biology	Technical University Munich	Train life sciences or medical students in all aspects of radiation biology, including radiation protection	<a href="https://www.med.tum.de/en/master-program-radiation-biology">https://www.med.tum.de/en/master-program-radiation-biology</a>
Master degree	Radiation and Environmental Protection	University of Surrey	Train bachelors in physics, environmental sciences, engineering, in radiation and environmental protection aspects of nuclear physics	<a href="https://www.postgrad.com/university-of-surrey-physics-radiation-and-environmental-protection/course/162172/">https://www.postgrad.com/university-of-surrey-physics-radiation-and-environmental-protection/course/162172/</a>
Undergraduate/ master/PhD courses	Nuclear and Radiation Safety, Radiation Hygiene, Radiobiology, Environmental Medicine, Environmental monitoring	Sakharov Environmental Institute of Belarusian State University	Train bachelors in Environmental monitoring and Environmental Medicine, engineers in ensuring radiation protection safety in different sectors of industry	<a href="https://en.wikipedia.org/wiki/International_Sakharov_Environmental_Institute">https://en.wikipedia.org/wiki/International_Sakharov_Environmental_Institute</a>

**Table 5.** – Radiation protection and emergency response training courses for professionals

Network or Organisation	Country or region	Training	website
REMPAN training activities	Different regions. Ex. Asia [Republic Korea] with KIRAMS	Regular workshops	<a href="http://www.rempan.ukw.de/en/news/who-rempan-e-newsletter.html">http://www.rempan.ukw.de/en/news/who-rempan-e-newsletter.html</a>
REAC/TS (REMPAN member, WHO collaborating center)	Oak Ridge, USA	Regular training programs for specialists across the world	<a href="https://orise.orau.gov/reacts/">https://orise.orau.gov/reacts/</a>
NERIS training courses	Different regions Ex. Gomel, Belarus	Training course on late phase nuclear accident preparedness and management	<a href="http://www.eu-neris.net/index.php/activities/training-courses/105-first-announcement-march-2016.html">http://www.eu-neris.net/index.php/activities/training-courses/105-first-announcement-march-2016.html</a>
DTU – PDC-ARGOS - NERIS training course	Roskilde, Denmark	Modelling and measurement training course	<a href="http://www.eu-neris.net/index.php/activities/training-courses/122-modelling-and-measurement.html">http://www.eu-neris.net/index.php/activities/training-courses/122-modelling-and-measurement.html</a>
SCK-CEN – NERIS Training Course	Mol, Belgium	Preparedness and response for nuclear and radiological emergencies	<a href="http://www.eu-neris.net/index.php/activities/training-courses/120-preparedness-and-response-for-nuclear-and-radiological-emergencies.html">http://www.eu-neris.net/index.php/activities/training-courses/120-preparedness-and-response-for-nuclear-and-radiological-emergencies.html</a>
REMPAN Collaborating Center Obninsk	Russian Federation	Radiation epidemiology training for Russian-speaking countries	
IAEA-ISEU regional courses on radiation protection and safety	Belarus		<a href="http://en.iseu.by/2016/10/opening-of-regional-postgraduate-educational-courses-in-radiation-protection-and-safety-of-radiation-sources-with-the-technical-support-of-the-iaea/">http://en.iseu.by/2016/10/opening-of-regional-postgraduate-educational-courses-in-radiation-protection-and-safety-of-radiation-sources-with-the-technical-support-of-the-iaea/</a>
Karolinska Institute	Sweden, Europe	T3d training programme for experts, on clinical management of radiation injuries	



**Table 6.** – Stakeholder participation spectrum  
(adapted from the International Association for Public Participation)

	<b>Inform</b>	<b>Consult</b>	<b>Involve</b>	<b>Collaborate</b>	<b>Empower</b>
<b>STAKEHOLDER PARTICIPATION GOAL</b>	To provide stakeholders with balanced and objective information to assist them in understanding the problems, alternatives and/or solutions.	To obtain feedback on analysis, alternatives and/or decisions.	To work directly with the stakeholders throughout the process to ensure that issues and concerns are understood and considered.	To partner with stakeholders in specific aspects of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision-making in the hands of the stakeholders.
<b>PROMISE TO THE STAKEHOLDERS</b>	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and provide feedback on how your input influenced the decision.	We will work with you to ensure that your concerns and issues are directly reflected in the alternatives developed and provide feedback on how your input influenced the decision.	We will look to you for direct advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.

**Affected populations:** The primary or directly affected population is the one that has suffered the direct effects of the disaster (deaths, injuries, material losses, evacuation) and that were in the affected geographical area at the time of the accident. The secondary and tertiary affected populations are defined as those that suffer the indirect effects of the disaster (socio-economic and psychological impact), the former being within or at the border of the geographical area and the latter being outside the area. Throughout this document, we refer to affected populations as those directly and indirectly affected by the radiation accident, unless otherwise specified.

**Autonomy:** the independence or freedom of will of a rational individual to make a decision that is informed and not coerced.

**Community:** a social group that shares common values and/or a common significant event.

**Determinants of health:** Determinants of health are factors which influence health status and determine health differentials or health inequalities. They are many and varied and include, for example, natural, biological factors, such as age, gender and ethnicity; behaviour and lifestyles, such as smoking, alcohol consumption, diet and physical exercise; the physical and social environment, including housing quality, the workplace and the wider urban and rural environment; and access to health care. All of these are closely interlinked and differentials in their distribution lead to health inequalities.

**Discrimination:** the prejudice or treatment of an individual because of the group that they do or are perceived to belong to.

**Epidemiological studies:** in the context of a radiation accident, they address the incidence and distribution of health-related states as a consequence of the direct or indirect effects of radiation exposure, with the aims of:

- evaluating whether the accident has impacted disease rate/risk (this can be done through “epidemiological surveillance”, based on population/hospital/health-insurance registries)
- where possible, improve our knowledge on effects of radiation, as well as other direct and non-direct effects of nuclear accidents on health - using analytical epidemiological approaches (that include cohort, case-control and cross-sectional studies to investigate causes and effects of disease).

**Equity:** when the decision taken is fair and impartial such that no person is favoured over another. It can also refer to equity in opportunity, access to resources, or the achieved distribution of societal resources.

**Health impact:** A positive health impact is an effect which contributes to good health or to improving health. For example, having a sense of control over one’s life and having choices is known to have a beneficial effect on mental health and well being, making people feel “healthier”. A negative health impact has the opposite effect, causing or contributing to ill health. For example, working in unhygienic or unsafe conditions or spending a lot of time in an area with poor air quality is likely to have an adverse effect on physical health status.

**Health inequality and inequity:** *Health inequalities* can be defined as differences in health status or in the distribution of health determinants between different population groups. For example, differences in mobility between elderly people and younger populations or differences in mortality rates between people from different social classes. It is important to distinguish between inequality in health and inequity. Some health inequalities are attributable to biological variations or free choice and others are attributable to the external environment and conditions mainly outside the control of the individuals concerned. In the first case it may be impossible or ethically or ideologically unacceptable



to change the health determinants and so the health inequalities are unavoidable. In the second, the uneven distribution may be unnecessary and avoidable as well as unjust and unfair, so that the resulting health inequalities also lead to inequity in health.

**Health screening:** a public health service in which members of a defined population are examined or tested in order to identify those that can benefit from further tests or treatment to reduce the risk of a disease or its complications.

**Health surveillance** – Health/medical surveillance aims to evaluate whether individuals affected by an accident suffer from any health (including psychological) conditions. This involves contact with and follow-up of affected individuals (e.g. in the form of medical check-ups, questionnaire surveys) and is also a basis for providing support or treatment as required.

**Holistic Approach:** a concept that the psychological, physical and social needs of the person must be considered in health care.

**Justice:** conformity to the principle of what is morally right, or to fair and transparent procedures for societal decision making.

**Low doses** – SHAMISEN recommendations do not provide absolute numbers for the initiation of surveillance, screening or mitigation actions, since dose is one of many criteria to be considered in such decisions. However, in order to put numbers in to context, we recognize the UNSCEAR definition of low dose as less than 100 mGy.

**'More good than harm':** means that the implementations of any programme (health surveillance, medical follow up, screening, etc.), plan (emergency and evacuation, compensatory programs) or other intervention (questionnaires, epidemiological surveillance or analytical studies, etc.) should be considered from the overall health approach taking into account not only the initial aims, but also all possible collateral important impacts during and after the implementation and after.

**Roster** A registry of people that belong to a particular group with basic information on health status. Pre-existing rosters will allow comparing pre and post-accident health status of the registrees, thus facilitating health surveillance and epidemiological studies.

**Probability:** the estimation of how likely it is that a statement is true or that an occurrence will happen.

**Risk:** the possibility that something has the danger of causing suffering, harm or loss to the individual.

**Risk communication:** the process of exchanging real-time information, advice and opinions between experts and people about potential hazards to their health, economic or social well-being in situations of high stress, concern or controversy. The purpose is to enable people at risk to take informed decisions to protect themselves and their families.

**Risk management:** the evaluation and identification of priority risks that will have a coordinated application of resources in order to limit and control the impact of an event.

**Risk perception:** the subjective judgement by an individual about the severity and type of risk from the hazard or threat.

**Stigmatisation:** a specific type of discrimination wherein individuals or groups are treated as (or suffer the experience of) being in disgrace or having a tarnished reputation.

**Uncertainty:** any situation of departure from the ideal of complete determinism.

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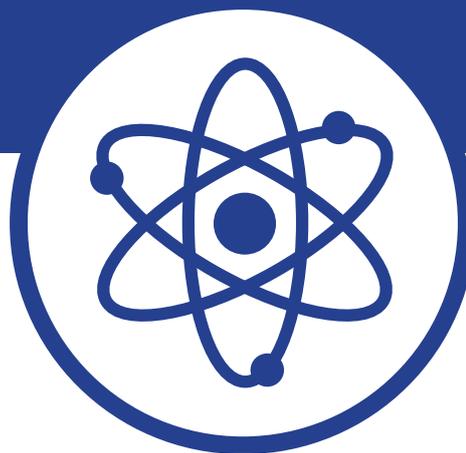
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