Environment International 146 (2021) 106200

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

The SHAMISEN Project: Challenging historical recommendations for preparedness, response and surveillance of health and well-being in case of nuclear accidents: Lessons learnt from Chernobyl and Fukushima

Takashi Ohba [a,b,1], Liudmila Liutsko [b,c,d,1], Thierry Schneider [e], Joan Francesc Barquinero [f], Pascal Crouaïl [e], Paola Fattibene [g], Ausrele Kesminiene [h], Dominique Laurier [i], Adelaida Sarukhan [b], Lavrans Skuterud [j], Koichi Tanigawa [a,k], Yevgeniya Tomkiv [l], Elisabeth Cardis [b,c,d,*]

[a] Fukushima Medical University, 1 Hikarigaoka, Fukushima 9601295, Fukushima, Japan
[b] Barcelona Institute for Global Health (ISGlobal), Doctor Aiguader 88, 08003 Barcelona, Spain[2]
[c] Pompeu Fabra University, Doctor Aiguader 88, 08003 Barcelona, Spain
[d] Spanish Consortium for Research and Public Health (CIBERESP), Instituto de Salud Carlos III, Av. Monforte de Lemos, 3-5. Pabellón 11. Planta 0, 28029 Madrid, Spain
[e] CEPN (Nuclear Protection Evaluation Centre), 28 Rue de la Redoute, 92260 Fontenay-aux-Roses, France
[f] UAB (Universitat Autònoma de Barcelona), Campus de la UAB, Plaça Cívica, s/n, 08193 Bellaterra, Barcelona, Spain
[g] ISS (Istituto Superiore di Sanità), Viale Regina Elena 299, 00161 Roma, Italy
[h] IARC (International Agency for Research on Cancer), 150 Cours Albert Thomas, 69372 Lyon CEDEX 08, France
[i] IRSN (Institut de radioprotection et de sûreté nucléaire), 31, avenue de la Division Leclerc, 92260 Fontenay-aux-Roses, France
[j] Norwegian Radiation and Nuclear Safety Authority (DSA), P. O. Box 329 Skøyen, NO-0213 Oslo, Norway
[k] FMC (Futaba Medical Center), 817-1 Otsuka, Moto-oka, Futaba Town 9791151, Fukushima, Japan
[l] CERAD (Centre for Environmental Radioactivity)/NMBU (Norwegian University of Life Sciences), Universitetstunet 3, 1433 Ås, Norway

ARTICLE INFO

Handling Editor: Adrian Covaci

Keywords:
Recommendations
Nuclear accidents
Health surveillance
Physical and mental health
Dose assessment
Evacuation

ABSTRACT

Experience suggests that current nuclear accident response planning in European countries mostly has a technical focus, with less attention paid to social, psychological and ethical issues. Information provided tends to be directed towards decisions made by experts, rather than for the support of affected populations. The SHAMISEN (Nuclear Emergency Situations - Improvement of Medical And Health Surveillance) consortium, composed of close to 50 experts from 10 countries, performed a critical review of current recommendations and experiences regarding dose assessment and reconstruction, evacuation decisions, long-term health surveillance programmes and epidemiological studies. The review included case studies and lessons drawn from the living conditions and health status of populations affected by the Chernobyl and Fukushima accidents, taking an integrative approach to health and well-being. Based on this work, SHAMISEN developed a series of comprehensive recommendations aimed at improving the preparedness, response, long-term surveillance and living conditions of populations affected by past or future radiation accidents, in a manner responding to their needs, while minimising unnecessary anxiety.

Abbreviations: ChNPP, Chernobyl Nuclear Power Plant; EURADOS, The European Radiation Dosimetry Group; FNPP, Fukushima Nuclear Power Plant; HERCA, Association of the Heads of European Radiological Protection Competent Authorities; MELODI, Multidisciplinary European Low Dose Initiative; NEA, Nuclear Energy Agency of the OECD; NERIS, European Platform on preparedness for nuclear and radiological emergency response and recovery; OECD, Organisation for Economic Co-operation and Development; SHAMISEN, Nuclear Emergency Situations - Improvement of Medical And Health Surveillance; SHARE, Social Sciences and Humanities in Ionising Radiation REsearch; UNSCEAR, United Nations Scientific Committee on the Effects of Atomic Radiation; WHO, World Health Organisation.

* Corresponding author at: ISGlobal (Instituto de Salud Global de Barcelona), Doctor Aiguader 88, 08003 Barcelona, Spain.
E-mail address: elisabeth.cardis@isglobal.org (E. Cardis).

[1] These authors contributed equally.

[2] T.O until May 2017.

https://doi.org/10.1016/j.envint.2020.106200
Received 8 July 2020; Received in revised form 30 September 2020; Accepted 5 October 2020
Available online 13 November 2020

1. Introduction

Nuclear emergencies, such as those which occurred in Chernobyl and Fukushima, have resulted in large numbers of persons being exposed to ionising radiation (UNSCEAR, 2014, 2010). In addition, they have caused major and continuing upheavals in the lives of populations affected by fallout, both directly (emergency and accident responders and recover workers, evacuees, persons living in areas where dose reduction measures were taken) and indirectly (persons living in less contaminated regions) (Oughton, 2013).

Some populations undeniably sustained health impacts from the radiological consequences of nuclear accidents, in particular early emergency workers in Chernobyl who suffered acute radiation syndrome (UNSCEAR, 2010) and young people who developed thyroid cancer as a result of fallout from the Chernobyl accident (Cardis and Hatch, 2011; UNSCEAR, 2010). Many others, however, have suffered serious consequences that were not directly related to the biological effects of radiation, but rather induced by the event itself, the presence of radioactive contamination and consequent emergency and remediation measures taken, and/or uncertainties about radiation levels and health effects. These include inpatients and institutionalised elderly persons evacuated after the accident at Fukushima (Tanigawa et al., 2012; Yasumura, 2015); clean-up workers who developed anxiety, depression, post-traumatic stress disorders and suicide ideation (Bennett et al., 2006; Bromet et al., 2011; Shigemura et al., 2012); and evacuees and residents of contaminated areas, whose lives were affected by the emergency and/or remediation actions taken, and who continue to experience social and economic disturbances resulting from raised levels of radioactivity in the environment (Bromet, 2014).

Strategies for preparedness and surveillance should aim to meet societal needs for accurate information on doses and health effects and provide a system of follow-up that allows affected population both to feel, and to be, well-monitored for radiation and its possible effects. Surveillance programmes raise ethical issues and challenges that need to be addressed, however: though affected populations may consider them beneficial in terms of health monitoring and care, the surveillance can create undue anxiety in populations; conversely, persons whose dose levels do not warrant particular medical surveillance may suffer psychological consequences if not included in the surveillance programme. At present, there are no well-established, comprehensive strategies for preparedness related to health surveillance and well-being in connection to radiation accidents. This highlights the clear need to learn from past experiences and plan measures that engage affected populations in their follow-up, enabling them to better manage their situation.

It is upon this background that the SHAMISEN (Nuclear Emergency Situations - Improvement of Medical And Health Surveillance) project was built, funded by the European Commission through the OPERRA project (Open Project for the European Radiation Research Area). The overarching objective of SHAMISEN was to build upon lessons learned from experience with populations affected by Chernobyl, Fukushima and other nuclear emergencies to develop recommendations for medical and health surveillance of populations affected by previous and future radiation accidents. The SHAMISEN recommendations (Liutsko et al., this issue-b) focused on the following three complementary aspects:

1. Dose assessment supporting emergency response, clinical decision-making in the aftermath of a nuclear emergency and long-term follow-up of exposed populations;
2. Improvement of living conditions of affected populations, responding to their needs and engaging them in surveillance programmes while avoiding generation of unnecessary anxiety; and
3. Improvement of population estimates of radiation-induced risk both for radiation protection and for communication with affected populations, if and where feasible.

The aim of the SHAMISEN project was to provide evidence-based recommendations to help improve health conditions of affected populations by addressing not only radiation protection and physical health, but also mental health, living conditions after an accident, communication, and ethical issues.

The novelty of the SHAMISEN project was its holistic approach to health, where all aspects of the accident (technical, psychological, social, economic and ethical) were considered. In fact, experience suggested that the latter had not been sufficiently addressed by response plans in many European countries, and that existing recommendations had a mainly technical focus, with less attention paid to psychological, socioeconomic and ethical issues. Furthermore, there was a need to consider recent changes in legal and ethical requirements for health studies (e.g. those related to data protection).

The current paper presents an overview of the SHAMISEN project, the results of which are described in more details in the other papers in this Special Issue (Albani et al., this issue; Barquinero et al., this issue; Cléro et al., this issue; Liutsko et al., this issue-a,b; Maître et al., this issue; Ohba et al., this issue; Oughton et al., this issue; Schneider et al., this issue).

2. Materials and methods

SHAMISEN brought together a multidisciplinary team of researchers from 19 institutions in Europe and Japan with comprehensive and complementary experience and a long track record in post-accident management, dosimetry, radiation protection, medical follow-up and screening, population health surveillance, health economics, radiation epidemiology, and ethics and sociology of radiation protection. The proposal also drew upon additional expertise from Belarus, Russia, Ukraine, Japan, Norway, the UK and the US, as was well as from outside the radiation research field.

SHAMISEN conducted extensive consultations, through stakeholder roundtables (including local populations and medical professionals in affected areas) and consultations (including local and national decision makers), as well as through workshops (Fukushima, March 2016; Oslo, December 2016) involving sociologists, psychologists and ethicists, radiation protection professionals, networks involved in emergency preparedness and in remediation, European Radiation Protection Research Platforms (MELODI, NERIS, EURADOS) and international organisations including the WHO.

Information obtained from this wide range of sources was integrated to maximise the coherence, credibility and usefulness of recommendations for health surveillance in the case of radiation accidents. Draft recommendations were prepared and shared for feedback with stakeholders via the SHAMISEN website https://radiation.isglobal.org/shamisen/project/ and a stakeholder workshop held in collaboration with the NEA at the OECD premises in Paris in March 2017. The recommendations were finalised based on stakeholder feedback and discussions.

3. Results

Work in SHAMISEN was organised in five complementary subtasks (ST) (Fig. 1): ST1 focused on learning from radiation accidents; ST2 on the needs of populations through case-studies; ST3 developed recommendations for health surveillance aimed at improving living conditions of affected populations and knowledge on health effects; ST4 focused on cross-cutting issues (stakeholder engagement, ethics, and economics of health surveillance); and ST5 on efficient project management.

Communication is central to successful health surveillance. Although SHAMISEN did not provide guidelines on risk communication, health surveillance programmes require dialogue with affected populations beyond straightforward information provision. Reviews and case studies therefore addressed the best means of involving and empowering a variety of stakeholders through such dialogue, so as to improve information exchange in designing health surveillance strategies.

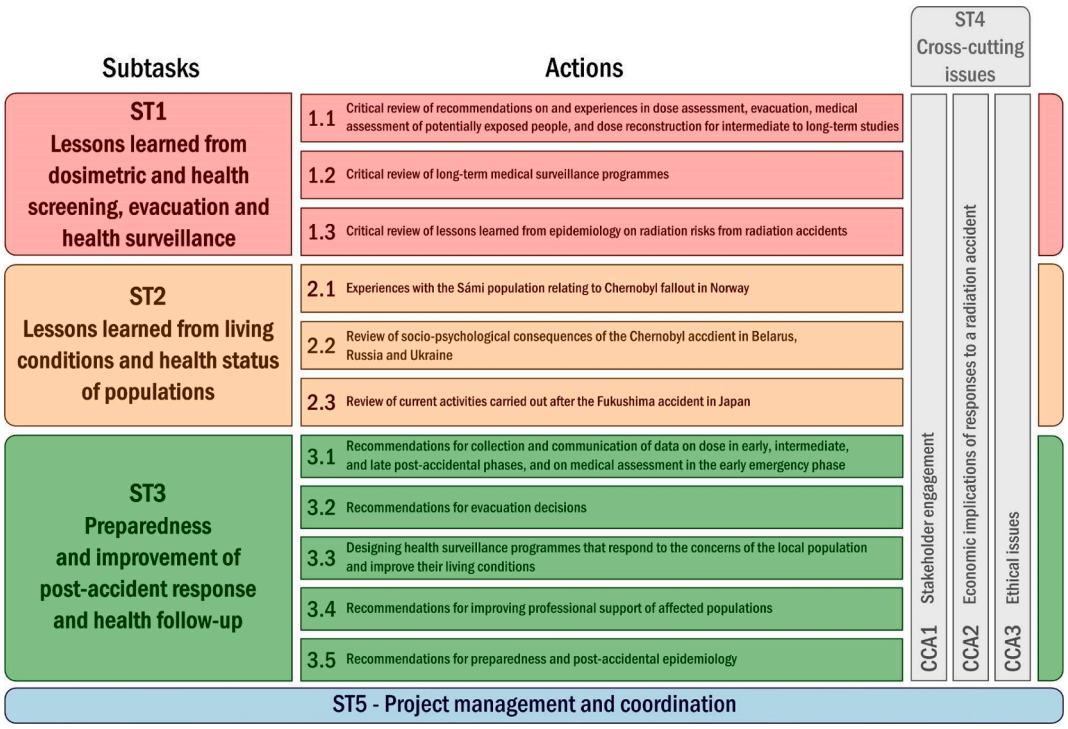

Fig. 1. Organisation of SHAMISEN in terms of subtasks, actions and cross-cutting actions.

3.1. Subtask 1 – Lessons learned from dosimetric and health screening, evacuation and health surveillance

The objective was to review guidelines and experiences from previous radiation emergencies regarding management of dosimetric screening, evacuation and health surveillance. This was achieved through three complementary actions covering the entire spectrum from emergency response and evacuation to health surveillance and epidemiological studies (Fig. 1).

A1.1. Critical review of recommendations on and experiences in dose assessment, evacuation, medical assessment of potentially exposed people, and dose reconstruction for intermediate to long term studies

The objective of this action was to draw lessons from previous experiences and to feed these into recommendations made in A3.1. This was achieved by conducting critical reviews of:

- Recommendations and experiences on dose assessment for external exposures and internal contamination in the accidental phase, the recovery phase and for long term surveillance as well for ensuring adequate dosimetric capabilities in the case of a nuclear accident (Barquinero et al., this issue).
- Guidelines and experiences on evacuation and their public health consequences (Ohba et al., this issue).
- Experiences in communicating dose assessment results to different stakeholders (including local populations, medical community and decision makers) (Barquinero et al., this issue; Maître et al., this issue).

A1.2 Critical review of long-term medical surveillance programmes

The objective was to provide a set of lessons learned from medical surveillance on physical and mental health of populations exposed to fallout from the Chernobyl and Fukushima accidents, as an input to ST3. Work under this action included:

- A review of recommendations, regulations, laws, decrees and long-term medical surveillance programmes of populations exposed following the Chernobyl and Fukushima accidents to evaluate impacts of long-term medical surveillance programmes in these populations;
- Workshops, including participation of medical surveillance experts from countries affected by the Chernobyl and Fukushima accidents, on the impact of surveillance measures on public health, and their justification from clinical and scientific viewpoints – in conjunction with A1.3;
- A summary of lessons learned for improving long-term medical surveillance of different categories of affected populations.

The work also included a generic assessment of recognized ethical challenges in medical screening, drawing on experience from other cases such as cancer screening, as well as real challenges from the Chernobyl and Fukushima cases. This formed part of the cross-cutting work on ethical issues (ST4, CCA3)

Details of the work and results of this action are summarised in this Special Issue (Cléro et al., this issue; Liutsko et al., this issue-a; Oughton et al., this issue)

A1.3 Critical review of lessons learned from epidemiology on radiation risks from radiation accidents

The objective of this action was to summarise lessons learned from epidemiological studies of radiation induced risks following previous accidents, as an input to recommendations on health surveillance and implementation of epidemiological studies of a potential radiation accident in Europe in A3.5. This involved a critical review of the organization and logistics of epidemiological follow-up of past radiation accidents. Key points considered were: 1) definition of the study populations (workers involved in the accident and its clean-up, and the general population, with particular attention to potentially vulnerable groups: children, pregnant women, elderly or ill); 2) their identification and follow-up (screening and collection of health data); 3) dose measurement and reconstruction (in collaboration with A1.1 and A1.2); and 4) acceptability to various stakeholders. Work focused on four accidental situations with different scopes (magnitudes of doses and populations exposed): Chernobyl, Fukushima, Fleurus and Three-Mile Island.

Lessons learned are summarised in this Special Issue (Liutsko et al., this issue-a) and served as input for recommendations in A3.5. The full

report on this subtask can be found at https://radiation.isglobal.org/blog/2017/03/14/lessons-learned-from-dosimetric-and-health-screening-evacuation-and-health-surveillance/.

3.2. Subtask 2 – Lessons learned from living conditions and health status of populations

The objective of the work was to review the health and concerns of populations living in contaminated areas following radiation accidents. In particular, ST2 aimed at identifying impacts on living and social conditions, and summarising the worries, needs and expectations of the affected populations with regards to their health and welfare. Socio-psychological consequences of the Chernobyl and Fukushima accidents were also analysed and discussed. This was achieved through a description and analysis of specific case studies as follows:

A2.1 Experiences with the Sámi population relating to Chernobyl fallout in Norway

The aim of this action was to learn from the experiences, needs and expectations of the Sámi reindeer herders affected by Chernobyl fallout with respect to their health surveillance, including information and communication strategies, and economic implications of both fallout and restrictions. This was achieved through a review of scientific reports and feedback from local stakeholders, both reindeer herders and local medical professionals; a questionnaire developed and sent to local stakeholders; and a seminar organised in Norway, marking the 30th anniversary of the Chernobyl accident.

A2.2 Review of socio-psychological consequences of the Chernobyl accident in Belarus, Russia and Ukraine

The aim of this action was to review the socio-psychological consequences of the Chernobyl accident on the populations living in (and evacuated from) contaminated areas of Belarus, Russia and Ukraine and to evaluate the success of programmes implemented for improving living conditions. This was achieved through a review, including experts from these countries, of studies on the sociological and psychological impacts of the Chernobyl accident; and of the results of the ETHOS (Hériard-Dubreuil et al., 1999; Lochard, 2007) and CORE (Trafimchick, 2005) projects in Belarus, evaluating their effectiveness at improving health and welfare of affected populations.

A2.3 Review of current activities carried out after the Fukushima accident in Japan

The aim of this action was to learn from the experiences and needs of populations affected by the Fukushima accident and from the interventions aimed at addressing these. This involved a review of the innovative approaches implemented in Fukushima prefecture to help local Japanese populations address issues relating to their health and living conditions. An analysis of case studies presented during the ICRP Dialogue initiative (Lochard et al., 2019) was also performed and a workshop of medical professionals, radiation protection experts and local stakeholders was held in Fukushima on the occasion of the 5th anniversary of the Fukushima accident to review the design and implementation of interventions addressing the health issues of the population.

The approach used and results of this subtask are summarised in this Special Issue (Maître et al., this issue). The full report of this subtask can be found at https://radiation.isglobal.org/blog/2017/03/14/lessons-learned-from-living-conditions-and-health-status-of-populations/.

3.3. Subtask 3 – Preparedness and improvement of post-accident response and health follow-up

The objective of this subtask was to develop recommendations and procedures for preparedness, screening, surveillance and medical follow-up of populations affected by a current or future radiation accident. Work built upon the reviews of guidelines and recommendations carried out in ST1 and the case studies and lessons learned in ST2. The scope and content of the recommendations were outlined at the start of the project, and covered emergency response, evacuation, improvement of living conditions, training of medical personnel and epidemiological studies. These were revised, consolidated and sent for stakeholder comments through the project website and at the Stakeholder meeting at OECD in Paris. The final recommendations are discussed in this Special Issue (Liutsko et al., this issue-b) and are available on the SHAMISEN website (SHAMISEN consortium, 2017). They have been disseminated to decision makers and radiation protection authorities for translation into policy, as well as to scientific, medical and non-expert audiences.

The recommendations take into account exposure levels, types of population (workers, general population, pregnant women), age (infants, children, adults, elderly) and health status of the population, and health/economic/and scientific impact of the surveillance.

Recommendations were intended to enhance interactions and collaboration between emergency preparedness networks (in Europe and elsewhere), radiation protection specialists, dosimetrists, health professionals, psychologists, epidemiologists and other specialists involved in accident response and implementation of health surveillance measures at various stages.

Work under this subtask included the following actions:

A3.1 Recommendations for collection and communication of data on dose in early, intermediate, and late post-accidental phases, and on medical assessment in the early emergency phase

The aim was to produce recommendations on procedures needed for dose and medical assessments after a potential radiation accident in Europe, drawing on lessons learned from ST1, particularly A1.1 in close collaboration with A3.4 and A3.5.

A3.2 Recommendations for evacuation decisions

The aim of this action was to design recommendations for evacuation criteria that take into account not only dose levels but also the health condition of populations (particularly sensitive subgroups such as children, pregnant women, elderly and hospitalised persons) and the availability of adequate means to evacuate them and facilities to receive them, in order to limit avoidable mortality and morbidity. This action built upon the work carried out in A1.1 (Ohba et al., this issue).

A3.3 Designing health surveillance programmes that respond to the concerns of the local population and improve their living conditions

The aim was to adapt or design, as appropriate, health surveillance strategies that address the concerns, needs and expectations of affected populations. This action built upon input from A1.2 and lessons learned from case studies carried out in ST2, discussing strategies that go beyond simple health monitoring and meet the broader objectives of improving living conditions of affected populations. This included the study of engagement of populations in the design of surveillance strategies and in identification of their own information needs.

A3.4 Recommendations for improving professional support of affected populations

The aim was to develop a holistic strategy for improving the medical, psychological, and social support of affected populations. Proposals included training and education of trusted local communicators: such as medical professionals (doctors, nurses, public health workers), particularly in primary care settings; teachers; and local elected persons on radiation effects, post-traumatic stress syndromes, and risk communication. This drew upon the reviews and lessons learned from ST1 and ST2.

A3.5 Recommendations for preparedness and post-accidental epidemiology

The aim of this action was to develop recommendations for health surveillance and, where appropriate, implementation of epidemiological studies after a potential radiation accident in Europe or elsewhere. Key points considered were preparedness for post-accidental medical follow-up/epidemiology, collection of health data, definition of study populations, and ensuring long-term sustainability of health surveillance processes. Work under this action included: 1) a review of existing means for health surveillance, and their usefulness in post-accidental situations, in different European countries (routine monitoring

systems and systematic registration of pathologies such as cancers, thyroid diseases or birth defects); 2) an evaluation of the feasibility and pertinence of employing various epidemiological approaches after a radiation accident in Europe or elsewhere, including an assessment of the usefulness of active screening. Recommendations will take into account dose level, type of population (remediation workers, general population), age and health status of the population. This action drew upon lessons learned from ST1 and ST2, and aspects relating to dose were conducted in close collaboration with A3.1.

The resulting recommendations and their justification are discussed in the final paper of this Special Issue and in the recommendation booklet on the SHAMISEN website (Liutsko et al., this issue-b; SHAMISEN consortium, 2017).

3.4. Subtask 4 – Cross-cutting issues

It was recognised from the outset that stakeholder involvement was necessary at all stages of accident preparedness, response and follow-up and that ethics and economic considerations were key aspects to be taken into account both in existing accidental situations and in planning for possible future accidents. Thus, three cross-sectional actions (CCA) were conducted within SHAMISEN, as follows:

CCA1 – Stakeholder engagement

The aim of this action was to foster engagement of stakeholders in designing a relevant and meaningful health surveillance programme in the aftermath of an accident. Stakeholders include affected individuals, health professionals, educators, health authorities at the local, regional, national and, where relevant, international level, as well as scientists and medical researchers. Work in this action involved addressing the following questions:

- How to engage stakeholders in health surveillance and follow-up;
- How to develop a practical radiological protection culture with these stakeholders;
- The feasibility and usefulness of engaging stakeholders in a common assessment of the radiological and health situation; and
- How to integrate citizens and other stakeholders in radiation protection programmes to improve living conditions.

Extensive consultations were carried out through stakeholder roundtables and workshops with sociologists, psychologists and ethicists, radiation protection professionals, networks involved in emergency preparedness and in remediation, European Radiation Protection Platforms (MELODI, NERIS, EURADOS, SHARE) and international organizations within STs 1–3. Stakeholder engagement was also addressed in the reviews in ST1 and ST2. The CCA1 team participated in SHAMISEN project meetings and workshops, with dedicated sessions on fostering stakeholder engagement and proposing ways to ensure stakeholder engagement and empowerment in ST3. Results of this work is discussed in several papers in this Special Issue (Barquinero et al., this issue; Liutsko et al., this issue-b; Maître et al., this issue).

CCA2 – Economic implications of responses to a radiation accident

The aim of this action was to provide estimates of costs/resources/benefits (based on anticipated health effects of both exposure and interventions, and resource implications of surveillance actions) associated with a response of a similar scale to that at Fukushima in the event of an accident in Europe. Work included:

- A review of the resource and cost implications of previous accidents, in particular that at the Fukushima NPP.
- Development of scenarios of health surveillance and scales and types of accident according to responses to previous accidents.
- Presentation of results in terms of resource use, costs and (dis)benefits as a baseline against which different types of response to a given accident are compared.
- Development of a set of balance sheets, a format ideally suited to public health decision-making.

Details of the approach and the results are presented in this Special Issue (Albani et al., this issue).

CCA3 – Ethical Issues

This cross-cutting action aimed to actively evaluate ethical challenges in the work of SHAMISEN. It is widely recognized that medical screening raises a number of ethical issues and challenges, many of which are of direct relevance to screening and health surveillance after radiation accidents. ST1 included a review of ethical issues and recommendations in health surveillance and screening, including a generic assessment of recognized ethical challenges in medical screening, drawing on experiences from previous cancer screening and public health surveillance cases. Specific ethical challenges relating to Chernobyl and Fukushima were assessed in the work of ST1 and ST2. Finally, the development of recommendations in ST3 included identification of ethical challenges and procedures to address these challenges for all the areas considered. Details of the approach and results are presented in this Special Issue (Oughton et al., this issue).

4. Discussion

SHAMISEN has conducted, for the first time, a critical review of the experiences of Chernobyl, Fukushima and other radiation accidents, and drawn lessons about the ways they were managed as a basis for making recommendations for health surveillance in the case of a radiation accident.

Addressing both the health effects of radiation and the societal and social, psychological and economic aspects of radiation accidents, and through engaging stakeholders, SHAMISEN represents the first consolidated effort to incorporate the broad WHO definition of health into recommendations for health surveillance of populations exposed to radiation, considering health not only in terms of absence of (radiation induced) disease, but as a full state of social and psychological well-being. By collecting information about the needs and expectations of populations with respect to health surveillance, it recognised the importance of engaging a broad range of stakeholders in designing and implementing health surveillance after an accident.

SHAMISEN was also unique in that it brought together a large multidisciplinary team of researchers and experts from Europe, Japan and the US with comprehensive and complementary experience and a long track record in post-accident management, dosimetry, radiation protection, medical follow-up and screening, population health surveillance, health economics, radiation epidemiology, and ethics and sociology of radiation protection. The project drew, in particular, upon expertise from Belarus, Russia and Ukraine, from Fukushima and from fields outside of traditional radiation research, including psychology mental health, sociology, economics, philosophy and ethics. Indeed, SHAMISEN was also a pioneer in combining social sciences and humanities with radiation protection.

Extensive consultations were conducted, through stakeholder roundtables (including local populations and medical professionals in affected areas) and discussions (including local and national decision makers), as well as through workshops involving sociologists, psychologists and ethicists, radiation protection professionals, networks involved in emergency preparedness and in remediation, European Radiation Protection Research Platforms (MELODI, NERIS, EURADOS, SHARE) and international organisations. Information obtained from this wide range of sources was integrated to maximise the coherence, credibility and usefulness of recommendations for health surveillance in the case of radiation accidents.

The final recommendations of SHAMISEN differ from those of previews reviews in that they are based on a holistic evaluation of the impact of accidents and not purely on technological considerations. As can be seen in the final paper of this Special Issue (Liutsko et al., this

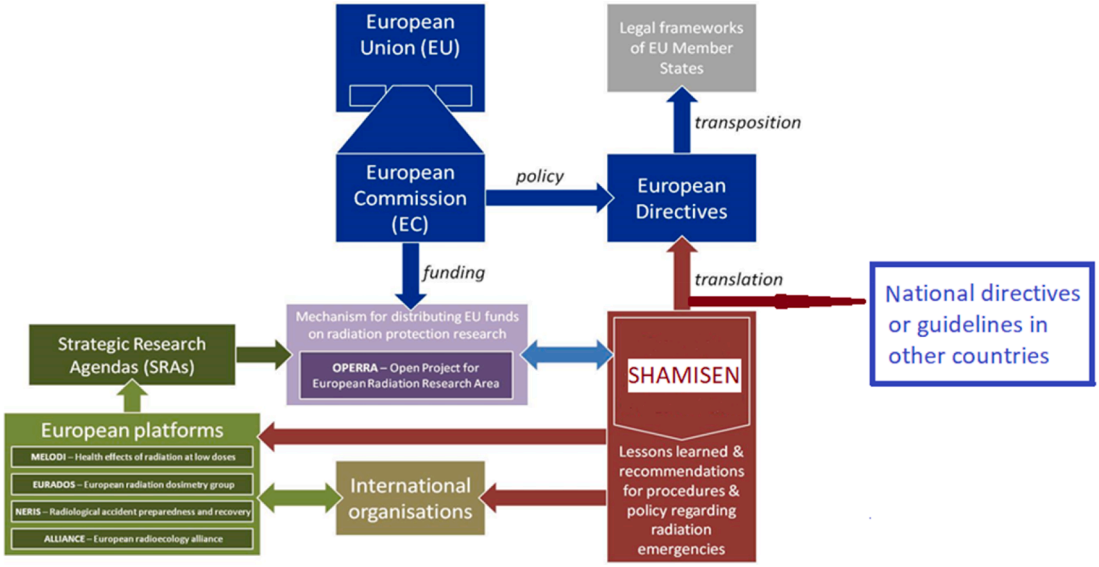

Fig. 2. The flow of SHAMISEN project results to expected impact and communication.

issue-b), the recommendations take into account not only exposure levels, but types of population (workers, general population, pregnant women), age (infants, children, adults, elderly), their health status as well as the health/economic/ethical and scientific impact of accident response and health surveillance. The outcome includes: guidelines or "good practice" in medical and dosimetric surveillance programmes; recommendations for greater engagement of stakeholders, for enhancing well-being and resilience of affected populations, for better two-way communication including the use of local interpreters to ensure the link between affected communities and experts; for building and maintaining a radiation protection culture and for optimal preparedness and response in the case of a possible future accident. Recommendations were also made for enhancing interactions and collaboration between emergency preparedness networks (in Europe and elsewhere), radiation protection specialists, dosimetrists, health professionals, psychologists, epidemiologists and other specialists involved in accident response and implementation of health surveillance measures at various stages.

4.1. Next steps

While the objective of the SHAMISEN project was the development of recommendations, their implementation into an operational framework in case of a future accident – as well as for continued health surveillance in areas affected by previous accidents – is important to ensure that the lessons learned from past nuclear accidents are adequately taken into account in local, regional, national and international plans for preparedness, early and intermediate phase and recovery phases of a nuclear accident.

A major issue relates to including the risk of non-radiological consequences in the justification of decisions for urgent protective actions such as evacuation and sheltering. This is discussed in more detail in the companion paper by Ohba et al. (this issue). It is difficult to include a formal criterion to account for the non-radiological consequences of an accident in the ICRP RP system, as these consequences will vary with country, culture, social background, communication strategies and messages, local resources and geographical factors, as well as with the specific circumstances of the accident. The fundamental principle needs to be included in the RP system, however. It is thus at the local, regional and national levels that sheltering/evacuation-related plans, including for vulnerable groups, should be elaborated in advance, in conjunction with all relevant stakeholders (including residents of potentially affected communities and local medical and educational professionals).

Another important issue in the conceptual framework for the implementation of the ICRP principles of optimisation and limitation is that of "reasonableness and tolerability of risk". Again, the non-radiological risks identified within SHAMISEN cannot be quantified in the same way as the radiological risks. While some of the impacts – for example increases in childhood obesity and diabetes due to lack of outdoor exercise and increases in suicides and substance abuse – can be quantified, there does not exist a direct relation with the level of radiation dose; rather, they are a function of numerous factors including the protection measures taken, the communication strategies, the level of trust of the population and the prevailing circumstances at the time of the accident. Further, other important impacts, such as on quality of life, stress and anxiety and socio-economic status are more subjective and qualitative, hence the concepts of reasonableness and tolerability of these risks need to be considered at the local, regional and national levels rather than summarised in a universally applicable index. Integrating these factors calls for adopting a multidisciplinary approach, balancing these factors with risk indicators. It introduces complexity and flexibility into the decision-making process, involving stakeholders and considering the variety of individual/family/community situations and giving special attention to the vulnerable groups.

As indicated in the Recommendations Paper of this Special Issue (Liutsko et al., this issue-b) a follow-up project, SHAMISEN-SINGS, has allowed SHAMISEN partners to build upon an important lesson drawn from SHAMISEN: the need to engage citizens in data collection for monitoring doses and health and wellbeing during the recovery and long-term phases after an accident. This led to recommendations concerning mobile apps that can help affected populations retake control of their lives and build resilience in the aftermath of an accident[3], thus reducing the psycho-social and economic impacts of an accident.

The SHAMISEN Consortium was created for research purposes and does not have the mandate or legitimacy to formally participate in the implementation of the Recommendations into an operational framework, or offer support and training activities to organisations willing to use and implement them. The Recommendations have been presented and discussed in national and international workshops and meetings and are being disseminated to all appropriate stakeholders. As mentioned in the

[3] https://radiation.isglobal.org/shamisen-sings/booklets/.

editorial of this Special Issue, "the SHAMISEN recommendations are now referred and used as basis of the reflections and the initiatives of national and international organizations for preparedness […] and for the management of the Fukushima situation with a key role of the Japanese partners involved in the SHAMISEN project" (Schneider et al., this issue). Further, individual members of the SHAMISEN Consortium are active at the National, European and International levels in accident preparedness, response and follow-up and endeavour to help translate the SHAMISEN recommendations into operations through their activities.

The writing of this paper has coincided with the COVID-19 pandemic and it is noteworthy that many of the SHAMISEN recommendations are applicable to the COVID situation, with similar issues related to protective measures, trust, psychological and socio-economic impacts https://www.isglobal.org/documents/10179/7943094/24_ISGlobal+COVID-19+y+SHAMISEN+EN/8751850b-e1f7-4f38-98eb-588404bd9b95. Conversely, the management of the COVID-19 pandemic provides key lessons for improving the preparedness to nuclear emergency and recovery management, emphasizing the interrelation of the health, economic, social and ethical issues as pointed out in SHAMISEN project. All countries face the complexity of developing decision-making processes where health is to be considered according to the WHO definition i.e. as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 1948). The current situation reinforces the importance of addressing the resilience of the countries and human communities with due consideration of abovementioned factors in the decision-making process.

5. Conclusion and expected impacts

The overall objective of the SHAMISEN project was to apply a holistic approach to the preparation of evidence-based recommendations for health surveillance and medical follow-up of populations affected by past or future nuclear accidents. Through a critical review of existing recommendations and experiences in the emergency and remediation phases of past nuclear accidents, expert workshops and stakeholder consultations, the Consortium has produced 28 recommendations for the preparedness, early and intermediate phase and recovery phases of a nuclear accident. These recommendations will help improve existing health risk estimates and clinical decision making in a manner that responds to the population's needs and avoids the generation of unnecessary anxiety.

The conclusions and recommendations from this project are expected to have a high profile, at the national and EC levels – both in Policy and in Radiation Protection Research through the European Platforms –, and internationally, as shown in Fig. 2. Translation of the recommendations to reach scientific/public health experts, decision makers, European radiation protection authorities, including HERCA (association of Heads of these Authorities), international organizations and non-expert audiences, is underway to achieve maximum impact.

6. Disclaimer

Where authors are identified as personnel of the International Agency for Research on Cancer / World Health Organization (IARC/WHO), the authors alone are responsible for the views expressed in this article and they do not necessarily represent the decisions, policy or views of the IARC/WHO.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The SHAMISEN project was supported by the EURATOM (European Atomic Energy Community) programme of the European Commission in the framework of the OPERRA (Open Project for the European Radiation Research Area) project (FP7 grant agreement No. 604984).

ISGlobal acknowledges support from the Spanish Ministry of Science, Innovation and Universities through the "Centro de Excelencia Severo Ochoa 2019-2023" Program (CEX2018-000806-S), and support from the Generalitat de Catalunya through the CERCA Programme (http://cerca.cat/en/). NMBU acknowledges the support of the Research Council of Norway, Grant No. 263856.

References

Albani, V., Vale, L.D., Pearce, M.S., Ostroumova, E., Liutsko, L., this issue. Aspects of economic costs and evaluation of health surveillance systems after a radiation accident.

Barquinero, J., Fattibene, P., Chumak, V., Ohba, T., Della Monaca, S., Nucetelli, C., Akahane, K., Kurihara, O., Kumagai, A., Challeton-de Vathaire, C., Grégoire, E., Poelzl-Viol, C., Kulka, U., Oestreicher, U., Peter, M., Jaworska, A., Tanigawa, K., Cardis, E., this issue. Lessons from past radiation accidents: Critical review of methods addressed to individual dose assessment of potentially exposed people and integration with medical assessment.

Bennett, B., Repacholi, M., Carr, Z. (Eds.), 2006. Health effects of the Chernobyl accident and special health care programmes -Report of the UN Chernobyl Forum expert group "Health"-. WHO Press, Geneva.

Bromet, E.J., Havenaar, J.M., Guey, L.T., 2011. A 25 year retrospective review of the psychological consequences of the Chernobyl accident. Clin. Oncol. R. Coll. Radiol. G. B. 23, 297–305. https://doi.org/10.1016/j.clon.2011.01.501.

Bromet, E.J., 2014. Emotional consequences of nuclear power plant disasters. Health Phys. 106, 206–210. https://doi.org/10.1097/HP.0000000000000012.

Cardis, E., Hatch, M., 2011. The Chernobyl accident–an epidemiological perspective. Clin. Oncol. R. Coll. Radiol. G. B. 23, 251–260. https://doi.org/10.1016/j.clon.2011.01.510.

Cléro, É., Ostroumova, E., Demoury, C., Grosche, B., Kesminiene, A., Liutsko, L., Mottref, Y., Oughton, D., Pirard, P., Rogel, A., Van Nieuwenhuyse, A., Laurier, D., Cardis, E., this issue. Lessons learned from Chernobyl and Fukushima on thyroid cancer screening and recommendations in case of a future nuclear accident.

Hériard-Dubreuil, G., Lochard, J., Girard, P., Guyonnet, J.F., Le Cardinal, G., Lepicard, S., Livolsi, P., Monroy, M., Ollagnon, H., Pena-Vega, A., Pupin, V., Rigby, J., Rolevitch, I., Schneider, T., 1999. Chernobyl post-accident management: the ETHOS project. Health Phys. 77 (4), 361–372.

Liutsko, L., Ohba, T., Kesminiene, A., Ostroumova, E., Van Nieuwenhuyse, A., Laurier, D., Cléro, É., Pirard, P., Cardis, E., this issue, a. Lessons learnt from epidemiological studies on past nuclear accidents.

Liutsko, L., Sarukhan, A., Oughton, D., on behalf of the SHAMISEN Consortium, this issue, b, The SHAMISEN Recommendations on Preparedness and Health Surveillance of Populations Affected by a Radiation Accident.

Lochard, J., 2007. Rehabilitation of living conditions in territories contaminated by the Chernobyl accident: the ETHOS project. Health Phys. 93, 522–526. https://doi.org/10.1097/01.HP.0000285091.08936.52.

Lochard, J., Schneider, T., Ando, R., Niwa, O., Clement, C., Lecomte, J.F., Tada, J.I., 2019. An overview of the dialogue meetings initiated by ICRP in Japan after the Fukushima accident. Radioprotection 54 (2), 87–101.

Maître, M., Croüaill, P., Schneider, T., Kuroda, Y., Miyazaki, M., Tanigawa, K., Oughton, D., Tomkiv, Y., Skuterud, L., Liutsko, L., Charron, S., Poelzl-Viol, C., Kesminiene, A., Ostroumova, E., this issue. Living conditions and health status of populations living in territories impacted by nuclear accidents - development of appropriate health surveillance programme.

Ohba, T., Tanigawa, K, Liutsko, L., this issue. Evacuation after a nuclear accident: critical reviews of past nuclear accidents and proposal for future planning.

Oughton, D.H., 2013. Social and ethical issues in environmental remediation projects. J. Environ. Radioact. 119, 21–25. https://doi.org/10.1016/j.jenvrad.2011.08.019.

Oughton, D., Tomkiv, Y., Liutsko, L., on behalf of the SHAMISEN Consortium, this issue. Ethical aspects of dosimetric, medical, health and welfare surveillance in the aftermath of a nuclear disaster.

Schneider, T., Oughton, D., Cardis, E., this issue. The SHAMISEN project - applicability of lessons learnt and recommendations for disaster situations.

SHAMISEN consortium, 2017. Recommendations and procedures for preparedness and health surveillance of populations affected by a radiation accident. ISGlobal. [WWW Document], URL https://radiation.isglobal.org/shamisen/ (accessed 07. 01. 20).

Shigemura, J., Tanigawa, T., Saito, I., Nomura, S., 2012. Psychological distress in workers at the Fukushima nuclear power plants. JAMA 308, 667–669. https://doi.org/10.1001/jama.2012.9699.

Tanigawa, K., Hosoi, Y., Hirohashi, N., Iwasaki, Y., Kamiya, K., 2012. Loss of life after evacuation: lessons learned from the Fukushima accident. Lancet 379, 889–891. https://doi.org/10.1016/S0140-6736(12)60384-5.

Trafimchick, Z., 2005. The CORE programme in Belarus: A new approach to the rehabilitation of living conditions in contaminated areas. Chernobyl Forum, Vienna.

UNSCEAR, 2010. UNSCEAR 2008 Report Vol. II. Effects of Ionizing Radiation (UNSCEAR 2008 Report). New York.

UNSCEAR, 2014. Sources, effects and risks of Ionizing Radiation (UNSCEAR 2013 Report). New York.

WHO, 1948. WHO definition of health. World Health Organisation, Geneva.

Yasumura, S., 2015. Evacuation effect on excess mortality among institutionalized elderly after the fukushima daiichi nuclear power plant accident. Fukushima J. Med. Sci. 60, 192–195. https://doi.org/10.5387/fms.2014-13.