Comparative qualitative and quantitative analysis of guidelines for nuclear accident recovery

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Received: 1 September 2023 / Accepted: 11 December 2023

Abstract – Nuclear accidents have impacted the territory, population, and environment over a long time. With their global and multifaceted impacts, increasing preparedness for such events will help achieve better and more sustainable long-term recovery. Recovery and response guidelines exist internationally for preparing for nuclear accidents. The qualitative and quantitative analysis of 13 recovery guidelines realized in this study help to better understand the general emphasis points, specificities, and potential topics that need to be further developed in the wake of sustainable remediation. Currently, recovery and remediation prioritize waste management, population protection, and well-being, with less focus on environmental and economic aspects. To meet sustainable needs, these less-emphasized areas should be addressed to foster more comprehensive and resilient recovery strategies.

Keywords: Recovery / remediation / nuclear post-accident / guideline

1 Introduction

Nuclear accidents, such as the Chernobyl and Fukushima Daiichi Nuclear Power Plant (FDNPP) accidents, not only cause environmental contamination by radioactive materials but also affect the socioeconomy through evacuation, relocation, restrictions on land use and agricultural shipments, decontamination, and compensation. Therefore, recovery plans must consider not only environmental recovery, but also social and economic restructuring. The Chernobyl accident in 1986 and FDNPP accident in 2011, highlighted the importance of preparedness and the need for international cooperation in managing nuclear accidents. The evolution of guidance occurred through regular and consistent updates, fueled by the acquisition of new knowledge and information aimed at better preparing society for future events. Vital lessons learned from past experiences, such as the Chernobyl and Fukushima incidents, serve as invaluable benchmarks for assessing the exigencies of effective response and recovery strategies (Ohba et al., 2021; Fushiki, 2013; Cléro et al., 2021). By continually learning from past incidents, we can increase our ability to respond effectively to nuclear emergencies and safeguard both public well-being and the environment.

Nuclear accidents progress in three phases, each requiring specific actions and considerations. The initial phase, known as the response or early phase, involves immediate emergency measures, such as rapid evacuation, containment, and decontamination, to minimize the release of radioactive materials and safeguard public health (ICRP No.146, 2020). This was followed by a transition phase as the situation became clearer. It is characterized by efforts to stabilize the situation and assess the extent of the damage. As the transition phase evolves and the situation stabilizes, the recovery phase ensues, focusing on the restoration of affected areas and the rehabilitation of impacted communities. This phase relies heavily on the implementation of remedial options, which encompass a range of strategies, including soil remediation, waste management, and infrastructure reconstruction. Management of the extensive volume of radioactive waste (IAEA No. NW-T-1.31, 2022) following a nuclear accident presents significant challenges, and is one of the main issues for recovery. Effective waste management practices are essential to ensure the safe disposal or containment of radioactive materials, thereby mitigating long-term environmental and health risks. The costs associated with nuclear accidents are important (JCER, 2019) and encompass various aspects including emergency response, transition planning, recovery efforts, remediation actions, and long-term monitoring. These costs include infrastructure repairs, compensation for affected individuals, and implementation of preventive measures for future incidents.

The recovery process following a nuclear incident encompasses not only environmental aspects, but also social and economic dimensions, making it a multidimensional
challenge. Decision-making during the recovery phase involves balancing technical expertise with the active involvement of stakeholders. It has been demonstrated that addressing the challenges faced by the affected regions requires collaboration and engagement from all stakeholders, providing insights and new perspectives to the local, regional, and national decision-making levels (Schneider et al., 2021). Economic considerations play a pivotal role in post-incident recovery. Remediation costs, both direct and indirect, can be substantial, as seen with the FDNPP accident cost (Yasutaka et al., 2016), necessitating a careful and informed risk–benefit evaluation for protective actions (IAEA, 2023). In addition to social and economic aspects, environmental considerations are an important part of the process of healing from a nuclear accident. (IAEA, 2011).

Regarding the multifaceted aspects of recovery, there has been growing interest in achieving sustainable remediation (Wieder et al., 2022) following radiological events during recovery, particularly in the aftermath of the FDNPP accident. It has had long-term effects on the region’s economic, societal, and environmental landscapes. Recognizing the importance of addressing such radiological incidents from a global perspective, international committees have emphasized the need to develop assessment tools and guidelines to evaluate the sustainability aspects of recovery actions (NEA, 2021). Currently, numerous guidelines and recommendations exist at both the international organizational and national institutional levels that address the aftermath and recovery of radiological events. This study was based on the concept of sustainable remediation defined by the United Kingdom’s Sustainable Remediation Forum (SurF) and linked to the US Environmental Protection Agency (EPA) concept of green remediation. Sustainable and green remediation represent actions with a net benefit to safety and the environment, society and economy, natural resources, and climate change (NEA, 2016).

As the previous comparative study (Bertho et al., 2022) who compared the different strategies implemented by different countries, this study aimed to determine the focus points of each of these guidelines, the main themes of response actions and recovery planning, and the kind of information that may be lacking from these guidelines in the wake of sustainable remediation (Social, environmental and economic aspects) by conducting a qualitative and quantitative analysis of guidelines and recommendations from diverse international and national institutions that pertain to nuclear accident response and recovery.

2 Methodology

The analysis of doctrines regarding nuclear accident recovery has predominantly been confined to accidents that occur at nuclear power plants. To undertake this comparative analysis, a study was conducted to collect nuclear accident management doctrines from European and North American countries that mentioned or were specific to the recovery (long-term) phase following nuclear accidents. The construction of the guideline corpus was restricted by the availability of official online documents and language of publication. This limitation aimed to mitigate the potential for misinterpretation arising from translation. The data collection method followed that of a previous comparative study (Bertho et al., 2022). Thirteen different guidelines were analyzed in this study (Tab. 1). Five were from international institutions and 8 from national institutions.

2.1 Qualitative analysis

A qualitative analysis was conducted on all previously mentioned documents. The analysis primarily focused on the recovery aspects of the guidelines, excluding chapters on emergency responses and protective actions during the response phase following a nuclear accident. A qualitative approach was considered relevant as it allowed a greater capacity to gain depth and meaning across the guideline corpus.

The analysis aimed to explore the main emphases of each guideline and gain an overall assessment of the recovery process in all combined guidelines. Analysis was performed by systematically reviewing each guideline individually using a step-by-step approach. As the objective was to identify the focal points of each guideline, special attention was paid to paragraphs mentioning sustainable remediation processes: protection of human health, stakeholder involvement in decision-making processes, environmental protection, and economic considerations.

2.2 Quantitative analysis

The quantitative analysis involved text mining using the open-access software KhCoder. It focused on every aspect of the guidelines. Every chapter, from the response to the recovery actions, was considered (Tab. S1). Chapter and subchapter titles, tables, figures, references, and certain annexes and appendices were excluded from the analysis. To ensure accurate identification and prevent data loss, all capital letters have been converted to lowercase letters.

The relevant text of each guideline was then compiled into a single Excel document for comparative analysis to create a single guideline corpus. The quantitative analysis covered all the thirteen documents except for France’s ‘Recommendations pour la gestion post-accidentelle d’un accident nucléaire (ASN Codirpa, 2022)’ as the document is written in French. However, the 2012 version, written in English, was included in the analysis. In total, 12 documents were analyzed, adding up to 176,797 words (Tab. S1). Common words, referred to as ‘stop-words’, such as ‘the’, ‘and’ were removed from the analysis using default parameters. Additionally, ‘e.g.,’, ‘i.e.,’, ‘al’, and ‘et’ were added to the stop-word list.

The overall data was analyzed by creating four main themes of interest in line with sustainable development goals: ‘Environment’, ‘Life’, ‘Ethics’, and ‘Economy’, along with nine sub-themes: ‘Economy’, ‘Radiological protection principles’, ‘Stakeholder involvement’, ‘Psychological impact’, ‘Food’, ‘Health’, ‘Land’, ‘Waste’, and ‘Ecosystems’. The themes and subthemes (Tab. 2) were created to categories the guidelines for specific topics related to sustainable remediation. The creation of these themes involved preliminary exploratory research on the nouns and adjectives linked to the main themes derived from the guideline corpus. This
preliminary research involved analyzing word frequencies, identifying co-occurring words, and conducting hierarchical cluster analysis. Nouns and adjectives occurring ten times or more were considered.

Correspondence and co-occurrence analyses using KhCoder software were performed on the subthemes in association with each guideline and with the topic of the guidelines. The topic of the guidelines represents the phases of nuclear incident management mentioned in the guidelines. The document analyzed belong to 4 different categories ‘all phases’ ‘early and transition phase’ ‘transition and recovery’ and ‘recovery phase’.

Correspondence analysis is a statistical method that explores and visualizes the relationships between two sets of categorical data in a two-dimensional plane. It helps visualize relationships between themes and subthemes that exhibit similar patterns, determining if they are characteristic of the analyzed guidelines.

Co-occurrence network analysis serves as a tool for visually representing the potential connections among concepts and facilitating a deeper understanding of their interrelationships. These networks offer insights into the underlying structures and interaction networks within the radiological protection guidelines by connecting pairs of concepts to the most frequent word occurrences within each theme. Consequently, the network diagrams depict the associations between the guidelines and previously established themes and subthemes. In these diagrams, the node size represents word frequency, line thickness indicates the strength of connections, and node color reflects the degree of association.

| Table 1. Guidelines analyzed. |
|-------------------------------|------------------|-----------------|-----------------|
| **Organization** | **Title** | **Reference** | **Phase considered** |
| International | ICRP | Radiological Protection of People and the Environment in the Event of a Large Nuclear Accident – Publication 146 | (ICRP, 2020) | All phases |
| OECD/NEA | Building a Framework for Post-Nuclear Accident Recovery Preparedness | (NEA, 2022) | Transition + Recovery |
| IAEA | GSG-11 arrangements for the termination of a nuclear or radiological emergency | (IAEA, 2018) | Transition + Recovery |
| | GSG-15 Remediation Strategy and Process for Areas Affected by Past Activities or Events | (IAEA, 2022) | Recovery |
| IFRC | Nuclear and Radiological Emergency Guidelines – Preparedness, Response and Recovery | (IFRC, 2015) | Recovery |
| National | Canada | Guidance on planning for recovery following a nuclear or radiological emergency | (Health Canada, 2020) | Recovery |
| France | Policy elements for post-accident management in the event of nuclear accident | (ASN Codirpa, 2012) | All phases |
| | Recommandations pour la gestion post-accidentelle d’un accident nucléaire | (ASN Codirpa, 2022) | Transition + Recovery |
| | Report n°175 : decision making for late-phase recovery from major nuclear or radiological incidents | (NCRP, 2014) | All phases |
| England | Public Health Protection in Radiation Emergencies | (PHE, 2019) | Recovery |
| Nordic countries* | Protective actions in a nuclear or radiological emergency | (STUK, 2022) | Early + Transition |

* Denmark, Norway, Sweden, Finland and Iceland.
Table 2. Theme and sub-themes.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Sub-theme</th>
<th>Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>Ecosystems</td>
<td>air, animal, aquatic, atmospheric, biodiversity, biota, ecological, ecosystem, environment, environmental, fauna, flora, forest, gathering, generation, ground, groundwater, habitat, livestock, meteorological, natural, nature, pet, river, soil, species, vegetation, wind</td>
</tr>
<tr>
<td>Waste</td>
<td>Land</td>
<td>capacity, disposal, landfill, storage, topsoil, transport, volume, waste area, country, evacuation, home, land, local, location, region, regional, rehabilitation, relocation, residence, site, territory</td>
</tr>
<tr>
<td>Life</td>
<td>Health</td>
<td>acute, adult, adverse, age, cancer, care, challenge, child, clothes, clothing, constraint, death, diet, dietary, disease, elderly, evacuee, exposure, family, fetus, group, habit, health, health-related, illness, individual, infant, infrastructure, inhabitant, inhalation, injury, life, lifestyle, lifetime, limit, livelihood, loss, medical, organ, pathology, people, population, pregnant, risk, school, self-help, skin, suffering, surface, symptom, threshold, tissue, victim, vulnerable, welfare, woman, young</td>
</tr>
<tr>
<td>Food</td>
<td></td>
<td>berry, consumption, crop, drinking, fishing, food, foodstuff, fruit, garden, hunting, ingestion, meat, milk, mushroom, restriction, water, wild</td>
</tr>
<tr>
<td>Psychological impact</td>
<td></td>
<td>anxiety, behavior, behavior, depression, disorder, emotional, fear, humanitarian, mental, poor, psychological, psychosocial, reassurance, social, societal, socio-economic, stress, trauma, well-being, wellbeing</td>
</tr>
<tr>
<td>Ethics</td>
<td>Stakeholder Involvement</td>
<td>ability, acceptable, achievable, appropriate, audience, autonomy, awareness, capability, center, choice, citizen, co-expertise, co-operation, co-ordination, communication, community, confidence, confusion, consistent, construction, consultation, cooperation, coordination, cultural, decision, decision-maker, decision-making, dialogue, discussion, education, efficient, engagement, expert, flexible, historical, inclusive, informed, initiative, input, involvement, knowledge, living, media, meeting, opinion, opportunity, participation, partnership, party, public, relationship, representative, resident, sharing, society, stakeholder, survey, trust, understanding, voluntary, volunteer</td>
</tr>
<tr>
<td>Radiological protection principles</td>
<td></td>
<td>acceptability, acceptance, access, benefit, culture, dignity, empowerment, ethical, fundamental, good, harm, holistic, iterative, justification, justified, optimization, optimization, principle, reasonable, resilience, resiliency, resilient, respect, sustainable, transparency, transparent</td>
</tr>
<tr>
<td>Economy</td>
<td>Economy</td>
<td>agricultural, agriculture, business, commerce, commercial, commodity, company, compensation, consumer, cost, customer, economic, economy, employee, employer, employment, farmer, financial, financing, funding, goods, housing, image, industrial, industry, job, market, monetary, owner, payment, producer, product, quality, raw, recreational, residential, restoration, resumption, rural, sale, sector, skill, socio-economic, supplies, supply, support, tourism, trade, working</td>
</tr>
</tbody>
</table>

3 Results

3.1. Category analysis

The categories were first analyzed, and their word frequencies represented approximately 15% of all words present in the analyzed text. It can be observed that the social aspect, namely ‘Ethics’ and ‘Life’ themes are the most prevalent across all the guidelines combined accounting for 79% of the four themes with the ‘Economy’ theme being the least prevalent at 9%. On average, approximately 11% of the words in each theme accounted for approximately 50% of the occurrences within the theme. For ‘Life’, the 5 most represented words are ‘exposure’, ‘area’, ‘risk’, ‘population’ and ‘health’. For ‘Stakeholder’, the 5 most represented words are ‘public’, ‘decision’, ‘community’, ‘stakeholder’ and ‘appropriate’. For ‘Economy’, the 5 most represented words are ‘support’, ‘economic’, ‘product’, ‘production’ and ‘cost’.

For ‘Environment’, the 5 most represented words are ‘waste’, ‘environment’, ‘disposal’, and ‘animal’. Overall, the most frequent words in the guidelines (Fig. 1) concerned actions to reduce radiological exposure. The ‘Life’ theme explores day-to-day life after the incident and health aspects such as diseases, health-related issues, and mental health. The ‘Ethics’ theme focuses on stakeholder involvement in the decision-making process, procedural values, and radiological protection principles. The ‘Economy’ theme examines the impact on actual and future businesses, direct costs of the incident, and production in sectors such as agriculture and industry. The ‘Environment’ theme addresses ecosystem protection, monitoring, and waste management.
All guidelines follow relatively the same structure (Fig. 2), meaning that all subthemes are represented, on average, in the same frequency with ‘Health’ and ‘Stakeholder involvement’, the most represented subthemes at 28% and 22%, respectively.

3.2. Correspondence analysis and co-occurrence network


Correspondence analysis from the three-dimension and co-occurrence networks (Figs. 3a, 3b and 4a) give similar results and indicate diversity in the themes focused on each guideline. It is important to note that a guideline located far from a theme does not imply a complete absence of discussion about that theme, but rather more of a situation instead of a yes/no. Thus, the following can be inferred:

– The ‘Health’ theme, located in the center seems to be a common theme among guidelines;
– The ‘Stakeholder involvement’ theme is a common theme in all guidelines, but less in ‘USA EPA’, ‘Codirpa’ and ‘STUK’ guidelines;
– The ‘Land’ and ‘Waste’ themes are mentioned more by the ‘USA EPA’, ‘IAEA GSG15’, ‘Codirpa’ and ‘STUK’ guidelines;
– The ‘Food’ theme is focused mostly by ‘STUK’ and ‘Codirpa’ guidelines;
– The ‘Ecosystem’ theme is mentioned more by ‘IAEA GSG 15’, ‘STUK’ and ‘Codirpa’ guidelines;
– The ‘Economy’ theme seems to be mentioned more by ‘PHE’, ‘Canada’, ‘ICRP’ and ‘Codirpa’ guidelines;

Fig. 1. Word cloud of the top 100 nouns and adjectives in all the guidelines combined.
Fig. 2. Subtheme repartition across all guidelines.
The Social aspect (RPPs, Health, Land, Stakeholder involvement) is the most common theme in all guidelines analyzed, whereas the environmental and economic themes are the least common. The co-occurrence network of the phase-related guidelines (Fig 4b) with the subthemes showed interesting results and allowed for clearer definitions of the transition and recovery phases. Guidelines focusing on this transition tend to emphasize food restrictions and environmental monitoring. The early phases focused primarily on protecting human health and psychological impacts. Recovery phase covers every subtheme except ‘food’ and ‘Health’ for which the latter was expected. Broader guidelines mentioning all phases focus more on ‘Land’, ‘RPPs’, ‘Psychological impact’, ‘Stakeholder involvement’, and ‘Health’. All preceding interpretations aligned relatively well with the structure of each guideline (Fig. 2).

4 Discussion

The qualitative analysis in this study offers a comprehensive overview of the focus of the analyzed guidelines. Overall, these guidelines exhibit similar structures and cover the same important and fundamental topics: protection of human health; ethics such as stakeholder involvement in decision-making processes; environmental protection; human life; and, economic considerations. Each guideline, national or international, also has a specific emphasis that is addressed in more depth than in other guidelines, such as waste consideration in NCRP 175 or food consideration in STUK.

These guidelines are consistent with the concept of sustainable remediation, which has been advocated in the environmental field in recent years. Principles of sustainable remediation that encompass relationships, rationale, and resources have been advocated. Incorporating sustainable environmental practices into the remediation of contaminated sites aligns with the remediation goals and guidelines linked to other industries (SuRF, 2020; EPA, 2008), and such considerations are increasing in the nuclear industry (Mobbs et al., 2019).

It is important to acknowledge that the analysis of both the data and guideline collection is shaped by the researcher’s viewpoint and personal beliefs. Consequently, qualitative analysis is inherently subjective because it relies on the researcher’s perspective. Moreover, the length of each document influenced the analysis as the longer it is, the more it will skew the results and the theme creation.

Across all guidelines, a central theme emerged: the significance of safeguarding the population, particularly in the early phase and throughout the transition and recovery phases. Stakeholder involvement in decision-making processes and the management of radioactive waste has been extensively emphasized in all guidelines. International guidelines delve deeply into stakeholder involvement, radiological protection principles, and procedural fairness, whereas national guidelines tend to offer specific protective and recovery measures.

4.1. Life

The recovery phase focuses on community enhancement and protection concepts such as improving the resilience of populations, the desire to return to a new normal, ensuring fair radioprotection principles, and developing a radioprotection culture. Human health protection actions in the recovery phase following a nuclear incident differ from those in the early transition phase. The guidelines specifically emphasize the assessment of psychological impacts (e.g., stress, depression, drug disorders; Maeda et al., 2018) resulting from factors such
as evacuation, job loss, and family related issues, which have been identified as the main causes of death related to the Fukushima disaster (Hasegawa et al., 2016). The objective was to support and accompany distressed populations and provide them with access to living and working conditions. The well-being of the affected population, especially following traumatic events, evacuation, and relocation, is highlighted as being a determining factor in health and illness recovery (Bromet et al., 2016). This process involves implementing zonal relocation and rehabilitating local structures (e.g., schools and transportation) in areas where radiation exposure risks are below reference levels. In such cases, remediation efforts continue from the early and transition phases, following the optimization principle which aims to reduce exposure to the population as much as reasonably achievable. Additionally, the guidelines prioritized radiological protection principles and procedural fairness as the core of recovery. It has become important to enhance community involvement (Geysmans et al., 2020), explore methods (IAEA, 2021), and review past experiences and difficulties linked to stakeholder involvement (Perko et al., 2020, Montero et al., 2020). Therefore, Stakeholder involvement should be integrated into every step of the decision-making process and throughout the emergency, mostly during preparedness and recovery. Clear cooperation and dialogue (Yasutaka, 2020) between experts, local stakeholders, and authorities as a co-expertise process is needed to rebuild (Lochard et al., 2020) social trust. The guidelines clearly reflect the radiological protection society’s commitment to responsibility and transparency to foster public understanding and acceptance of nuclear activities, and to ensure procedural fairness. The ‘Life’ aspect of nuclear management and recovery is a common topic addressed in depth in all guidelines.

4.2. Environment

Waste management and remediation were the central aspects addressed in all guidelines. It is a substantial part of the recovery process and remediation efforts because of its impact on territory, economy, environment, and health. A significant amount of radioactive waste is expected to be generated during nuclear accidents and the subsequent remediation efforts. The amount of waste generated following the Fukushima disaster was expected to be approximately 14 million m³ (MOE), exemplifying the magnitude of this challenge. Effective remediation of such waste and residual contaminated materials is one of the most essential components for enabling populations and the environment to return to a new normal. National and international preparations for such events are mandatory, and will contribute to lowering the exposure and cost of remediation. All the guidelines agree on the necessity of preparing storage and transportation arrangements for such waste, understanding the associated timescales, and involving and informing the population. Comprehensive planning and implementation of waste remediation strategies are at the core of the guidelines for the long-term recovery and restoration of affected areas, alongside the protection of human health.

Important aspects of recovery are the characterization of the environment, monitoring soil contamination, and air dose rate. The aim is to enable the population to resume food production and to be able to hunt, fish, and forage for wild berries or mushrooms (Yagi, 2019; Takada et al., 2020). However, non-human biota, landscape, and ecosystem protection following a nuclear accident or remediation actions are either mentioned briefly or not addressed at all by the guidelines.

4.3. Economy

Overall, the economic aspects of recovery were mentioned less frequently in the guidelines. This can be attributed to the prioritization of health protection, regardless of the cost. However, optimized preparation of the cost for remediation and planning of the future economic landscape of the affected territory play an important role in achieving sustainable and efficient recovery. The cost of remediation for the Fukushima disaster (JCER, 2019) highlights the importance of this aspect, sufficiently considering the economic aspects, remedial costs, and compensation in preparation for recovery. Along with
waste generation, remediation efforts are linked with high costs and are expected to reach more than 5 trillion yen (Yasutaka et al., 2016) in Fukushima. Recent efforts have also focused on supporting local businesses, mitigating the impact on production (Schneider et al., 2021), and planning for future land usage and the development of a new economy. (Schreurs, 2021). Management of recovery from a nuclear accident can be accompanied by a clear definition of the future land usage, industry, and economic landscape. However, these topics are briefly mentioned in the guidelines or lack clear guidance.

5 Conclusion

The qualitative and quantitative studies have revealed the main concerns and actions to be taken during the remediation phase following a nuclear accident. Three major points emerge: protection of the population and its well-being, involvement of the population in the decision-making process, and management of radioactive waste generated as a result of the accident and decontamination efforts. However, impacts, particularly environmental resulting from remediation efforts (release of wastewater, displacement of large volumes of soil) and economic impacts (compensation, relocation, closed businesses), are part of a sustainable remediation process. These aspects are less frequently mentioned in the guidelines, or even absent in some cases.

It was clear that there were specificities in each guideline. However, common subjects such as health or waste management were covered extensively throughout the guidelines. To further incorporate sustainability into the recovery process, explicitly addressing economic aspects and providing clear guidance for non-human biota and ecosystem protection is important. These aspects would contribute to more effective guidelines for a sustainable nuclear accident response and recovery and help for the development of guidance for a sustainable remediation approach, taking into account holistically environmental/radiological aspects, economic aspects, social aspect.

The quantitative analysis allowed us to notice similarities between guidelines, but also specific aspects ‘more’ or ‘less’ mentioned in those guidelines. It is also a tool that enables us to corroborate the qualitative analysis in a positive manner, and limits subjective interpretation. The visualization permits quick and easy characterization of the subject and emphasizes of guidelines. The dual analysis allows for a comprehensive view of post-accidental management and of specificities in each country or organization. It also highlights differences in regulatory structures, raising the question of the best way to produce these recommendations.

Acknowledgements

This research was performed by the Environment Research and Technology Development Fund (JPMEERF22S20930) of the Environmental Restoration and Conservation Agency provided by the Ministry of the Environment of Japan. The funders had no role in study design, data collection, and analysis, decision to publish, or manuscript preparation.

We would like to thank Yumiko Kanai and Shinko Fujii for advising this research and Editage (www.editage.com) for English language editing.

5 Conclusion

The authors declare that they have no conflict of interest.

Data availability statement

All data used are already listed in the reference list of the manuscript.

Author contribution statement

L. Carnet: Methodology, Writing original draft, Visualization, Investigation. T. Yasutaka: Conceptualization, Writing-Reviewing and Editing. M. Takada: Methodology and Writing-Reviewing and Editing.

Ethics approval

Ethical approval was not required.

Informed consent

This article does not contain any studies involving human subjects.

Supplementary Material

Table S1: Characteristics of each guideline considered.
Table S2: Top100 words and their frequency in the guideline corpus.

The Supplementary Material is available at https://www.radio pro-journal.org/10.1051/radiopro/2023043/olm.

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health and social issues following a nuclear accident: The case of Fukushima.


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Cite this article as: Canet L, Takada M, Yasutaka T. 2024. Comparative qualitative and quantitative analysis of guidelines for nuclear accident recovery. Radioprotection 59(2): 69–79