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PAPER

Awareness of disaster preparedness between administrative staff and residents in the vicinity of the Genkai and Ikata nuclear power plants following the Fukushima Daiichi nuclear power plant disaster

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Keywords: nuclear power plant disaster, disaster preparedness, evacuation protocols

Abstract

When considering disaster preparedness, one challenge is mitigating the health impacts of evacuations. Nuclear disaster preparedness has evolved based on past experiences from numerous disasters, including the Fukushima Daiichi Nuclear Power Plant (FDNPP) accident. However, there is a lack of comprehensive reporting on the awareness of administrative staff, medical personnel, and residents in the areas surrounding nuclear power plants (NPPs). This study reports on a survey aimed at gaining insights into the understanding and current state of disaster preparedness and elucidating the differences in perceptions of nuclear disaster preparedness among the relevant stakeholders surrounding NPPs. Interview surveys were conducted from 14 to 16 September 2022 in the area surrounding Kyushu Electric Power's Genkai NPP in Saga Prefecture and from 11 to 13 January 2023 in the area around Shikoku Electric Power's Ikata NPP. The surveys targeted administrative, medical, and nursing care facilities and residents. Responses from 57 participants indicated a lack of awareness of natural and nuclear disasters, challenges in evacuation planning, and a gap between nuclear disaster training and residents' understanding of evacuation protocols. This study highlights inadequacies in nuclear disaster preparedness and the need for a better understanding among residents regarding evacuation procedures. This study identified three key issues: (1) a lack of awareness about disasters, including nuclear disasters; (2) concerns about complex disasters and the difficulties in creating evacuation plans; and (3) a discrepancy between nuclear disaster training and residents' understanding of evacuation procedures. To bridge this gap, it is important to deepen residents' understanding of nuclear disasters, continuously convey the lessons learned from the FDNPP accident, and regularly reassess and update nuclear disaster preparedness strategies.

1. Introduction

Radiation disasters not only cause direct health effects due to radiation exposure but also lead to significant health impacts due to the evacuation procedures associated with the disaster. Health impacts on residents due to evacuation have been reported in past studies. For example, there are issues such as the worsening of non-communicable diseases, including diabetes [1, 2] and hypertension [3–5], and mental health problems [6, 7] due to the psychological pressures experienced when evacuating. Mitigating these health impacts is one of the challenges in disaster preparedness.

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In Japan, the 'Basic Act on Disaster Management' is the foundation for disaster prevention and response. Nuclear disaster prevention is specifically governed by the 'Act on Special Measures Concerning Nuclear Emergency Preparedness'. The Basic Act on Disaster Management was enacted in 1961 and underwent significant revisions after two specific disasters [8]. The first was after the 1995 Great Hanshin Earthquake, which led to amendments in disaster preparedness plans, the development of information systems, and the incorporation of support for vulnerable groups, such as older adults and persons with disability, in disaster risk management. The second revision, enacted in April 2021, followed the 2011 Great East Japan Earthquake (GEJE). This revision made it mandatory for municipalities to create individual evacuation plans for people requiring assistance during evacuation. Nuclear disaster preparedness measures are guided by the 'Guidelines for Nuclear Disaster Preparedness', based on the Nuclear Disaster Special Measures Act [9, 10], established following the 1999 Tokaimura nuclear accident in Tokai Village, Ibaraki Prefecture, Japan. These include the development of medical response systems for nuclear disasters and the designation of Emergency Planning Zones as protective action zones.

The 'Guidelines for Nuclear Disaster Preparedness' have been continually updated in response to disasters. In March 2011, the GEJE and Fukushima Daiichi Nuclear Power Plant accident (FDNPP) (International Nuclear and Radiological Event Scale: INES Level 7) occurred. These events led to revisions in the Act on Special Measures Concerning Nuclear Emergency Preparedness, and in 2012, the Nuclear Regulation Authority formulated the refreshed 'Guidelines for Nuclear Disaster Preparedness'. These guidelines introduced the designation of Nuclear Disaster Preparedness Priority Areas (PAZ: Precautionary Action Zone, UPZ: Urgent Protective Action Planning Zone), the implementation of protective measures based on Emergency Action Level and Operational Intervention Level, and clarification of the predistribution and administration of stable iodine tablets. These measures emphasised the swift assurance of residents' safety as an initial response to a nuclear accident. Indoor sheltering in a UPZ area is one such policy [11] that aims to reduce radiation exposure risks and prevent confusion during evacuation [12], thereby promoting effective evacuation procedures. In addition, in 2015, enhancements were made to the medical response system for radiation exposure, specifically targeting the treatment of casualties in complex disasters involving both natural and radiation hazards. While research [13] has considered policy-making officials' awareness regarding these changes to nuclear disaster prevention policies due to various disasters, including the FDNPP accident, there is a lack of comprehensive reporting on administrative staff and residents' perceptions of these policies in areas surrounding nuclear power plants (NPPs).

This study reports on a survey conducted near NPP sites. The survey was initiated with the hypothesis that the perception of nuclear disasters among the locations of Japan's other NPPs may have changed and improved following the FDNPP accident. This study aims to uncover the differences in awareness of nuclear disaster preparedness procedures among municipal employees tasked with disseminating information on nuclear disaster prevention and the perceptions of hospitals, nursing care facilities, and residents. The survey also explores challenges that may impact future nuclear disaster prevention efforts, with the expectation of gaining insight into developing tailored nuclear disaster preparedness initiatives to meet the specific needs of residents, hospitals, and other vital stakeholders.

2. Method

Interviews were conducted with 25 disaster preparedness officials in the areas surrounding Kyushu Electric Power's Genkai NPP in Saga Prefecture. The survey period was from 14 to 16 September 2022. The survey covered seven cities and towns, namely: Karatsu, Hirado, Imari, Genkai, Itoshima, and Takeo. The interviews were conducted at each city office or hospital across ten facilities. Subsequently, from 11 to 13 January 2023, further interviews were conducted with 32 disaster preparedness officials and members of two voluntary disaster prevention associations near Shikoku Electric Power's Ikata NPP. This included officials from four cities and towns, namely: Yawatahama, Ikata, Seiyo, and Matsuyama. The interviews were conducted across 12 facilities, spanning city offices, prefectural offices, hospitals, and special nursing homes.

The interviews were conducted to test the hypothesis that perceptions of NPP disasters might have changed or improved following the FDNPP accident, through questions on the following topics.

(1) Current status of disaster preparedness initiatives
(2) Primary concerns in the event of a major disaster
(3) Challenges in decision-making regarding evacuation and indoor sheltering in the event of a nuclear accident

The aim was to gather information on the initiatives and understanding of disaster preparedness for natural and nuclear disasters among local stakeholders in the PAZ and UPZ around NPPs.

This study was approved by the Institutional Review Boards of Minamisoma Municipal General Hospital (approval number: 2-07) and Fukushima Medical University (approval number: 2019-269). All the participants provided informed consent before participating in the interviews. This study was conducted per the principles of the Declaration of Helsinki.

3. Results

A summary of the survey findings on disaster preparedness efforts, including those for nuclear disasters and the national indoor sheltering policy in the case of a nuclear disaster around two NPPs, are presented below.

Kyushu Electric Power's Genkai NPP, located in Saga Prefecture, is presented in figure 1. As of August 2023, one of the plant's four nuclear reactors was operational, one was undergoing regular inspection, and two were being decommissioned [14]. Although the plant is located in Saga Prefecture, the PAZ includes parts of Nagasaki Prefecture located in the west, and the UPZ includes areas of both the Nagasaki and Fukuoka Prefectures (Fukuoka Prefecture located east of Saga Prefecture). The Shikoku Electric Power's Ikata NPP, located in Ikata Town, Ehime Prefecture, is presented in figure 2. As of August 2023, one of its three reactors is operational, and two are scheduled for decommissioning [14]. Considering its location, Ikata Town has designated a PAZ and precautionary evacuation area, which includes five cities and two towns in Ehime Prefecture, as well as one town in Yamaguchi Prefecture across the Seto Inland Sea.

Table 1 presents the characteristics of the 57 participants. There were 20 municipal staff members and five hospital staff members in the area surrounding the Genkai NPP ($n = 25$). In the vicinity of the Ikata NPP, there were 14 municipal staff, 15 hospital and nursing care facility staff, and three residents who participated as volunteers.

The responses from the areas around the NPPs within the PAZ are summarised in table 2. In the PAZ around the Genkai NPP, municipal staff frequently mentioned a lack of experience with natural disasters and insufficient awareness of the risks associated with natural and nuclear disasters. The change in awareness toward nuclear disasters following the FDNPP accident was insignificant, with a notable number of residents believing that 'an accident will not happen'. As part of nuclear disaster preparedness, prefecture-led disaster drills are conducted with the participation of administrative and hospital/facility staff. While some facilities are proactive in disaster response, hospital and nursing care facility staff have highlighted issues, such as 'insufficient awareness of nuclear disasters' and the 'inability to adequately accommodate patients and residents during complicated disasters'.

In the PAZ around Ikata NPP, concerns about evacuation were raised due to its unique location at the base of a narrow peninsula, including 'difficulty in securing evacuation routes and potential road congestion' and 'shortage of caregivers for older adults due to the ageing population in the region'.

Responses in the UPZ are compiled in table 3. In the UPZ around the Genkai NPP, only responses from municipal staff were available, as surveys with hospitals and nursing care facilities could not be conducted. The municipal staff expressed concerns about the 'lack of sufficient awareness toward nuclear disasters despite experiences with typhoons and floods' and 'difficulty in securing evacuation routes and a shortage of caregivers for the vulnerable'.

In the UPZ around the Ikata NPP, the responses highlighted challenges in evacuation planning. The following opinions were expressed: 'The possibility of simultaneous natural and nuclear disasters make organising viable evacuation plans difficult' and 'lack of disaster experience makes the inclusion of concrete measures in evacuation plans challenging'.

Table 3 presents the distinctive responses from officials in the UPZ of both the Genkai and Ikata NPP regarding decision-making for evacuation and indoor sheltering in nuclear disasters, as outlined in the Guidelines for Nuclear Disaster Preparedness. Older adult residents and those preferring home care indicated: 'There is no resistance to indoor sheltering at home' and 'Many patients prefer to stay at home during disasters'. However, there were concerns that 'while residents in the PAZ evacuate in an organised manner, those in UPZ waiting at home may feel psychologically distressed' and that some residents feel 'left behind'.

Regarding nuclear disaster prevention, municipal staff reported conducting training and raising awareness about evacuation but identified challenges like 'both PAZ and UPZ drills are conducted on the same day, making it difficult to properly understand the timeline of evacuation procedures'. Additionally, residents who support individuals with disabilities expressed: 'There is insufficient understanding of nuclear disasters even among able-bodied people'. This highlights the need to advance general public understanding and accurately convey it to people with disabilities.

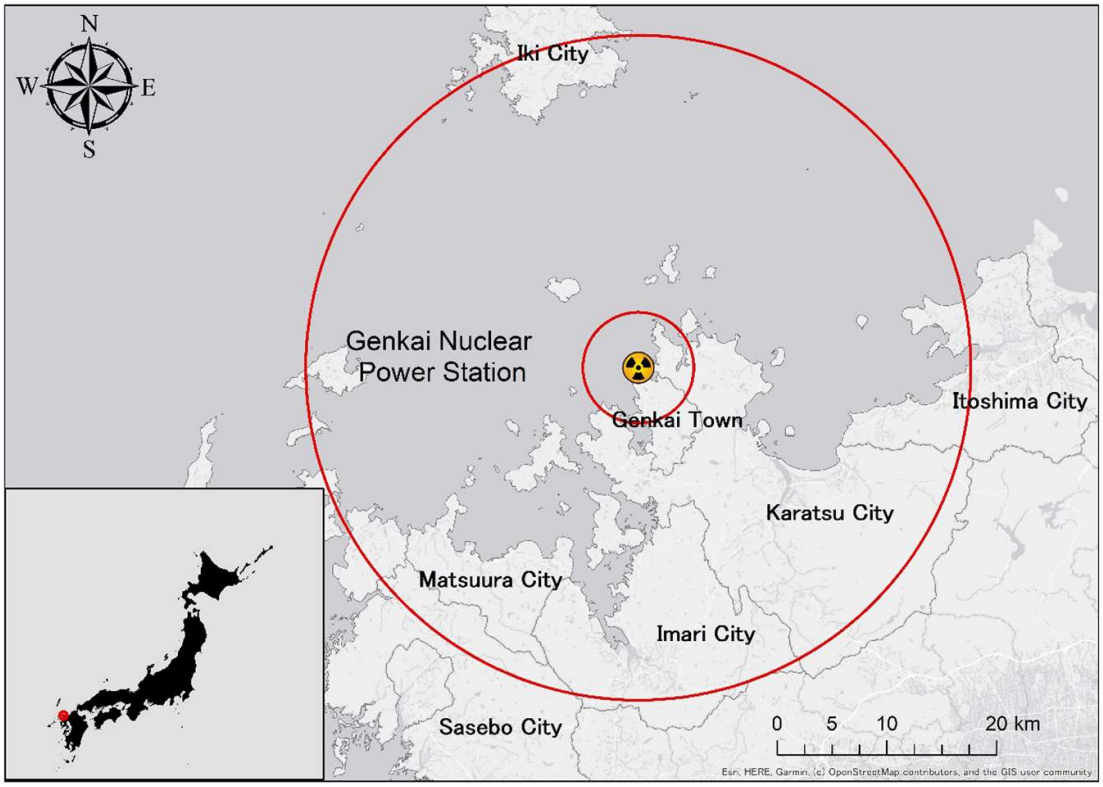

Figure 1. Kyushu electric power company, Genkai nuclear power plant.

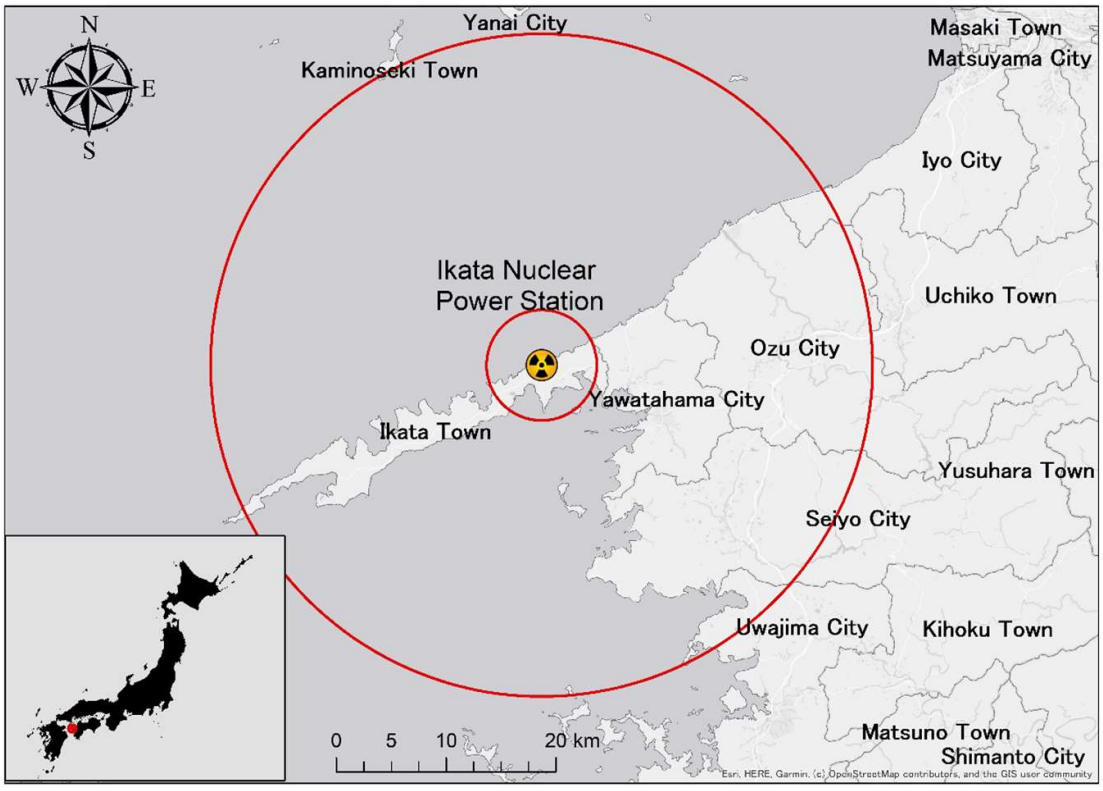

Figure 2. Shikoku electric power company, Ikata power plant.

Table 1. Characteristics of interview respondents ($N = 57$).

	Genkai NPP ($n = 25$)	Ikata NPP ($n = 32$)
Municipal staff	20 (35%)	14 (25%)
Hospital & nursing care facility staff	5 (9%)	15 (26%)
Residents	0	3 (5%)

Table 2. Responses from PAZ areas around Genkai and Ikata nuclear power plants.

Stakeholder	Perspective	Genkai NPP	Ikata NPP
Administration	Characteristics	Lack of crisis awareness of disaster risks Differences in budget allocation by administration	Difficult evacuation due to the unique geographical features of the nuclear plant location
	Initiatives	Conducting nuclear disaster prevention and disaster drills Implementation of nuclear education Creation of individual evacuation plans	Conducting nuclear disaster prevention and disaster drills Implementation of nuclear education Creation of individual evacuation plans
	Issues	Shortage of supporters due to ageing population	Concerns about rapid information exchange due to the relocation of the offsite centre
Hospitals & nursing care facilities	Characteristics	Lack of crisis awareness of nuclear disaster risks	Concerns about disaster countermeasures; limited budget
	Initiatives	Implementation of disaster drills	Implementation of disaster drills
	Issues	Limitations in accepting patients	Differences in evacuation efforts by facility
Residents	Characteristics	Lack of crisis awareness of natural and nuclear disasters	Lack of crisis awareness of nuclear disasters Anxiety over evacuation actions due to ageing population Shortage of supporters for voluntary disaster prevention due to ageing population

4. Discussion

This study revealed the perceptions of administrative staff, hospitals, nursing care facilities, and residents in the PAZ and UPZ around the Genkai and Ikata NPPs regarding nuclear disaster preparedness a decade after the FDNPP accident. Three key issues emerged as gaps between current field practices in nuclear disaster management and the legal framework: (1) a lack of awareness of disasters, including nuclear disasters, (2) concerns about complex disasters and difficulties in creating evacuation plans and (3) a discrepancy between nuclear disaster training and residents' understanding of evacuation behaviours.

First, this study identified a lack of awareness of disasters, including nuclear disasters, even in the PAZ and UPZ of some Japanese NPPs. In both regions covered in this study, the interviews revealed that both residents and municipal staff lacked awareness of disasters, posing a critical challenge to preparedness and response. Although these areas have experienced natural disasters such as typhoons and heavy rains, they lack experience with other major disasters such as earthquakes and tsunamis. Therefore, residents and municipal staff may find it difficult to envision evacuation actions and respond to unfamiliar disasters. Furthermore, following the FDNPP accident, there was an insufficient change in residents' perception of nuclear disasters, with some believing that 'accidents will not happen' and perceiving them as distant threats. Although concern about accidents could enhance disaster preparedness awareness, this study indicates that

Table 3. Responses from UPZ areas around Genkai and Ikata nuclear power plants.

Stakeholder	Perspective	Genkai NPP	Ikata NPP
Administration	Characteristics	Awareness of disasters such as floods and landslides	Difficulty of creating evacuation plans considering geographical challenges
	Initiatives	Implementation of nuclear disaster prevention and disaster drills; nuclear education; clarification of evacuation areas within the UPZ's 44 administrative districts; creation of individual evacuation plans	Implementation of nuclear disaster prevention and disaster drills; nuclear education; understanding of the number of hospitals, facilities, and patients in PAZ and UPZ; creation of individual evacuation plans
	Issues	Limited disaster experience leading to anxiety about evacuation actions Shortage of evacuation supporters Anxiety due to the geographic isolation of islands	Diminished sense of crisis towards landslides; difficulty in securing evacuation sites
Hospitals & nursing care facilities	Characteristics		Abundant initiatives by the medical association; sense of mission as hospitals accepting patients during disasters
	Initiatives		Implementation of disaster education; disaster training; voluntary indoor sheltering drills; promotion of understanding for individuals with hearing impairments during disasters
	Issues		Uncertainty in staff availability at the time of disaster; potential difficulty in securing evacuation routes due to location; challenges in creating disaster preparedness documents
Residents	Characteristics	Lack of crisis awareness of nuclear disasters	Older adult residents have a low awareness toward evacuation (conflicted between the difficulty of evacuating and the desire to spend the end of life at home)
Decision-making on indoor sheltering		Difference between the administration's promotion of 'indoor sheltering' and residents' desire to 'evacuate outdoors'; The administration is conveying to the residents that evacuation includes not only physical movement but also staying in place.	Prioritisation of evacuation consciousness over fears of tsunami and landslides, low awareness towards outdoor evacuation; need for persistent public relations to foster correct understanding of nuclear disasters and radiation among residents

apprehension regarding nuclear disasters does not directly translate into improved disaster readiness among the populace. This may suggest that the perceived low probability of nuclear incidents and the interpretation of the FDNPP accident are insufficient motivators for realistic disaster preparedness efforts. Additionally, it highlights a broad underestimation of nuclear disaster risks, potentially impeding an effective emergency response. These factors may be associated with the geographical distance between the two survey sites and the FDNPP, which might be too extensive for stakeholders to feel a direct sense of involvement. Therefore, sharing the experiences and lessons learned from the FDNPP accident with residents and municipal staff in nuclear facility vicinities emerges as a valuable strategy for developing more robust countermeasures.

Second, the interviews elucidated concerns regarding complex disasters and difficulties in creating evacuation plans among both residents and administrative staff. Nuclear disasters are not likely to occur in isolation but may occur in combination with natural disasters, as seen in the GEJE and FDNPP accidents. While evacuation in the event of a standalone nuclear disaster might follow specific plans and routes, complex disasters amplify damage through factors such as the destruction of homes and roads and the disruption of infrastructure. Creating evacuation plans for such complex situations is challenging, especially when the specific vulnerabilities and characteristics of the location are considered. Following the FDNPP accident, legal disaster preparedness for nuclear accidents was significantly revised and measures were taken to enhance the medical response system for radiation exposure to handle multiple casualties in complex disasters involving both natural and nuclear incidents. However, this study highlights ongoing difficulties, including preparing for complex scenarios such as a nuclear disaster caused by an earthquake or tsunami, which present challenges due to the complexity of planning for diverse patterns and difficulties of implementation considering geographical and human resources. Although individual evacuation plans for people requiring assistance are being developed, there is still a large shortcoming regarding support during evacuation procedures and in cases where evacuation plans have not been established. Furthermore, evacuation plans in hospitals and facilities are not shared in detail among municipalities, coordination is limited within prefectures, and information sharing and collaboration with adjacent prefectures is lacking. The FDNPP accident caused emergency evacuations without sufficient preparation, leading to numerous patient deaths in hospitals within the PAZ [15, 16]. Studies suggest the need for prior coordination, such as predetermined evacuation destinations, to reduce the burden of evacuation on vulnerable patients [17]. To address these challenges, conducting risk assessments for complex disasters and strengthening and promoting collaboration beyond prefectures and municipalities is necessary. Additionally, involving local communities in the reviews, awareness, and enhancement of evacuation plans and training can improve the efficiency and safety of evacuation actions during complex disasters.

Third, there are discrepancies between nuclear disaster training and residents' understanding of evacuation behaviours. Prefecture-led nuclear disaster preparedness training was conducted in each municipality, and evacuation procedures were disseminated to residents of the PAZ and UPZ through drills and pamphlets. However, a clear gap was identified between the residents' perceptions of evacuation actions and the content of the training sessions. A particular concern is that nuclear disaster training is conducted in a single day, potentially affecting the residents' appropriate understanding of the timing for 'indoor sheltering' in the UPZs. This discrepancy may increase the risk of delayed evacuation and confusion during a nuclear disaster. It is crucial to address this issue by revising the content and methodology of nuclear disaster training and enhancing awareness activities that consider residents' understanding and evacuation needs, ensuring they can grasp and respond appropriately to nuclear disasters.

This study has several limitations. One is that the survey participants were limited to individuals who consented to cooperate with the survey. This selection process may lead to selection bias, meaning the responses from each participant group might not reflect the overall perception of the population. Additionally, responses from government officials, in particular, given their role in nuclear disaster prevention in the region, may be susceptible to response bias. Therefore, caution is necessary when generalizing the results obtained from this study. However, we believe that the opinions obtained from the participants are valuable for understanding the current situation in the target area of this survey.

5. Conclusion

Following the FDNPP accident, legal measures and disaster preparedness drills were implemented for nuclear disaster prevention, with a focus on ensuring the safety of residents in Japan. However, this study revealed a discrepancy between grassroots-level disaster preparedness and legal frameworks in the vicinity of NPPs. Therefore, to reduce the discrepancy in the residents' understanding of evacuation procedures, deepening their understanding of nuclear disaster management and continuously teaching the lessons learnt from the FDNPP accident are essential. Additionally, it is necessary to regularly assess residents' perceptions and continually update and improve their preparedness for nuclear disaster prevention.

Data availability statement

The data cannot be made publicly available upon publication because they contain sensitive personal information. The data that support the findings of this study are available upon reasonable request from the authors.

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