

ARTICLE

Investigation of local governments' preparation for evacuation in nuclear emergency in Japan

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Abstract – In Japan, the Nuclear Emergency Response Guidelines were announced in 2015 after the Fukushima Daiichi nuclear power plant accident, and each local government is currently formulating a plan for the evacuation of its residents and a subsequent radioactive contamination inspection. However, there are no reports about the state of preparation of the local governments. Therefore, in this study, we conducted a questionnaire survey regarding the preparation status of each local government responsible for the evacuation of its residents and contamination inspections in Japan and the education training status of staff and summarized the results. Results indicated that 17 of 21 local governments, which answered our questionnaire, have been conducting large-scale evacuation drills at least once a year since 2015 in Japan, demonstrating a high awareness of nuclear emergency response. Conversely, results revealed that the number of local government officials familiar with the evacuation plan and/or contamination inspection flow was small, and issues about education for local government officials were discovered. Statistical analysis suggested that the frequency of training might be related to the high educational needs for risk communication.

Keywords: accident / nuclear / countermeasure / education / emergency planning / emergency / radiological

1 Introduction

In March 2011, the Fukushima Daiichi nuclear power plant (FDNPP) accident occurred in Japan following a major earthquake (IAEA, 2015a; Ohtsuru *et al.*, 2015). This nuclear disaster forced approximately 170,000 residents to evacuate (IRSN, 2019; Hasegawa *et al.*, 2015), a turning point that has heightened the awareness of the importance of preparing materials and laws regarding the evacuation of residents during and after a nuclear disaster. In 2012, following the FDNPP accident, Japan's nuclear emergency response was reconsidered by revising relevant laws such as the Atomic Energy Basic Act and the Act on Special Measures Concerning Nuclear Emergency Preparedness (Tsujiguchi *et al.*, 2019b). The Nuclear Emergency Response Guideline (NERG), which sets out specific action guidelines, was formulated by the Nuclear Regulation Authority (NRA) Japan following the revision of the Act on Special Measures for Nuclear Emergency

Countermeasures (NRA Japan, 2012). Evacuation and medical care systems for residents experiencing a nuclear disaster have been improved by revisions of the NERG and laws (Yamada *et al.*, 2019; Tsujiguchi *et al.*, 2018).

At the time of the NERG revision in 2015, it was determined that the Evacuation Exit Inspection (EEI) should be conducted as one of the protective measures for evacuees in case of nuclear emergency (Tsujiguchi *et al.*, 2018, 2019a). The EEI is an inspection to determine whether there is external radioactive contamination of residents who evacuate from a Precautionary Action Zone (PAZ; within approximately 5 km of the nuclear power plant) and Urgent Protective action planning Zone (UPZ; from the outer rim of the PAZ extending a distance of 30 km). If contamination exists, simple decontamination is to be conducted at the EEI site. Figure 1 shows the EEI flow chart shown by NRA Japan. The primary purpose of EEI is to minimize health effects. To achieve this purpose, evacuees who have exceeded significant contamination criterion as stipulated in the International Atomic Energy Agency (IAEA) technical documents (IAEA, 2017), such as Operational Intervention Level (OIL) 4, will be identified and

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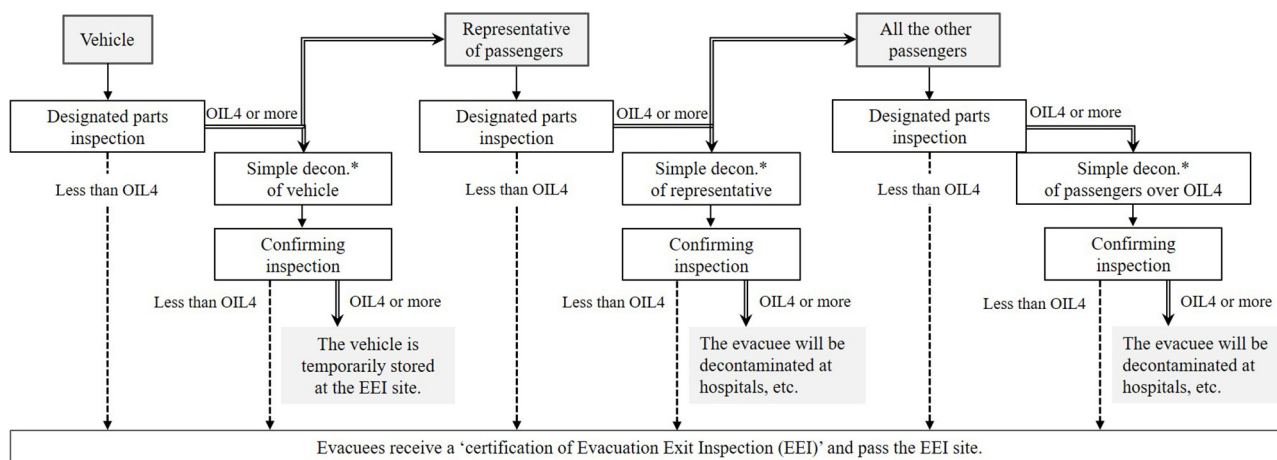


Fig. 1. The process of Evacuation Exit Inspection (EEI). This figure was created by referring to the “manual of evacuation exit inspections and simplified decontamination at nuclear disaster” (NRA Japan, 2015). * “decon.” stands for “decontamination”.

simple decontamination will be conducted if necessary. In addition, an important purpose of EEI is to prevent reputational damage. There are reports that radioactive contamination from the FDNPP accident caused reputational damage, affecting industries of foods and products from Fukushima prefecture and residents from contaminated areas (Kudo and Nakayachi, 2014; Yasumura *et al.*, 2013; IAEA, 2015b). Moreover, when residents near the FDNPP evacuated after the accident, some evacuees were refused to enter the evacuation shelter because they had no certificates of being “radiation free”. To deal with this problem, one of Japan’s central ministries (Ministry of Health, Labor and Welfare) has asked each prefecture to instruct each evacuation shelter not to refuse evacuees. Considering these cases, it is shown that the contamination is not only a cause of physical damage but also a cause of reputational damage. In brief, the role of EEI is important to protect the health and reputation of refugees.

Tsujiguchi *et al.* (2018) reported the flow of EEI established in Japan since 2015 and the situation of nuclear emergency drills/EEI training in local governments. The report indicated the flow of conducting “designated parts inspections” on residents and vehicles evacuated from PAZ and UPZ after the nuclear emergency, followed by a “confirmation inspection” and “simple decontamination”. Vehicles and evacuees who are deemed to be free of contamination before or after simple decontamination can receive the certificate of EEI and pass through the EEI site. However, if contamination remains in vehicles and evacuees after simple decontamination, the vehicles will be temporarily stored at an EEI site, etc., and the evacuees will be transported to a decontamination-capable medical facility for decontamination. At the EEI site, in addition to the inspection for contamination of vehicles and evacuees, the spatial dose rate is continuously monitored and staff communicates with external institutions.

In order to carry out the EEI, it is necessary to customize plans based upon the actual situation of each local government, *e.g.*, establishing the layout of the flow line of vehicles/evacuees, the allocation of personnel and supplies, etc. Local government officials, who typically conduct the EEI, are required to play a leading role regarding the EEI in formulating

plans. In addition, local government officials are required to maintain a variety of knowledge and preparations during the planning and implementation stages. However, the status of their preparations was not clear, and there had been no survey report on them. In this study, we surveyed the preparation status of local governments implementing EEI and the education status of officials of local government in Japan. The aim of the study is to comprehensively summarize these results and to propose data that will contribute to the development of nuclear emergency response and a resident evacuation system.

2 Materials and methods

2.1 Target of the questionnaire survey and the survey period

Japan is divided into 47 prefectures, of which 24 prefectures have nuclear facilities and UPZ. Specifically, there are 16 prefectures with nuclear facilities and there are eight prefectures that include UPZ related to nuclear facilities in neighboring regions, creating a total of 24 prefectures. Each of these 24 local governments must plan for the evacuation of its residents and the EEI in preparation for nuclear emergency. Our questionnaire survey was conducted within administrative departments in charge of nuclear emergency response in 24 local governments. A questionnaire was sent by mail and e-mail, and after receiving a response from the department representative of each local government, tabulation and analysis were performed. The response period was two months, from June to August of 2019.

2.2 Questionnaire survey items

The questionnaire was formulated to survey the preparation status and the awareness and educational training of staff of local governments responsible for EEI (Tab. 1). It included six questions that asked for a single answer, multiple answers, or free entry.

Table 1. Questions items for local governments with nuclear facilities or UPZ.

Question		Answer format	Answer options
Q1	How many times per year are the inspection trainings conducted in your prefecture?	Single choice	<input type="checkbox"/> More than once per year <input type="checkbox"/> Once per year <input type="checkbox"/> Less than once per year <input type="checkbox"/> Never
Q2	How many staff members who can manage the inspection are there in your local government?	Single choice	<input type="checkbox"/> 1 <input type="checkbox"/> 2–5 <input type="checkbox"/> 6–9 <input type="checkbox"/> 10 or more <input type="checkbox"/> Under training <input type="checkbox"/> Others (requires detailed description)
Q3	Have they ever participated in trainings or lectures of the EEI?	Single choice	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Q4	What are difficulties in planning or conducting the EEI for your local government? Please choose from the options and do not choose the options that you think are not difficult	Multiple choices allowed	<input type="checkbox"/> Guiding vehicles and evacuees <input type="checkbox"/> Conducting designated parts inspection <input type="checkbox"/> Conducting confirming inspection <input type="checkbox"/> Conducting simple decontamination <input type="checkbox"/> Temporarily storing evacuees' contaminated vehicles and baggage <input type="checkbox"/> Headquarter activities of EEI site and information management <input type="checkbox"/> Distributing certificates of the EEI <input type="checkbox"/> Managing stable iodine agents (<i>e.g.</i> , distribution method) <input type="checkbox"/> Preparing adequate radioprotective materials and devices <input type="checkbox"/> Planning staffing at EEI sites <input type="checkbox"/> Planning flow line at EEI sites <input type="checkbox"/> Others (free description)
Q5	If you have a goal, please tell us how many officials you want to train for the EEI?	Single choice	<input type="checkbox"/> More than one expert at each EEI site <input type="checkbox"/> More than one expert and replacement staff at each EEI site <input type="checkbox"/> No goal <input type="checkbox"/> Under consideration
Q6	What education do you think is necessary for training of your local government officials? Please choose from the options and do not choose the options that you think are not necessary	Multiple choices allowed	<input type="checkbox"/> Methods of guiding vehicles and evacuees <input type="checkbox"/> Cooperation with other institutions (<i>e.g.</i> , self-defense force) <input type="checkbox"/> Cooperation with disaster countermeasure headquarters of the prefecture <input type="checkbox"/> Methods of using radiation measurement equipment (<i>e.g.</i> , GM survey meter) <input type="checkbox"/> Simple decontamination methods <input type="checkbox"/> Temporarily storing evacuee's contaminated vehicles/baggage <input type="checkbox"/> Operational Intervention Levels (OIL) <input type="checkbox"/> Managing stable iodine agent (<i>e.g.</i> , distribution method) <input type="checkbox"/> Risk communication with evacuees <input type="checkbox"/> Others (requires detailed description)
	If you have opinions about options you choose, please tell us	Free description	–

2.3 Statistical analysis

To analyze correlation between data obtained from the questionnaire, the Chi-square independence test was performed with OriginPro 2019 (LightStone Corp., Tokyo, Japan).

2.4 Ethical considerations

Before conducting the survey, we described the purpose of the survey, privacy protection, and anonymity on paper or *via* e-mail. In addition, we established that the name of the responding individual was not required. This study was approved by the Committee of Medical Ethics of Hirosaki University Graduate School of Health Sciences, Hirosaki, Japan. Approval number is 2018-057.

3 Results

Twenty-one questionnaires were collected, with no incomplete answers. All were treated as valid data (questionnaire collection rate was 87.50%). Of the 21 responses, 14 were from local governments that own nuclear facilities and seven were from local governments that do not own nuclear facilities. The results are presented below, based upon the survey items shown in [Table 1](#).

3.1 Simple counting results from the questionnaire survey (results of Q1 thru Q6)

Regarding the implementation status of nuclear emergency response drills (EEI training) by local governments, 17 of 21 local governments (80.95%) conduct training at least once a year ([Fig. 2\(1\)](#)). However, there were local governments that had never conducted training (14.29%). At the time of the survey, more than half (57.14%) of the local governments had specialized staff at an EEI site; however, the number of staff was less than nine in all the local governments ([Fig. 2\(2\)](#)). In addition, 28.57% of local governments responded “under training” for specialized human resources of EEI, and 14.29% have not trained. The 76.2% of local governments that reported specialized human resources of EEI had experienced some type of drill, such as a nuclear emergency response drill ([Fig. 2\(3\)](#)). [Figure 2\(4\)](#) presents the difficulties local governments experienced in planning and implementing the EEI, from most difficult to least. The most challenging was the plan for manpower (66.67%), followed by vehicle/resident guidance (57.14%) and traffic line layout at the EEI site (47.62%). 9 local governments (42.86%) did not set a target number regarding human resources with expertise in EEI ([Fig. 2\(5\)](#)). There were four local governments that set targets, which was the number of people who could have two experts (responsible persons, assistants) assigned to each EEI site, or the number of people plus the number of substitutes. Other local governments responded that they are considering or will consider doing so. For education that seems especially necessary for human resource development, the most selected option was collaboration with other organizations and collaboration with the Prefectural Disaster Response Headquarters (71.43%) ([Fig. 2\(6\)](#)). In addition, the options selected by more than half of the

local governments were vehicle/resident guidance (61.90%) and risk communication with evacuees (52.38%).

3.2 The relationship between various factors and the difficulty of the EEI plan or the need for education

Using the Chi-square test of independence, the statistical correlations between several results of the questionnaire were investigated. Specifically, we investigated the correlation between the following items:

- 1 nuclear facility and EEI training frequency (Q1);
- 2 nuclear facility and number of staff who can manage EEI (Q2);
- 3 nuclear facility and difficulties in planning/conducting the EEI (Q4);
- 4 nuclear facility and necessary educations for training of officials (Q6);
- 5 EEI training frequency (Q1) and difficulties in planning/conducting the EEI (Q4);
- 6 EEI training frequency (Q1) and necessary educations for training of officials (Q6).

NPPs are located in 14 of the 21 prefectures that answered the questionnaire. No statistically significant association was found for (i) to (iv) above (data not shown). The result of (v) and (vi) are shown in [Table 2](#). The only statistical relationship found was between the training frequency and the need for risk communication education ([Tab. 2](#)).

4 Discussion

In the safety standards and technical documents published by the IAEA, the radiation protection of the general population in the event of a radiation emergency such as a nuclear disaster is proposed as a strategic issue (IAEA, 2017, 2018). The epidemiological study, which found that “radioiodine released into the atmosphere due to the Chernobyl nuclear power plant accident increased the number of cases of childhood thyroid cancer”, is all too famous (Kazakov *et al.*, 1992; Jacob *et al.*, 2006). Protecting residents from such health effects is especially important. In addition, it is known that radiation or radioactive materials caused by a nuclear disaster affect not only physical health, but also mental health. For example, a survey of psychological distress scales conducted after the FDNPP accident reported that residents in Fukushima prefecture had a higher proportion of distress compared to other areas (Hasegawa *et al.*, 2015, 2016; Yabe *et al.*, 2014). Negative psychological consequences are caused by a variety of factors, including fear of radiation and concerns about health effects, rifts within the community associated with evacuation, and unemployment (Hasegawa *et al.*, 2015). The best solution is to prevent radiological accidents. However, in order to minimize the health effects of radiation on the residents, and to minimize the impact on community formation and reputation, formulating a local evacuation plan and a contamination inspection plan for each local government would be an effective measure. According to our results, more than 80% of the local governments that responded to the survey, including nuclear facilities and the UPZ, have conducted successful

Table 2. The relationship between frequency of EEI training and difficulty about EEI or necessity for officials' education.

Questions Items	Frequency of EEI trainings		<i>P</i> -value*	
	Once per year or more	Less than once per year or never		
Q4. Difficulties in planning or conducting the EEI				
Guiding vehicles and evacuees	Select	10	2	0.748
	No	7	2	
Conducting designated parts inspection	Select	6	1	0.694
	No	11	3	
Conducting confirming inspection	Select	11	1	0.149
	No	6	3	
Conducting simple decontamination	Select	11	1	0.149
	No	6	3	
Temporarily storing evacuees' contaminated vehicles and baggage	Select	7	1	0.549
	No	10	3	
Headquarter activities of EEI site and information management	Select	6	0	0.160
	No	11	4	
Distributing certificates of the EEI	Select	3	0	0.364
	No	14	4	
Management of stable iodine agents	Select	5	1	0.861
	No	12	3	
Preparing adequate radioprotective materials and devices	Select	8	1	0.422
	No	9	3	
Planning staffing at EEI sites	Select	12	2	0.432
	No	5	2	
Planning flow line at EEI sites	Select	9	3	0.422
	No	8	1	
Q6. Necessary educations for training of officials				
Methods of guiding vehicles and evacuees	Select	12	1	0.091
	No	5	3	
Cooperation with other institutions	Select	12	3	0.861
	No	5	1	
Cooperation with disaster countermeasure headquarters of the prefecture	Select	8	1	0.422
	No	9	3	
How to use radiation measurement equipment	Select	12	3	0.861

Table 2. (continued).

Questions Items		Frequency of EEI trainings		P-value*
		Once per year or more	Less than once per year or never	
	No	5	1	
Simple decontamination methods	Select	7	1	0.549
	No	10	3	
Temporarily storing evacuee's contaminated vehicles/baggage	Select	4	1	0.950
	No	13	3	
Operational Intervention Levels (OIL)	Select	3	1	0.736
	No	14	3	
Management of stable iodine agent (e.g., distribution method)	Select	3	1	0.736
	No	14	3	
Risk communication with evacuees	Select	11	0	0.020 (<0.05)
	No	6	4	

* Chi-square test.

evacuation drills at least once a year. It was suggested that awareness of nuclear emergency response was increasing in Japan.

Conversely, survey results also indicated that there were issues related to radiation education for local government officials and evacuation plans for each local government. For example, one local government has plans to provide as many as 14 EEI sites in the event of an emergency, taking into consideration the location of nuclear facilities and population of the area. According to Japanese Nuclear Emergency Response Guidelines, the inspection manager and assistants at the EEI site were required to have undergone basic training on nuclear disaster prevention and to maintain the necessary knowledge for EEI. To clarify, if two experts (inspection manager and assistant) from local governments are assigned to each of the 14 EEI sites, nearly 30 experts will be required. In some cases, it may take days to complete the evacuation of residents, so in practice, local governments may need to increase their number of experts. However, according to the results of this survey, there is no local government that has secured more than 10 experts who can play a leading role, suggesting that there is a shortage of human resources. Local governments are required to take on diverse roles; deploying sufficient radiation measurement equipment for contamination inspections, building networks between medical institutions, health physicists, and other specialists. In addition, our results prove that human resource development issues are very important.

Given the shortage of human resources, further education opportunities are needed in all of the local governments. In recent years, there have been many positive reports in

Japan, including those on training courses for EEI and the development of a new radiation measurement instrument for the thyroid (Tsujiuchi *et al.*, 2018, 2019a; Yamada *et al.*, 2018; Yajima *et al.*, 2019; Li *et al.*, 2019). It is expected that education opportunities will be expanded in the future. In addition, based upon the results of the questionnaire, the most important items required for the education of local government officials were related to the coordination of activities with other organizations and the disaster response headquarters. Thus, we can conclude that it would be effective to hold a regularly scheduled multi-disciplinary joint training on a municipal scale to share and discuss the issues. It is also interesting to note that the frequency of EEI training is only related to the need for risk communication education (Tab. 2). This result may indicate that local government officials who conducted the training with actual residents felt difficulty explaining the topic to the residents and responding to radiation anxiety. Since the Fukushima accident, there have been reports that fear of radiation persists in Japan (Hasegawa *et al.*, 2018). Thus, it is very important to prepare materials for risk communication and to educate officials.

Difficulties in implementing or planning the EEI include planning the number of required personnel, guiding evacuees/vehicles, and laying out traffic lines in the EEI area. Solutions might involve local governments sharing their plans and training examples with each other, and combining exercise-style training to further develop human resources. Guidance on evacuees and vehicles is clearly in high demand because more than half of local governments have cited it as necessary educational material.

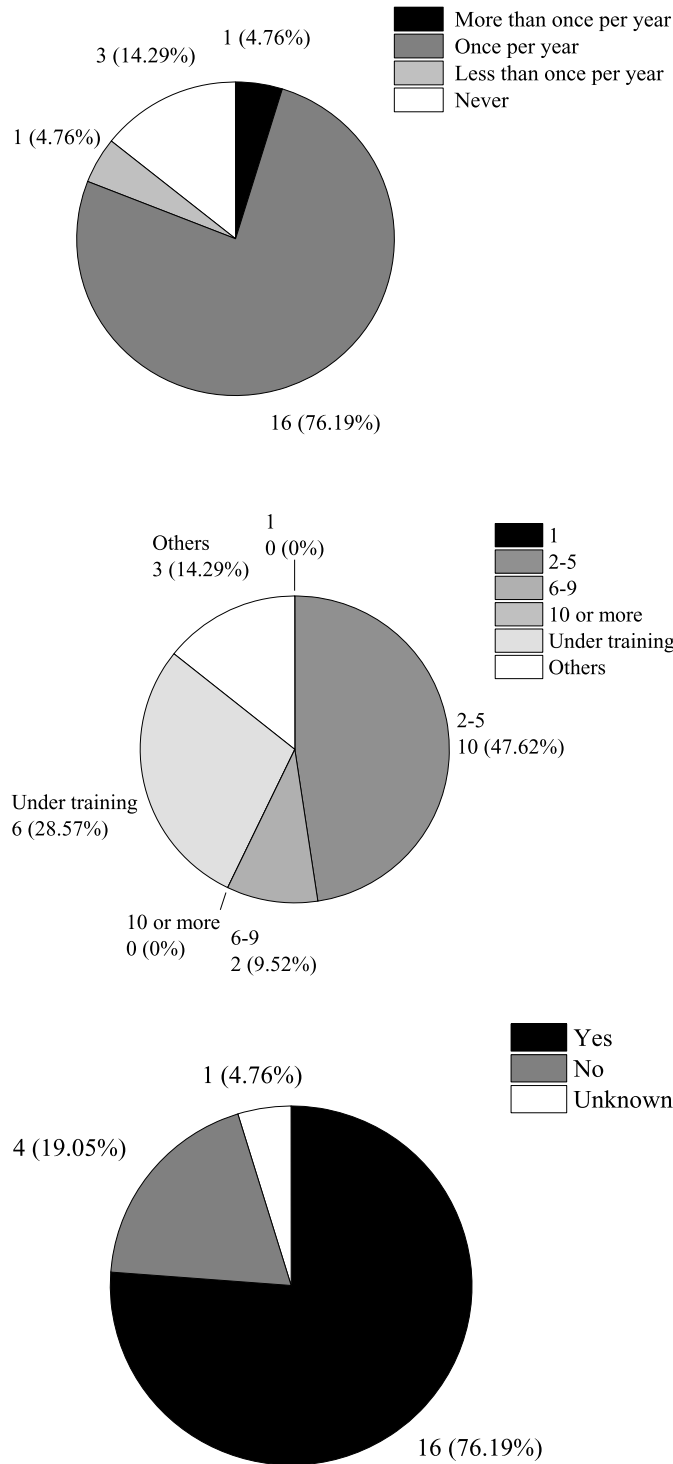
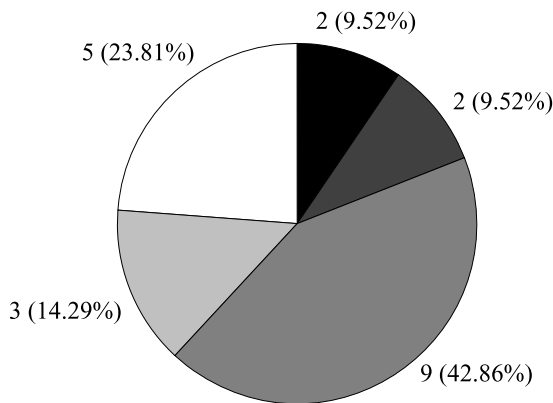
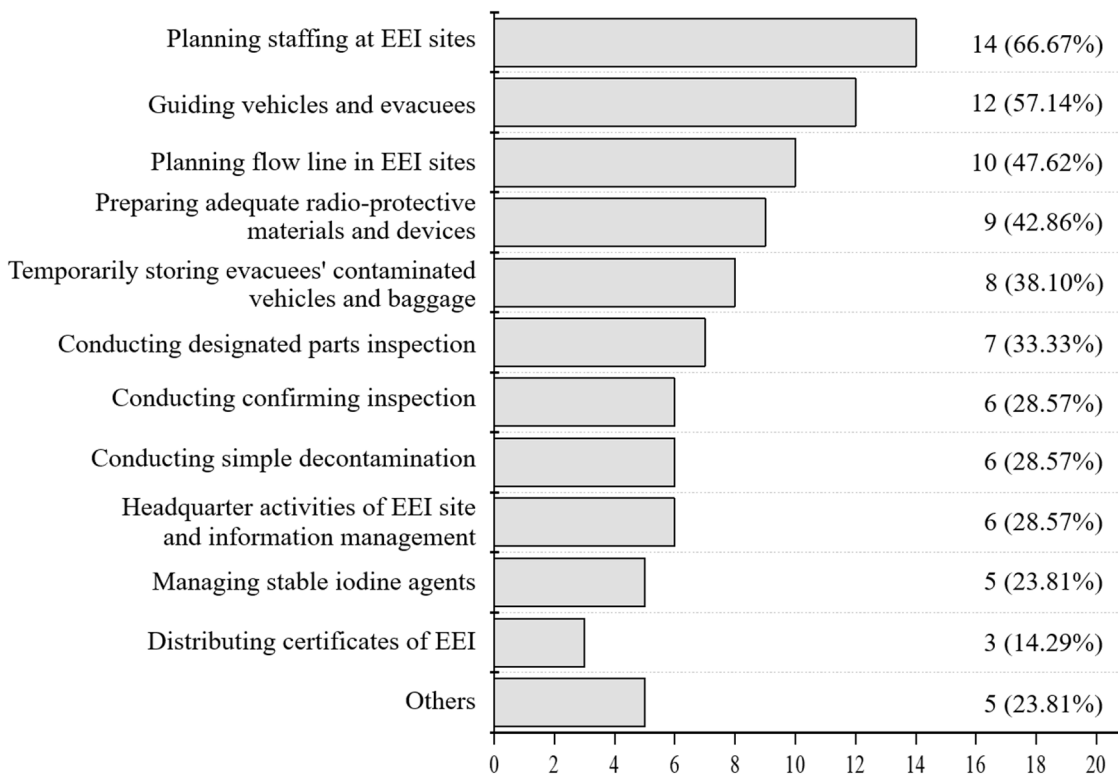


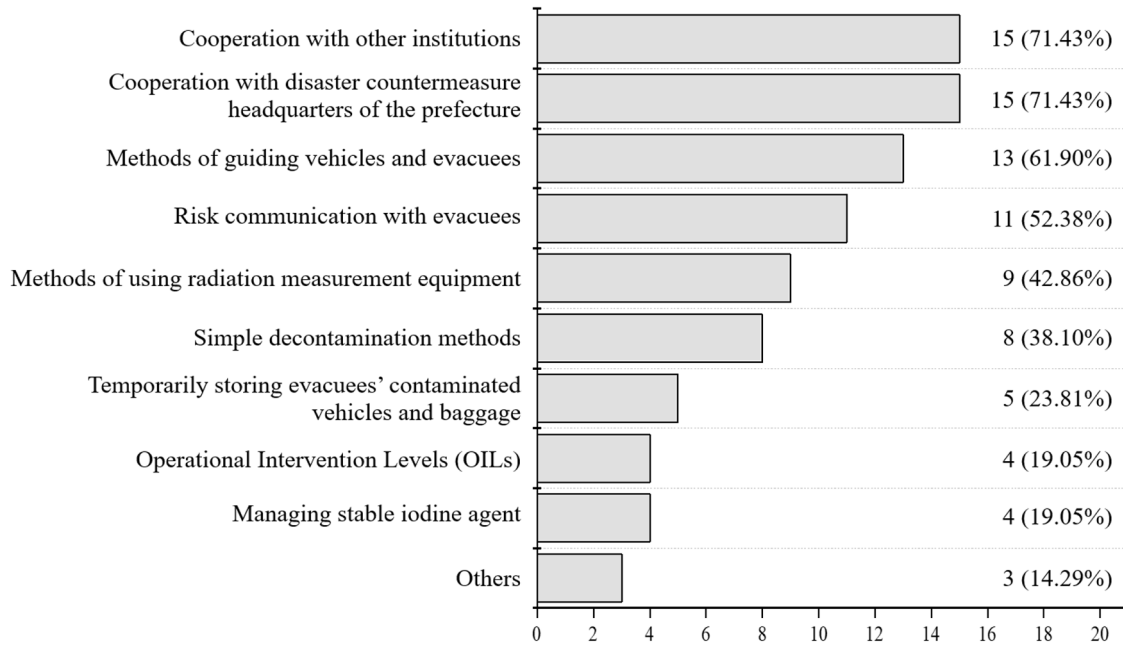
Fig. 2. Each local government’s answers to questions from 1 to 6: (1) How many times per year are inspection trainings conducted in your prefecture?; (2) How many members who can manage the EEI are there in your local government?; (3) Have they ever participated in trainings or lectures of the EEI?; (4) What difficulties are encountered in the planning or conducting of the EEI for your local government? Please choose from the available options and provide a concrete example for the option you choose; (5) If you have a goal, please tell us how many officials you would like to train for the EEI (five of the local governments did not respond, so there were 16 total responses to this question); (6) What education do you think is necessary for training your local government officials?

Fig. 2. (Continued).



- More than one expert at each EEI site
- More than one expert and replacement staff at each EEI site
- No goal
- Under consideration
- No answer

Fig. 2. (Continued).



5 Conclusion

In this study, we investigated the preparatory situation of local governments regarding their evacuation system for residents in the event of nuclear emergency in Japan. Results indicated that the primary issues that need to be addressed relate to human resource development. In addition, it clarified potential issues such as conducting multi-occupation-linked training, managing risk communication, and temporarily storing contaminated vehicles and belongings. Thus, we can conclude that it would be effective to hold a regularly scheduled multi-disciplinary joint training on a municipal scale to share and discuss the issues. We hope that these research results will reach stakeholders in nuclear disaster prevention, and incite them to contribute to the improvement of nuclear emergency response in local and regional scales in Japan.

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