Developing an Educational Program to Help Students Learn about the Resident Evacuation Protocols and Contamination Inspection Undertaken during Nuclear Disasters

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The Nuclear Regulatory Authority Japan mandates municipalities to prepare for “inspection to confirm whether radiation protection measures should be implemented for evacuees in case of nuclear disaster (Evacuation Exit Inspection: EEI)”1, 4, 5) While the EEI system itself was built after Fukushima accident, there are few educators nationwide who understand the details. Therefore, in this study, we developed desk-top teaching materials that comprehensively helps students understand the purpose and outline of EEI and confirmed its educational effect. As a result, 81% of the trainees understood the objectives of EEI after they had undergone a two-hour lecture that involved the utilization of the developed teaching materials. By combining these desk-top teaching materials with evacuation drills that include actual residents, it will be possible to initiate the human resource development necessary for building and implementing a stronger nuclear disaster prevention system. Development of such an educational program is very important for improving nuclear disaster prevention in Japan.

KEY WORDS: nuclear emergency protection measures, resident evacuation protocols, evacuation exit inspections, nuclear disaster, residential evacuations, educational program.

I INTRODUCTION

The Japan’s nuclear disaster response system has undergone major changes triggered by the Fukushima Daiichi nuclear power plant (FDNPP) accident.1–3) Due to the FDNPP accident in 2011, the Nuclear Emergency Response Guidelines were revised in 2015, and reviews of the command system of the medical institutions, resident evacuation plans, and systemization of human resource development are now underway. Among these, the residential evacuation plans and contamination inspection at the time of nuclear disaster were systematically changed.1, 4, 5) The Nuclear Emergency Response Guidelines released by the Nuclear Regulatory Authority Japan mandate the objectives of EEI, the layout setting of the inspection site, and the relevant learning materials are necessary. Therefore, in this study, we developed the desk-top teaching materials reflecting the latest nuclear protection standards. In addition, we tested the developed teaching materials by teaching 43 undergraduate students who, as municipal officials in the future, may have to deal responsibly with the staff of EEI in case of an emergency. The purpose of this study is to report the summary of the desk-top teaching materials we developed and the results of examining its educational effects.

II MATERIALS AND METHODS

1. Development of EEI simulation teaching materials
(a) Setting an educational goal
As the first step in developing the teaching materials, our research group selected learning items that we wanted the undergraduate students to understand completely. Items that we wanted the undergraduate students to understand were divided into three categories: 1) Objectives of EEI: To quickly grasp the radiation pollution situation residents are facing so that the residents’ evacuation is as undisturbed as possible.
possible, 2) Outline of the inspection: the response when contamination is discovered in the flow inspection and residents, and 3) Equipment and materials: We discussed how we would think about and arrange the equipment and staff necessary for implementing EEI and the layout of the venue. We then developed the desk-top teaching materials so that the undergraduate students would be able to acquire an understanding of these three principles.

(b) Assumption of nuclear disaster and determining the number of inhabitants

In order to create teaching materials that can help responders experience the situations involving contamination inspection of evacuee residents on a simple desk-top, it was necessary to make specific assumptions about nuclear disaster situations, the number of evacuees, and evacuation methods. In the teaching material that we created, the scenario, set in a nuclear facility facing the release of radioactive substances, was based on that of the FDNPP accident. Based on the report on nuclear emergency disaster prevention published by municipalities across Japan, the number of evacuees and the evacuation method of residents became concrete. In addition, the Nuclear Regulatory Authority Japan recommended that EEI should be carried out on the edge of the Urgent Protective Action Planning Zone (UPZ), which is generally within 30 km radius from the nuclear facility, when release of radioactive materials from the nuclear facility is confirmed. Therefore, we determined that any potential teaching materials for such a situation would also have to conform to this guideline. The specific procedure of residents’ contamination inspection at the EEI is shown in Fig. 1.

(c) Making assumptions about radiation measurement equipment

We assumed that the Geiger-Mueller (GM) survey meter (for evacuees’ contamination inspection), the NaI(Tl) scintillation survey meter (for environmental dose measurement), and gate monitoring (for vehicle contamination inspection), which are generally popular in Japan, can be used for EEI.

2. Implementing the developed teaching materials

Utilizing the developed teaching materials, we taught 43 undergraduate students (31 male, 12 female) from a medical radiologic technologist training course, who would have to potentially engage in nuclear disaster prevention as municipal officials in the future. The provided practice time was 2 hours, and, after completion of the course, we tested whether they understood the abovementioned three goals (EEI objectives, outline of inspection, and equipment and materials). This study was approved by The Committee of Medical Ethics of Hirosaki University Graduate School of Health Sciences, Hirosaki, Japan.

III RESULTS

1. The teaching materials

Table 1 and Fig. 2 show the contents and guidelines of the developed teaching materials. After the undergraduate students were taught the purpose and outline of EEI, the assumption underlying the exercise was explained to them. After that, assuming that the release of radioactive substances starts with the nuclear disaster, we made EEI preparations in the area of the UPZ boundary, and the students started to simulate the

Fig. 1 Flow chart of EEI. Procedure for contamination inspection when residents in the vicinity of nuclear facilities are evacuated by vehicles. All conform to the protocol indicated in the Nuclear Emergency Preparedness Guidelines. Operative Interactive Level 4 (OIL4) is a criterion for implementing protective measures in Japan, and if contamination levels exceeding 40,000 cpm (within one month after the accident) are identified by a Geiger-Mueller survey meter with a detection surface area of 20 cm², evacuee residents undergo simple decontamination. If the results after simple decontamination do not fall below the OIL4, it is necessary to send an order to a specialized agency. In addition, this figure was created by modifying the authors’ past paper.
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Table 1 Contents and instruction methods of the developed EEI teaching materials.

A. Scenario of nuclear disaster and content that students simulate.

| Phase | Nuclear disaster | Scenario | Behavior of municipal officials | Parts played by students |
|-------|------------------|----------|--------------------------------|--------------------------|
| 1     | In the XXX nuclear power plant, trouble occurred in the cooling system inside the nuclear reactor owing to power loss due to the tsunami. | Receive reports that accidents occurred and prepare a system for resident’s evacuation | – |
| 2     | Progress to an emergency situation where the emission of radioactive substances from nuclear power plants to the environment is inevitable | Began preparing to implement the EEI with the citizen gymnasium at 30 km from the nuclear plant as the venue | ○ |
| 3     | Release of radioactive substances to the environment (there is a possibility of contamination for evacuee residents after this phase) | Start EEI of residents who evacuated gymnasium after this phase | ○ |

B. Assumption of the number of evacuees and evacuation methods.

| Evacuation method | Number of people |
|-------------------|------------------|
| Vehicle           | Number           |
| Private car       | 20               | 60 (3 /car) |
| Bus prepared by municipality | 5 | 150 (30 /bus) |

C. Guidelines and instructions for utilizing the teaching materials.

| Format              | Practical time (min) | Instruction methods                                                                 |
|---------------------|----------------------|-------------------------------------------------------------------------------------|
| Lecture             | 30                   | 1. Tell the outline and purpose of EEI                                             |
|                     |                      | 2. Tell them to simulate the flow of the EEI and the layout of the inspection site  |
|                     |                      | 3. Tell them about simulation assumptions                                            |
| Practice (simulation) | 40                 | 4. Have the staff and radiation measurement instrument magnets be placed on the white board |
|                     |                      | 5. Have the flow line of the evacuee residents considered                            |
| Lecture (discussion and test) | 50            | 6. Discuss whether placement of personnel and movement lines of refugee residents are appropriate |
|                     |                      | 7. Discussion on current disaster prevention system problems that emerged through simulation |
|                     |                      | 8. Test whether you understood the EEI summary                                      |

Table 1A. As shown in Table 1B, the evacuees were supposed to escape in the vehicle. In addition, Table 1C shows detailed guidelines for lectures using these materials and optimal time allocation for these lectures. At the end of the lecture, we organized a "discussion time," which was aimed at deepening the understanding of the students. The content of the discussion encouraged the students to express their own thoughts about the appropriateness of the layout and identify any problems in checking the contamination of residents and vehicles.

2. Practice teaching materials

Using the developed teaching materials, we instructed 43 undergraduate students. The undergraduate students were divided into groups of 5 to 6 people, and each group was tasked with simulating the layout of EEI and so on (Fig. 2). The undergraduate students were asked to create the EEI layout while making careful decisions about whether to implement decontamination with OIL4 as a standard and how to guide the residents according to their judgment. If contamination above the OIL4 level was identified through vehicle and representative inspection, decontamination of the vehicle was carried out, and the students proceeded to inspections 3 and 4 as shown in Fig 1. In other words, the exercise was meant to make students realize that lack of proper guidance to residents can lead to confusion at the EEI inspection site, which, in turn, may interfere with quick evacuation progress during a nuclear disaster. After undergraduate students were provided with explanations so that they could understand these points, they created the layout.

3. Confirming educational effect

Confirmation tests were conducted to test the understanding of the students who took the lectures, and further opinions were summed up in the discussion. The results of the confirmation tests showed that more than 90% of the students were able to understand the purpose of EEI, the proper protocols for inspection, and the necessary equipment and personnel arrangements (Fig. 3). On the other hand, compared to their degree of comprehension regarding the EEI purpose, they had a tendency to show low understanding of the flow of inspection, appropriate responses for contamination situations, and necessary equipment and personnel. In the time allotted for discussion, some students
expressed the opinion that local governments should decide how to explain the issue to the residents when contamination is identified and how to transport residents who could not be decontaminated to specialized institutions/contact systems.

IV DISCUSSION

In this study, we developed teaching materials that can allow students to experience the proper protocols for resident evacuation and contamination inspection at the time of a nuclear disaster and confirmed the educational effect of this program. The EEI staff will be trained to appropriately decontaminate residents who are suspected of contamination and internal exposure, transport them to specialized agencies, and grasp information. Moreover, it is necessary to conduct the procedures smoothly so as not to hinder the evacuation of residents. Regarding these points, more than 90% of the students had a general understanding of the concepts and objectives of EEI and the flow of inspection (Fig 3). Based on the results shown in Fig 3, we were able to help students understand the objectives of EEI; moreover, we were able to help students realize the importance of each municipality building a communication system and explanation methods for interacting with residents effectively during nuclear crisis situations.

During the FDNPP accident, many residents, including those from Fukushima Prefecture, were forced to evacuate, and more than 1,700 people died because they could not receive appropriate medical care.9) The fact that it is important to arrange and provide appropriate and effective preparation and planning while conducting disaster operations for vulnerable evacuees such as the elderly and hospitalized patients. Furthermore, since the nuclear disaster, Fukushima Prefectural government started an ultrasound-based examination program for thyroid cancer for all residents aged 18 years or younger who were living in Fukushima Prefecture at the time of the FNPP accident.10–12) In fact, the problem of
thyroid cancer has become a significant topic of discussion and a major issue in news and social media. At the time of FDNPP accident, there were only 1,000 surveyed cases the thyroid exposure to radioactive iodine among the evacuees.13–15) In the future development of the system, cooperation is required such as providing information to specialized agencies when residents, who are suspected of contamination at the time of evacuation, exit inspection. In addition, assuming nuclear terrorism or a radiation accident, some people with ARS symptoms may also appear among the evacuee residents, so triage tools and methods that can pick up high doses of exposure and/or contamination from evacuee residents are a social requirement.16–18)

From such previous reports, it is clear that it is important to educate local government officials on nuclear disaster preparations and response operations during peacetime. This type of education is indispensable for confirming the presence or absence of contamination and for promptly completing resident evacuations. Several municipalities in Japan have developed and conducted their own training and evacuation time simulations based on the number of inhabitants and vehicles in their localities.8, 19–22) By combining these training and research activities with peacetime education, each local government can confirm problems related to disaster prevention, and furthermore, implement careful disaster prevention plans.

Although the flow of contamination inspection at the time of resident evacuation is generally followed during large-scale evacuation drills that help to train actual inhabitants in appropriate evacuation practices,1, 23, 24) persons involved in nuclear disaster response can learn about it through desk study based on the contents introduced by this paper. Professionals in the disaster response field can utilize the contents introduced in Table 1 and Fig. 2 to educate persons involved in disaster prevention; thus, our developed teaching materials have the potential to be widely used. As shown by our results, these teaching materials have a certain educational effect, and it is also possible to change assumptions about EEI at the time of nuclear disaster by taking advantage of the equipment and geographical features of each municipality. The results of this research can be considered to provide meaningful information to educators in the field of disaster prevention. Moreover, proper and well-organized practice of these teaching materials by municipal officials involved in nuclear disaster prevention, radiation experts, and medical staff members could lead to an increased awareness of how nuclear disaster prevention systems work and how they can be improved. Development of such an educational program is very important for improving nuclear disaster prevention in Japan.

V CONCLUSION

In this paper, the outline of the material about EEI which we developed was reported, and it became clear that the material showed the educational effect to the student. Development of teaching materials incorporating such latest nuclear protection standards is very important for nurturing human resources responsible for nuclear disaster prevention.

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