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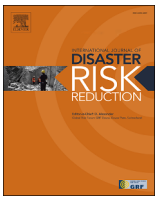

Assessment of drug needs and contributions of pharmacists in the aftermath of the 2011 triple disaster in Fukushima, Japan: A combined analysis

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ABSTRACT

After a major disaster, drug logistics are crucial for maintaining medical care. Although pharmacists play a vital role in healthcare institutions, their role is not well defined, and their recognition from other healthcare professionals is lacking. This was evident at Minamisoma Municipal General Hospital in Fukushima, Japan, which was affected by the Great East Japan earthquake, tsunami, and nuclear power plant accident. The supply of drugs and related information was severely disrupted. In response, two pharmacists were interviewed and the data was analyzed through a thematic approach. Additionally, prescription data collected by pharmacists was analyzed quantitatively. The results from the qualitative survey showed that pharmacists made efforts to supply drugs and collect information, despite facing various psychological challenges, such as confidence, responsibility, anguish, and conflicts. The "leadership" of the hospital's upper managers was instrumental in supporting the pharmacists. The prescription data revealed that drug supply continued for approximately one month without interruption, and the demand for antihypertensive and psychiatric drugs increased. A majority (72.3 %) of the patients (N = 3,518) were 60 years of age or older, which might have contributed to the demand for chronic disease drugs. This study provides an example of the role of pharmacists and drug logistics during major disaster situations, including nuclear accidents.

1. Introduction

Drug logistics after major disasters are essential to sustain and normalize medical care [1]. Their importance has been indicated repeatedly in previous large-scale natural disasters and outbreaks of major infectious diseases [2,3]. Typically, the major determinants of disaster drug logistics have been the coordination of distribution, determination of facilities for distribution, and coordination of inventories [4]. Therefore, various management models have been developed to optimize them [5], most notably, a central-

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ized drug distribution model in disaster settings. Practically, the more widespread the disaster, the more likely it is that the functioning of local medical facilities and drug supplies will be disrupted across a wide area for an extended period [6,7]. Disasters may result in confusion in the central health care system, which could lead to delays in drug supply to primary health centers [8]. Therefore, a centralized drug distribution model in disaster settings may not be effective. Furthermore, even if successful, it will be necessary for each medical institution to make decisions on drug logistics independently before the centralized system functions well. Therefore, each local medical institution would require an individual to take up a leadership role.

Moreover, pharmacists would play a central role in maintaining the logistics of drugs in large-scale disasters, for example: 1) establishing drug supplies and 2) normalizing the medical systems in evacuation shelters and medical facilities through the establishment of logistics [9–11]. Therefore, it is crucial for pharmacists to collaborate with healthcare providers effectively to ensure a continuous supply of drugs. Previous studies have proposed simulations of pharmacists' roles and drug suppliers during disasters, the establishment of disaster education programs in pharmacy schools and an emergency logistics network, and a model for scheduling pharmaceutical logistics [12–14]. However, it has been demonstrated that pharmacists may be unable to effectively participate in disaster medical care due to lack of awareness regarding other healthcare providers [15,16]. During disasters, the core competencies of "leadership," "consultation and collaboration," and "management" are needed among pharmacists to effectively engage in professional practice in collaboration with other healthcare providers [17]. However, specific references regarding the ways in which pharmacists should execute these core competencies may be insufficient [17]. Therefore, it is important to verify and accumulate knowledge obtained from pharmacists who have participated in medical care during large-scale disasters.

Therefore, the Great East Japan Earthquake (GEJE) and tsunami on March 11, 2011, and the subsequent nuclear power plant accident (referred to as "triple disaster") may be useful in examining pharmacists' role during large-scale disasters. In the coastal areas of Fukushima Prefecture, human and material support was disrupted by the triple disaster, especially the nuclear disaster [18]. Minamisoma City, Fukushima Prefecture is located 10–35 km north of the Fukushima Daiichi Nuclear Power Plant (FDNPP). Even before the disaster, its ageing population was substantial, with the proportion aged 65 years and over exceeding 27 %, which was higher than the national average of 23.1 % [19]. Located 23 km north of the FDNPP, Minamisoma Municipal General Hospital (17 departments and 230 beds) had 151 employees, including six pharmacists, at the time of the triple disaster [20,21]. After the disaster, the number of staff decreased. However, the hospital maintained its medical functions and accepted community outpatients, despite the fact that it was located within the 20–30 km "Urgent Protective action planning Zone (UPZ)" where residents were voluntarily subjected to indoor sheltering within a 30 km radius from the FDNPP [21]. Furthermore, three of the six pharmacists were evacuated, and the remaining three made efforts to supply drugs, while simultaneously collecting prescription data [20]. Therefore, conducting interviews with those pharmacists and analyzing their prescription data could provide useful insight into their roles during the triple disaster.

The purpose of this study is to conduct qualitative interviews with pharmacists involved in disaster medicine and examine the factors that influence pharmacists' behaviors toward drug logistics during a disaster.

2. Methods

2.1. Study setting and design

This study comprised qualitative, in-depth interviews with pharmacists working at Minamisoma Municipal General Hospital at the time of the triple disaster, in addition to a quantitative survey of prescription data recorded by the pharmacists after the disaster. Since the prescription data was recorded during the chaotic period immediately after the disaster, some of the data had been scattered, and it was assumed that the accuracy of data might not be fully ensured. The retention period for prescription data at the hospital (3 years) had passed, making it difficult to conduct additional research. However, the importance of collecting as much data as possible during a disaster is recognized [22], hence the need for conducting this study.

2.2. Qualitative in-depth interviews

Semi-structured interviews were conducted in Japanese with two pharmacists, a male pharmacist in his 40s ("pharmacy staff"; PS) and a male pharmacy director in his 60s ("pharmacy director"; PD). The participants were unaware of the interviewer's identity other than her name, gender, and that she was a healthcare professional. The study objective was explained, and written informed consent was obtained from both participants. The interviews were conducted on January 19, 2021 for the PS and on February 9, 2021 for the PD. Both interviews took approximately 1 h. The interviews were recorded as audio data and first transcribed in Japanese by a trained researcher. The transcriptions were then translated into English and anonymized. The transcribed interview data were examined using thematic analysis based on Braun & Clark's method [23]. Multiple meetings were held among the co-researchers to discuss the methodology of the thematic analysis, using the 32 checklists in the Consolidated Criteria for Reporting Qualitative Studies (COREQ) [24]. Keywords were coded to reflect participants' "post-disaster experiences," and themes were then established. After Hashimoto led the analysis to establish original codes and themes, all researchers reviewed and finalized the themes in terms of coherence and consistency. In accordance with COREQ, the final theme was confirmed with the interviewees.

The medicine notebook (Okusuri-techo) mentioned in the interview is a pocket-sized notebook containing a list of a patient's regular medications, which a patient has in their possession.

2.3. Quantitative survey

Pharmacists of Minamisoma Municipal General Hospital had already aggregated the prescription data, and we received the data and conducted secondary analysis. The pharmacists did not have the source data, and it was also impossible to retrieve them from the hospital. The data obtained included the number of patients, age group (0–6, 7–12, 13–19, 20–29, 30–39, 40–49, 50–59, 60–69, and

70+ years), and name and category of the drug. In terms of drug category, the following most frequently used drugs were extracted: antihypertensive drugs (calcium channel blockers, angiotensin-converting enzyme inhibitors, angiotensin II receptor blockers, beta-blockers, alpha-blockers, diuretics, etc.), gastric drugs (proton pump inhibitors, histamine-2 receptor blockers, gastric mucosa protectants, etc.), antithrombotic drugs (antiplatelet agents, anticoagulants, etc.), drugs for dyslipidemia (statins, etc.), diabetes drugs (sulfonylureas, alpha glucosidase inhibitors, biguanides, insulin, etc.), and psychiatric drugs (minor tranquilizers, typical antipsychotics, atypical antipsychotics, sleep medications, serotonin agonists, etc.).

2.4. Ethical considerations

The institutional review boards of Minamisoma Municipal General Hospital (approval number: 3–12) and Fukushima Medical University (approval number: General 2021-218) approved this study.

3. Results

3.1. Qualitative in-depth interviews

All questions and responses were counted as one set for 199 sets in total: 118 from the PS and 81 from the PD. After coding responses, 71 codes were identified (Supplementary Table). Based on the identified codes, five themes were obtained: 1) "supply of drugs," 2) "information and coordination," 3) "leadership," 4) "psychology of pharmacists," and 5) "drug needs." Table 1 illustrates questions upon which the themes were based.

3.1.1. Theme 1: "supply of drugs"

It was found that pharmacists' behaviors changed over time due to external factors, such as the nuclear disaster and the resulting difficulties of obtaining drugs by wholesalers.

Immediately after the earthquake, infusions, and other drugs were prepared for traumatic injuries by referring to past earthquake damage and assuming that patients were injured by a tsunami and/or trapped under debris. However, it was found that little was actually needed.

> PD: "I thought that I had prepared a lot of drugs for first aid, such as Ringer's and antibiotic drugs, but they did not help at all."

As healthcare professionals from nearby hospitals and pharmacies were evacuated, it was assumed they might accept patients from the community, and thus, a concern of drug shortages was raised.

> PS: "Since we had originally stocked about a week's worth of drugs, it was unlikely that we would run out of them. Fortunately, there was no panic."

Regarding the drug supplies, although pharmaceutical wholesalers directly transported drugs until March 14, 2011, delays occurred because the UPZ was issued on March 15, after the FDNPP accident. On March 18, the Japan's Self-Defense Forces (SDF) began transporting drugs. At that time, pharmaceutical wholesalers transported drugs up to the 30 km point, where they were handed over to the SDF.

> PD: "The SDF started transporting drugs on March 18."

> PS: "Pharmaceutical wholesalers would come as far as the 30 km zone, and the SDF would take over there."

These findings revealed factors determining the "supply of drugs." Immediately after the earthquake, ""past earthquake experience" was an important determinant of pharmacists' behaviors. They prepared drugs for trauma patients, but they found that there was a limited need for them. The "lack of access to the supply of drugs" due to the UPZ determined the pharmacists' behaviors, and they had to cope with the hospital's drug stocks. After March 18, "support for the supply of drugs by the SDF" became the determinant factor.

Table 1
Research questions, themes and examples of participant excerpts.

Research Questions	Themes	Illustrative quotes
What was the situation like after the Great East Japan Earthquake? How were you working?	Supply of drugs	*"I think the phone was connected on the evening of the day of the Great East Japan Earthquake. At that time, there was still no mention of the nuclear accident, so we said that the tsunami would be triggered by an earthquake and that we should secure IV fluids and other drugs in case of such an earthquake. I remember having the pharmaceutical wholesaler bring me more drugs than usual."*
Did you have any coordination with pharmacists at other medical facilities?	Information and coordination	*"There was no information provided by the local pharmacy association about which pharmacies had closed. Information on the opening and closing of pharmacies in the neighborhood came through the local government."*
What was the process for prescribing?	Leadership	*"The physician worked out the prescription process and we dispensed according to their instructions, which was good. It was also very good that the hospital managers met with us daily to unify our intentions."*
Has there been any inconvenience to the patient regarding the drugs?	Psychology of pharmacists	*"Our original duty was to provide a steady supply of drugs for chronic diseases, such as a month's supply. However, since we could not, we were forced to shorten the prescription to a three-day or one-week supply, or change to an alternative drug of the same efficacy based on our stock. I still think that was a bad idea."*
What drugs have become important?	Drug needs	*"They were so-called chronic disease drugs. There was a clear increase in demand for drugs for hypertension, diabetes, and hyperlipidemia. What was actually missing were these drugs."*

3.1.2. Theme 2: "information and coordination"

Pharmacists focused on the following when conducting disaster drug logistics: providing drug information to hospitalized patients during the evacuation process, the characteristics of patients in the community attending their hospital, and the pharmacist's response to them, sources to identify drugs administered to patients, and difficulties during information sharing.

Many outpatients were elderly or mentally ill and unable to drive.

> PS: "Everyone who came to the hospital's outpatient department was elderly. I think there were no young people who could drive a car by themselves."

> PS: "Our family patient or someone with mental illness remained behind without evacuating."

Half of all patients had a medicine notebook, which was helpful in identifying outpatients' regular drugs. The pharmacist's ability to differentiate between drug imprints was also helpful.

> PD: "I think that about half of all patients had the medicine notebook. I remember that it was useful."

> PD: "Even if a patient brought naked drugs, I could identify what kind of drugs they were by looking at the imprint."

There was no information whether nearby dispensing pharmacies were open, and prescriptions could not be issued. Additionally, no information was shared regarding evacuation.

> PD: "On March 15, 2011, all the dispensing pharmacies were evacuated and gone, and patients living there were without drugs. Then they reopened on the 31st."

> PD: "The local pharmacists association did not take the initiative to inform us about which pharmacies had closed. Information that pharmacies reopened on the 31st was also received through the local government."

Lack of information from outside sources led to the pharmacists' own attitudes toward information gathering. Medicine notebooks were helpful in identifying administered drugs. Identifying drugs to be administered from the drug's imprint is a specialty unique to pharmacists and was helpful.

3.1.3. Theme 3: "leadership"

Together with leadership within the pharmacy department, the PD was responsible for managing drug supplies.

> PS: "All decisions regarding ordering drugs were made by the PD."

Leadership demonstrated by the hospital director and deputy hospital director led to unity and a feeling of stability among staff. It was discovered they had been instrumental in supplying drugs, heeding pharmacists' demands.

> PD: "After listing the missing drugs and submitting them to the director and deputy director, the drugs came in within the next day or three days."

> PD: "It was good that the doctor's prescription was accurate. The hospital managers also met daily, which I believe helped to unify the staff. They took the leadership and set the direction of the path, which was helpful."

Conversely, dissatisfaction existed for both pharmacists concerning that the local pharmacy association did not take the initiative to compile information about the opening and closing of neighborhood pharmacies.

> PS: "I wanted the pharmacy association to compile and communicate the status of pharmacy openings and closings. I did not know because I had no information. I wanted the pharmacists association to take the initiative and open one or two pharmacies."

> PD: "I still remember that there was no coordination between pharmacies."

For pharmacists to be effective in disaster situations, leadership of the PD and hospital managers, such as the director and deputy director is necessary. Unity of intent from upper management to front-line staff was found to be an important factor in improving the quality of drug supplies during a disaster. Conversely, the local pharmacy association did not assume a leadership role in drug supplies during disasters, and the extent of its contribution was unknown.

3.1.4. Theme 4: "psychology of pharmacists"

Psychological differences were observed between the PS and PD in assuming responsibility for drug supplies during the disaster. The PS focused on "confidence/responsibility," whereas the PD focused on "anguish/conflict."

> PS: "I think the reason we were delegated the job was because we were recognized for not doing a lousy job on a regular basis."

> PD: "As for drugs for chronic diseases, we believe it is our duty to provide a stable supply, but we have not been able to do so. I still believe that changing to another drug due to lack of stock was problematic."

Whether or not the pharmacist was in charge of the pharmacy department made a difference in the "*psychology of pharmacists.*" Regarding the PS, confidence based on previous experience and knowledge was evident. The PD regretted the lack of a stable drug

supply. Because the PS and the PD were conscious of dispensing and stock management, respectively, it was assumed that their roles were divided based on their usual position in the supply of drugs during a disaster.

3.1.5. Theme 5: "drug needs"

Drug needs envisioned by the pharmacists involved drugs for chronic diseases, such as hypertension, diabetes, and dyslipidemia, and for psychiatric disorders for which withdrawal leads to the worsening of symptoms.

> PS: "Those who could move were evacuating by themselves. The remaining people who could not evacuate kept coming to the hospital. There were quite a few people with mental illnesses, and then there were people with dementia, and the elderly."
>
> PD: "After the earthquake, the number of patients with chronic diseases. such as hypertension, diabetes, and dyslipidemia, had clearly increased."

Conversely, pharmacists did not see a need for infusions used for trauma or for pediatric drugs.

> PD: "Since most of the children were evacuated and gone, I did not feel the need for pediatric drugs."
>
> PD: "I remember that there were not that many patients who needed large amounts of extracellular fluid."

The need to keep records of prescription data, which is also related to "*2. Quantitative survey results,"* is described later.

> PD: "I remember counting the number of prescriptions for drugs very diligently. I thought it would be better to keep a count."
>
> PD: "I think hospital managers were also interested in keeping records. They thought they would keep the records if they could. Naturally, I remember that we immediately took action."

Pharmacists had been working whilst simultaneously anticipating various drug needs immediately after the earthquake. Extracellular fluid and other infusions were assumed necessary with reference to previous earthquakes. However, there was no actual demand. Pharmacists worked while envisioning the need for drugs for the elderly, patients with dementia or mental illness, children, and other vulnerable populations during disasters. In fact, they have responded to the growing number of chronic disease patients. The pharmacists' act of recording prescription data was seen as an expression of their awareness of the need to objectively support the validity of "drug needs."

3.2. Quantitative survey results

The following drug prescription data were collected after the earthquake.

3.2.1. Number and age of patients

Table 2 illustrates the age distribution of patients who came in and were issued prescriptions during the month of March 12 to April 11, 2011. The number of patients during the study period was 3,518. By age group, those aged 70 years and older accounted for approximately half the total number of respondents (1,738; 49.4 %). Conversely, 102 (2.9 %) were younger than 20 years old.

3.2.2. Trends in the number of patients

The trend in the number of patients is shown in Figure. The "number of new patients" in the line graph indicates the number of patients accepted at the hospital and treated at other medical institutions.

Until March 14, the hospital had been handling out-of-hospital prescriptions (issuing prescriptions to be shown to pharmacies), but after the "UPZ request" issued on March 15, in-hospital prescriptions (drugs provided in the hospital) became the main system. A gradual increase in the number of patients who received in-hospital prescriptions from immediately after the earthquake to the end of March was observed. Since April, the percentage of out-of-hospital prescriptions had increased.

3.2.3. Number of drugs per patient

Weekly trends were presented for the total and the top six drugs in terms of number of prescriptions (Table 3). Before and after the earthquake, the only existing data were those for out-of-hospital and in-hospital prescriptions, respectively.

Table 2
Number and age of patients (March 12–April 11, 2011) (N = 3,518).

Age group	Number (%)
0–6 years	39 (1.1)
7–12 years	35 (1.0)
13–19 years	28 (0.8)
20–29 years	71 (2.0)
30–39 years	109 (3.1)
40–49 years	217 (6.2)
50–59 years	474 (13.5)
60–69 years	807 (22.9)
70+ years	1738 (49.4)

Table 3
Number of drugs per patient.

	Before the earthquake [Ref]	After the earthquake				
	March 5–11	March 12–18	March 19–25	March 26–April 1	April 2–8	April 9–15
Prescription	Out-of-hospital	In-hospital				
Total	3.5	4.7	4.6	4.6	4.2	3.3
Antihypertensive drugs	0.6	1.0	1.1	1.0	0.8	0.5
Gastric drugs	0.4	0.5	0.5	0.5	0.4	0.4
Antithrombotic drugs	0.2	0.3	0.2	0.2	0.2	0.1
Drugs for dyslipidemia	0.2	0.2	0.2	0.2	0.2	0.1
Diabetes drugs	0.2	0.2	0.2	0.3	0.2	0.1
Psychiatric drugs	0.2	0.4	0.5	0.5	0.3	0.3

Note: A drug count of one or more indicates that, on average, at least one drug was prescribed to every patient.
At the time of the disaster, out-of-hospital prescription data was obtained from the period March 5 to 11, and in-hospital prescription data was obtained thereafter.

The number of prescriptions for antihypertensive drugs increased after the earthquake, and on average, more than one drug was prescribed to every patient. This trend had been declining since April. An increase in the demand for psychiatric drugs was observed, with an average of 0.5 prescriptions (i.e., one per two patients) from March 19 to April 1. No changes were observed for other drugs.

Prescription data and interview data were validated against each other. About half of the patients were elderly (Table 2), and the rising number of prescriptions for antihypertensive and psychiatric drugs (Table 3) supported the pharmacists' assumptions in *Theme 5 "drug needs."* The uninterrupted flow of community patients (Fig. 1) was the result of *Theme 3 "leadership"* of the PD and the hospital managers regarding drug supply.

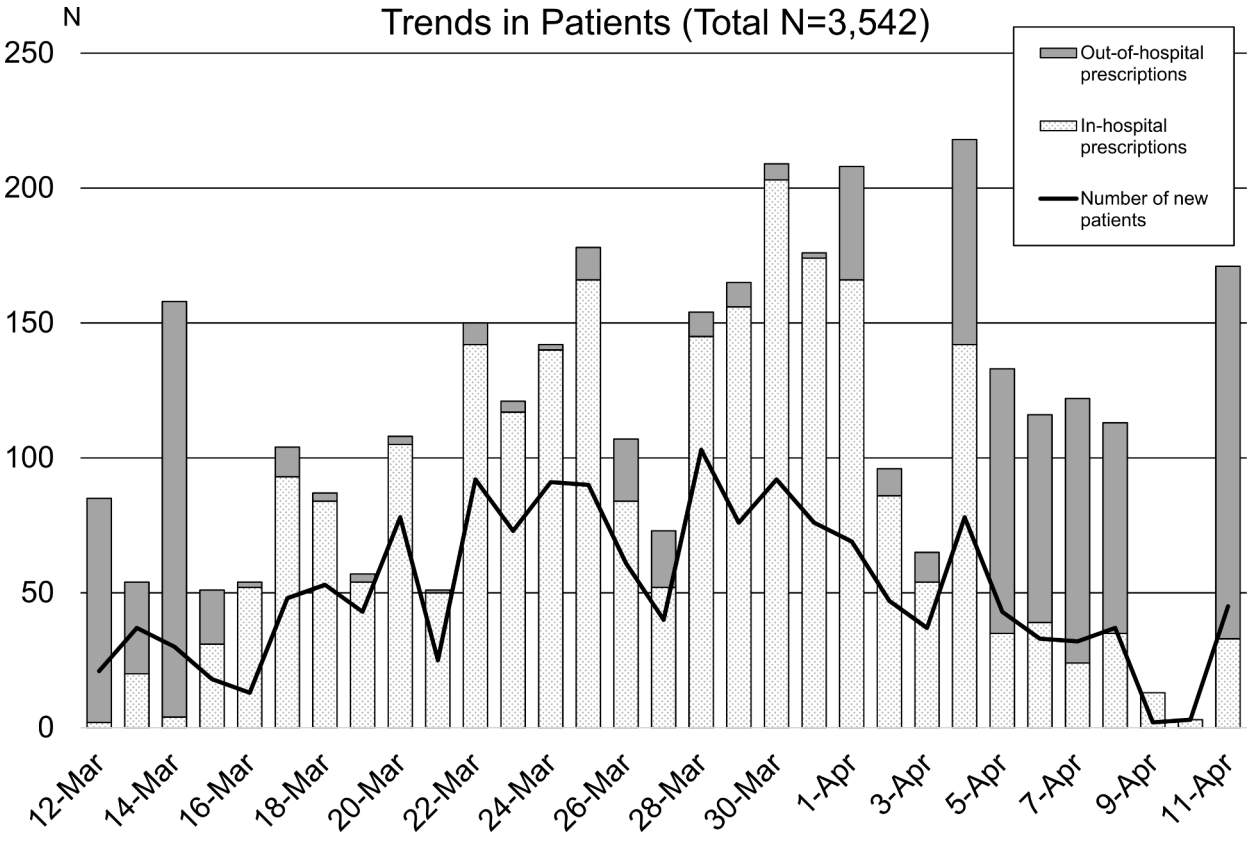

Fig. 1. The trend in the number of patients.
"Number of new patients" indicates the number of patients accepted at the hospital and treated at other medical institutions.
"Out-of-hospital prescriptions" indicates issuing prescriptions to be shown to outside pharmacies.
"In-hospital prescriptions" indicates providing drugs in the hospital.

4. Discussion

In this study, the role of pharmacists and drug logistics during the triple disaster were clarified. After analyzing the interview contents, five themes were discovered: *1) "supply of drugs," 2) "information and coordination," 3) "leadership," 4) "psychology of pharmacists,"* and *5) "drug needs."*

Regarding the broader picture of the themes and their interrelated relationships, we considered the following. *Theme 1 "supply of drugs"* and *Theme 2 "information and coordination"* were both disrupted by the nuclear disaster, and thus considered "external" threats. However, *Theme 3, "leadership"* was an "internal" factor derived from the relationship between the pharmacists and the hospital managers. *Theme 4, "psychology of pharmacists"* was reflected in the basis for the pharmacists' decisions.

The pharmacists' actions in response to the external threat of disruption of *Theme 1, "supply of drugs"* were preparing drugs for acute diseases immediately after the earthquake, checking drug stockpiles, and collaborating with the SDF. Although an important role of pharmacists after a major disaster was preparing drugs for trauma patients [9], there was not much need for this. This was thought to be related to the following: prior to the GEJE, Japan had a disaster medical system specializing in the treatment of trauma patients based on lessons learned from the Great Hanshin-Awaji Earthquake [25], and most survivors did not suffer life-threatening injuries because the main cause of death was drowning [26]. After the nuclear disaster, drug supplies were disrupted for several days. However, the stockpiling of drugs and the coordination with the SDF worked well. Therefore, no problems related to the *"supply of drugs"* occurred during the entire study period.

In response to the external threat of disruption (*Theme 2): "information and coordination,"* pharmacists demonstrated two roles: 1) sending and receiving information between external support organizations, and 2) identifying patient medications. It was suggested that the disruption of coordination with outside pharmacies and local pharmacists associations led to the motivation of pharmacists to collect and analyze prescription information themselves. More than half of the patients were elderly (Table 2), and they were taking a combination of three or four medications (Table 3). On the other hand, the year before the GEJE, the aging rate (rate of the population aged 65 years and older) in Minamisoma City, Fukushima Prefecture was 26.6 % [27]. This suggests the fact that elderly individuals who were unable to evacuate on their own were left behind. Toward this situation, the pharmacists' skills for checking medicine notebooks and recognizing drugs based on tablet color and shape were helpful. Following the Hurricane Irma and Hurricane Maria disasters in the United States in 2017, 78.1 % of patient prescription information was missing when referring patients to well-equipped medical facilities after treatment in shelters, suggesting difficulties in identifying prescription information during disasters [28]. Although e-prescription has advanced in recent years, it is possible that communication might be disrupted during a disaster [29]. Furthermore, if collaboration with local pharmacies had been established, it could have been possible to obtain more detailed prescription information when admitting patients. This was not possible in this study.

For *Theme 3, "leadership,"* we found that the PD's leadership facilitated the supply of drugs, and the leadership of the hospital managers supported the activities of pharmacists. *"Leadership"* was a key factor in reducing anxiety among nurses when responding to the COVID-19 pandemic [30]. Additionally, *"leadership"* was assumed as one of the important factors in supporting pharmacists' psychological states, such as "confidence, responsibility, anguish, and conflict," which were raised in *Theme 4, "psychology of pharmacists."* It was reported that leaders' decisions during emergencies could be a motivating factor for the continuity of medical care [31], which could reassure pharmacists working after the triple disaster. Conversely, the local pharmacists associations did not provide sufficient leadership. Based on this, a system to educate pharmacists on disaster drug logistics was established in Japan [32]. This study suggested that internal leadership by managers from the same organization was important for pharmacists' performance during disasters.

Theme 5, "drug needs" could reflect pharmacists' actions in obtaining drugs based on patient characteristics. The pharmacists approached hospital managers and outside pharmaceutical wholesalers to obtain drugs based on patient needs. In some aspects, the prescription data shown in Table 3 and Fig. 1 might reflect evidence of pharmacists' behavior as quantitative numbers. The *"supply of drugs"* for patients with chronic diseases is one of the roles of pharmacists during disasters [10], but there have been no reports of detailed prescription data. To the best of our knowledge, our study is the first to report on the status of drug stockpiles and the role of pharmacists during a disaster, using both interviews and prescription data.

This study has two limitations. First, there were only two interviewees and their memories were from approximately 10 years ago, which raised concerns about information bias, such as fading memories and ambiguity. Second, the prescription data had exceeded its storage period at the hospital (3 years). In this study, while acknowledging the limitations of both the interview survey and prescription data, an attempt was made to complement each other's information. As a result, the interview content and prescription data were interrelated, thereby allowing for a robust and reasonable coverage of the post-disaster situation. However, if we had been able to conduct interviews more promptly, pharmacists' recollections might have been even more accurate, and we could have potentially extended the interviews to individuals from other departments involved in disaster drug logistics, such as the Self-Defense Forces, hospital executives, and local pharmacists association, integrating more comprehensive perspectives. Additionally, supplementary investigations based on hospital medical records could have been conducted regarding prescription data, again possibly contributing to a more comprehensive evaluation.

The notable strength of this study lies in the insights derived from the unprecedented disasters of the GEJE and the FDNPP accident. During these disasters, the affected areas were completely cut off from external support immediately after the earthquake, and there was a shortage of professionals across various fields, including medical doctors. As a result, on-site pharmacists exerted great efforts to supply drugs to incoming outpatients using only the available pharmaceutical resources and their judgment. Furthermore, even in the chaotic circumstances, prescription data were collected in parallel with disaster medical care. Such a unique case study is rare, and this research can provide valuable insights into the role of pharmacists during disasters. Specifically, the importance of conducting training for pharmacists in disaster-related medication supply and enhancing the authority of trained pharmacists is empha-

sized. Currently, in Japan, disaster-related training for pharmacists is conducted, but the authority remains unchanged, thereby requiring pharmacists to have prescriptions or medication records in order to dispense medications [33]. On the other hand, citing the example of pharmacist medication supply activities during the Tasmanian bushfires, the Tasmanian state government allowed pharmacists to supply medications for a period of three days without a physician's prescription to patients on ongoing treatment [34]. Similarly, this study also suggests that allowing pharmacists to exercise judgment in medication supply might be effective during the acute phase immediately following large-scale disasters, given that it took several days for medication supply to resume after external support was cut off.

A comprehensive study for pharmacists' role during disasters stated that their role in chemical, biological, radiological, and nuclear (CBRN) disasters could not be found due to insufficient evidence [10]. Our study revealed that there is a possibility of discontinuation of external drug support during CBRN disasters. Currently, major countries heavily rely on nuclear power generation as a source of electricity [35], and Japan also plans to depend on it for approximately 20 % of its electricity needs by 2030 [36]. In the future, it will be necessary for medical institutions to establish a system to supply drugs independently in preparation for nuclear accidents. Learning from these experiences, the expected pharmacists' roles when working in medical institutions near nuclear power plants are as follows: (a) to formulate a drug supply plan considering the possibility of disrupted external support during disasters, (b) to select prescriptions based on drug stockpiles and needs, and (c) to collaborate with external organizations—such as local governments, pharmacists associations, or community pharmacies—to ensure a continuous supply of drugs. Following the FDNPP accident, the stable iodine tablets that Fukushima Prefecture had stockpiled were hardly distributed, primarily due to insufficient coordination between central and local administrations [37]. In contrast, it is believed that hospital pharmacists, by understanding drug needs and collaborating with local administrations or pharmacists associations, should establish a system for the use of stockpiled drugs.

5. Conclusion

In conclusion, our study provided useful findings for medical institutions to conduct drug logistics independently in future nuclear disasters. Particularly, pharmacists' accurate judgments and actions, as well hospital managers' leadership, were assumed to have resulted in smooth disaster drug logistics. Based on this experience, a disaster drug-logistics plan and a pharmacists' activity plan should be established.

Declaration of competing interest

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

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2023.104102.

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