

ORIGINAL ARTICLE

Long-term mental health crisis among municipal public employees caused by the Fukushima nuclear accident and subsequent disasters: Questionnaire survey 10 years postdisaster

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Abstract

Aim: After the Fukushima nuclear accident in 2011, several municipal offices were forced to evacuate, and municipal public employees (MPEs) had to perform many administrative tasks related to the disaster. Typhoons and the COVID-19 pandemic also affected the area afterwards. We conducted a survey for MPEs to investigate the mental health impacts and related factors.

Methods: This survey was conducted in the 10th year after the accident. Participants were MPEs working in the severely affected areas. We used a self-administered questionnaire that included participants' psychological distress (K6), experience during/after the disaster, job-related stress, current problems, and the impacts of subsequent disasters. Based on K6 total scores, we analyzed factors related to mental health and the current problems among high-risk MPEs.

Results: Of all the 775 participants, the number of high-risk MPEs was 101 (13.0%) and many of those had comorbid suicide risk. Factors related to high-score K6 were some individual-related stress factors, including male and younger people, and some job-related stress factors, including unaccustomed work and uncertainty about the future. The mental health status of MPEs in areas severely affected by the disaster has remained very serious more than 10 years later.

Conclusion: The problems and processes caused by the nuclear disaster, such as long-term evacuation, were very specific compared to those of natural disasters. Compared to affected residents, MPEs could be more severely affected by the disasters over the long term. We consider it important to develop a mental health care system to prepare for future disasters.

KEYWORDS

disaster, mental health, municipal public employees, Fukushima nuclear accident, stress

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INTRODUCTION

The Great East Japan Earthquake (GEJE) on March 11, 2011 caused a nuclear disaster in addition to the damage from the earthquake and tsunami. In Fukushima, where the nuclear accident occurred, the situation is quite different from other affected areas and is called the “Fukushima disaster.”¹ The government declared a nuclear emergency, and soon after, evacuation notices were issued to residents living near the nuclear power plant (NPP).² In April of the same year, the International Atomic Energy Agency rated the nuclear disaster as Level 7 on the International Nuclear Radiological Event Scale,³ equivalent to the 1986 Chernobyl disaster, and fear of radiation exposure spread throughout Japan. In particular, the anxiety of Fukushima residents reached an extreme level, and at its peak, ~165,000 people evacuated from their homes.⁴ Even 10 years after the disaster the number of evacuees in Fukushima exceeded 27,000 (2023).⁴

The Fukushima Daiichi NPP, where the nuclear accident occurred, is located on the coast of the Futaba District (FD) in Fukushima (Figure 1). There are eight municipalities in this area: the towns of Hirono, Naraha, Tomioka, Okuma, Futaba, and Namie, and the villages of Kawauchi and Katsurao. Right after the accident, the area within 20–30 km of the NPP was designated as a no-go zone as a rule, and residents were forced to evacuate for a long period.⁵ Many residents were forced to move from one site to another during evacuation.⁶ Municipalities in FD were also forced to relocate their offices and functions, and many of the municipal public employees (MPEs), along with residents, were mass evacuated to one or more locations.⁷

Since then, radiation measurements and decontamination have been conducted continuously in this area, and the evacuation order

has been lifted step by step. The timeline for the return of municipal offices varied greatly by town, taking from 1 to 11 years (March 2012⁸ to September 2022⁹), and all of them have now returned. During the absence of the municipal offices, infrastructure such as roads and buildings could not be repaired, and the devastation of the community was severe and long-lasting.¹⁰ In Fukushima, there were significantly more disaster-related deaths than direct deaths from the earthquake and tsunami.⁶ Notably in FD, the number of disaster-related deaths exceeded 1500 due to evacuation.¹¹ All in all, this area was the most severely affected by the nuclear disaster in Fukushima.

The MPES of FD were both direct relief workers for the affected residents and survivors themselves who experienced cruel evacuation and return. They also had to deal with multiple typhoons, including Hagibis, which hit the district in 2019, and the COVID-19 pandemic. We considered that these prolonged disaster responses may have caused serious psychological burdens on the MPES of FD.

In Japan, MPES are mainly responsible for local government services such as welfare, education, firefighting, and the maintenance of public roads and water supplies. Also, MPES are legally obligated by the civil service system to give priority to their official duties, especially during disasters, and they function as essential workers, similar to healthcare workers. For example, they will make central contributions to maintaining the health of the affected population, rebuilding their lives, repairing damaged infrastructure, and reconstructing the affected areas from the acute phase to the recovery phase during a disaster. On the other hand, unlike temporary disaster relief workers, MPES are long-term residents in the affected area, therefore they are more likely to face multiple stressors and their burdens are unique.

In recent years, the health problems of disaster relief workers have been considered one of the most critical issues. Most previous

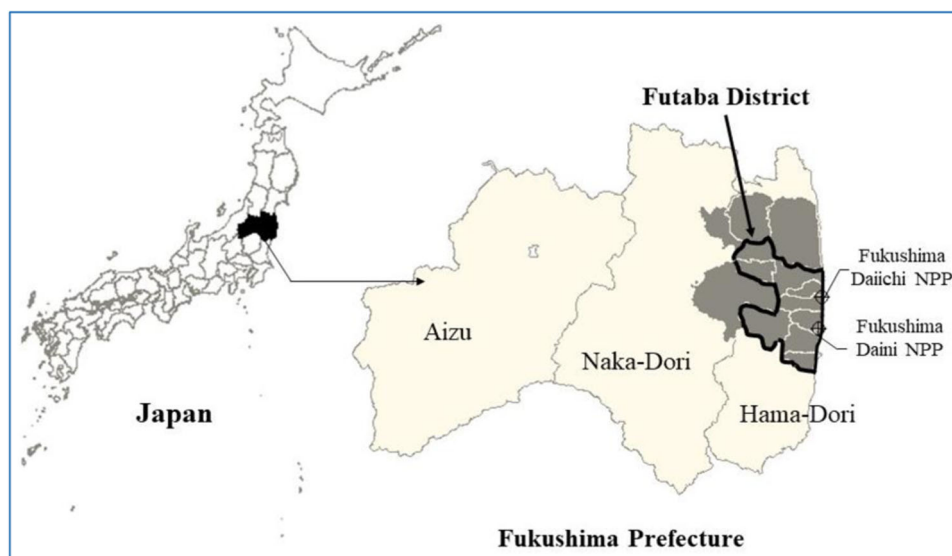


FIGURE 1 The location of Futaba district in Japan. NPP, Nuclear Power Plant. †Fukushima is one of the prefectures located in the Tohoku region of Japan. The region is divided into three areas: Aizu, Naka-Dori, and Hama-Dori. Two nuclear power plants, including the Fukushima Daiichi NPP destroyed by the tsunami, were on the east coast in the Futaba District of Hama-Dori.

studies have focused on the stress of relief workers in the early stages of disasters.^{12,13} In the GEJE, some research studies have been conducted on the mental health of MPES in the early phase of disasters.¹⁴ As far as we know, there are no studies that have followed the burden and impact on MPES over the long term.

We therefore conducted a survey with questionnaires for MPES of FD, coinciding with the 10th year since the GEJE. The present study has two purposes: one is to clarify mental health impacts among MPES working in the affected areas very close to the nuclear plant, and the other is to analyze factors relating to their mental health status. These findings could contribute to developing a mental health care system to provide adequate psychosocial support for MPES during/after disasters.

METHODS

This cross-sectional study was carried out about 10–11 years after the GEJE and used self-administered questionnaire surveys on an anonymous basis for MPES of FD. We made the survey request to each municipality in the summer of 2021, and directly distributed questionnaires to MPES and collected them through the General Affairs Division. The period of collecting questionnaires was September 2021 to January 2023.

Participants

Participants in this study were MPES working at eight municipalities in FD, most severely affected by the nuclear accident in Fukushima. According to the report of Suzuki et al.,¹⁵ the number of MPES at each municipal office was ~30–320, including both regular and irregular employees, and the total number of MPES was assumed to be 1270 (as of April 1, 2022).

For over 10 years, MPES of FD have been providing administrative services for returning residents, new residents moving in, and previous residents who evacuated to other areas. In addition, their services have extended to a broad range of tasks such as establishing new communities and revitalization of industries.¹⁵ Within this context, we considered these MPES had experienced higher stress for a longer time than those working in other affected areas after the GEJE.

Measures

Demographic data included gender, age range, place of residence at the time of the NPP accident and current place of residence, frequency of relocation and/or evacuation after the disaster, job situation at the time of the NPP accident (student/not working, same as current employment, different from current employment), and type of employment (regular employment, irregular employment, other).

Measurement of mental health used the Japanese version of K6 (the six-item Kessler psychological distress scale),¹⁶ which is a self-administered scale to measure general psychological distress. The K6 Japanese version is well-validated^{17,18} and widely used in disaster situations in Japan.^{19–22} Each question item of K6 is rated on a five-point Likert scale from 0 (none of the time) to 4 (all of the time). The total score of K6 ranges from 0 to 24, with 13 or higher indicating severe stress status and the potential presence of mood and anxiety disorders. Additionally, as a suicidal ideation-related item, one item (“Thoughts that I would be better off dead” or “Thoughts of hurting myself in some way”) from the Japanese version of the nine-item Patient Health Questionnaire²³ was added using the same Likert scale from “none” (0 points) to “all the time” (4 points).

Regarding physical damage, evacuation-related issues, and social responses that the participants experienced during/after the disaster, we asked participants whether they experienced each situation on the 17 items of the questionnaire, using multiple-choice questions, such as collapse of a house, death of close person/people, and evacuation (see Appendix 1). For the procedure before analysis, we grouped together the 17 items into the following seven similar categories: (1) houses collapsed or washed out, losing their home, (2) bereavement during and after the disaster, (3) losing work, (4) frightening experience for self and/or family members, (5) evacuation, (6) deterioration of one's own health and/or family member's health, and (7) deterioration of relationships with others.

Additionally, 17 multiple-choice questions concerned job-related stress participants experienced after the disaster, such as busyness and difficulty in getting holidays. As buffering factors, two more questions were asked on helping each other in the workplace and opportunities to develop work-related skills (see Appendix 2). We summarized the questions into 10 categories based on previous research^{19,21,24,25} as follows: (1) busyness and shortage of manpower, (2) increase in unaccustomed work, (3) difficulty in getting rest and holidays, (4) deterioration of relationships within the workplace, (5) uncertainty about the future, (6) frustrations with organizational policies, (7) life–work balance conflicts, (8) complaints and criticisms from residents, (9) helping each other in the workplace, and (10) opportunity to develop work-related skills.

Furthermore, we asked participants to answer multiple-choice questions on the following 12 current problems and stresses: (1) fatigue, (2) lack of exercise, (3) sleep disturbance, (4) dietary problems, (5) lack of time with family and friends, (6) cannot rely on others, (7) less laughing, (8) working too much, (9) guilt over taking a break, (10) prioritizing to others' needs, (11) lack of mental capacity due to work, and (12) no confidence to continue work. The original question items were already used by the authors for our previous studies (see Appendix 3 for details).²⁶

Finally, we asked participants if the series of disasters, such as COVID-19 and the typhoons in the areas after the Fukushima disaster, affected their mental health, with answers on a five-point scale. “Yes” (4 points) and “Yes, very much” (5 points) were categorized as “1 = affected” and other answers were categorized as “0 = not affected.”

Statistical analyses

We adopted the widely used K6 cutoff point and determined a total score of 13 or higher to be high-risk group (HRG). For the items related to suicidal ideation, “sometimes” (2 points) to “all the time” (4 points) are categorized as HRG. Then we looked at the comorbidity of both.

Next, we conducted two statistical analyses to examine mental health factors. For the first statistical analysis, we conducted our analysis with the total score of K6 as the dependent variable, and demographic data, disaster-related experience, job-related stress, and impact of subsequent disasters as independent variables. Poisson regression analysis was chosen because cross-sectional studies dealing with prevalence have shown that its use is more appropriate, and the prevalence of this study was relatively high.²⁷ For the second statistical analysis, to investigate current problems associated with HRG, we categorized those who showed in HRG as 1, and others as 0. As covariates, we added 12 current problems and conducted logistic regression analysis to obtain the odds ratio (OR). For the analyses, we used Rstudio 4.3.3.

Ethical considerations

This study was conducted in accordance with the Declaration of Helsinki as revised in 2013 and approved by the Ethics Committee of Fukushima Medical University (Certification Number: General 2021-074 approved on June 2021). For ethical considerations, the questionnaire clearly stated participation in the survey was voluntary, participants could withdraw from the study at any time, there was no disadvantage after withdrawal, and personal information was confidential. Participants gave prior agreement to participate in the survey.

RESULTS

Collected data and demographic

We obtained data from 807 participants (~63.5% response rate). After eliminating the participants who did not provide us with consent and whose data had missing values on K6, 775 (477 male, 295 females, 3 other/not stated) were eventually analyzed as valid responses. Table 1

TABLE 1 Demographic data.

		Number	(%)
Sex	Men	477	61.5
	Women	295	38.1
	Unanswered	3	0.4
Age (years)	≤29	110	14.2
	30–39	158	20.4
	40–49	197	25.2
	50–59	179	23.1
	≥60	128	16.5
Residential region at the time of disaster ^a	In the coastal area of Fukushima	262	33.8
Current residential region	In the coastal area of Fukushima	622	80.3
Employment at the time of disaster	Current workplace	272	35.1
	Otherwise (including students)	501	64.6
Employment type	Regular employment (men)	531 (371)	68.5 (77.6)
Mental health effects of subsequent COVID-19 and typhoons hitting the area	Yes	336	43.4
		Average (SD)	Median
Number of times moved after the disaster		2.6 (1.9)	2.0
Number of evacuations after the disaster		2.2 (2.3)	2.0
Years in the job		12.1 (11.6)	8.0
K6 total score		6.1 (5.5)	5.0
Suicidal ideation		0.4 (0.9)	0

Abbreviation: SD, standard deviation.

^aSince the Fukushima Daiichi Nuclear Power Plant was located in the coastal area of Fukushima Prefecture, residents living in the coastal area at the time were strongly traumatized and many of them evacuated from their homes.

shows the demographic data of the participants. Only 35% of them were working at their current workplaces after the Fukushima disaster and the remainder were hired after the disaster. Furthermore, the participants moved or evacuated two or more times on average and some of them experienced 10 or more moves.

The number of HRG on K6, suicidal ideation, and its comorbidities

Of all the 775 participants, the number in the HRG on K6 was 101 (13.0%). For suicidal ideation, a total of 80 (10.3%) fell within the HRG. There were 54 (7.0%) people who met both HRGs ($K6 \geq 13$ and suicidal ideation ≥ 2).

Factors related to mental health

For Poisson regression analysis, 749 participants (469 males and 280 females) were analyzed after eliminating the missing values of independent variables. The results identified the following as factors related to high-score K6 (Table 2): male, people younger than 30 years compared to those in their 50s or older, people who were students or working at different places at the time of the disaster, deterioration of one's own or one's family members' health, deterioration of relationships with others, and the impacts of the subsequent disasters. The experience of bereavement was significantly related to a low score of K6.

Job-related stress factors for the K6 high-score group were unaccustomed work, difficulty in getting rest and holidays, deterioration of relationship with others in the workplace, and uncertainty about the future. On the other hand, the K6 score was significantly low when factors such as helping each other in the workplace and opportunities to develop occupational skills were shown.

Current status related to the HRG of mental health issues

In logistic regression, 11 items were entered as covariances, not including the item of "prioritizing to others' needs," which did not show any significant difference in the two variable analyses. As a result, the following seven items were extracted as current problems related to a high risk of mental health issues ($K6 \geq 13$): "fatigue," "sleep disturbance," "dietary problems," "can't rely on others," "less laughing," "working too much," and "lack of mental capacity due to work." The respective OR and 95% confidence interval (CI) are shown in Table 3.

After we analyzed the current problems of the HRG in K6 by gender using the χ^2 test, three items were significantly more common among women than men: dietary problems ($P \leq 0.05$), working too much ($P \leq 0.05$), and lack of mental capacity due to work ($P \leq 0.01$).

DISCUSSION

This study was conducted on the long-term mental health of MPES of FD, the most severely affected area in the Fukushima disaster, and three essential findings were made. First, due to the further effects of the subsequent disasters, the prevalence of psychological distress among MPES remained high after more than 10 years. Second, the percentage of high-risk MPES was higher than that in the general affected population, and MPES had a variety of long-lasting unique and multiple stresses specific to nuclear disasters. Third, several factors were identified that could increase the stress and prevalence of psychological distress in MPES while some factors, conversely, could alleviate stress.

Several studies on mental health were conducted for MPES early in the GEJE. Fukasawa et al.²² reported that the prevalence of severe psychological distress ($K6 \geq 13$) 2 months after the GEJE was 3.0% in the less affected group and 5.9% in the more affected group, indicating a greater mental health impact on staff working in tsunami-affected coastal areas than in inland areas. Sakuma et al.²⁰ conducted a survey 14 months after the GEJE among relief workers (firefighters, MPES, and hospital healthcare workers) in coastal areas of Miyagi Prefecture and found a 14.9% prevalence of severe psychological distress among MPES. In the Fukushima disaster, Maeda et al.²⁸ conducted a mental health diagnostic interview survey with MPES in two coastal municipal offices (including those we studied in this research) 2–3 years after the disaster, and the prevalence rates for depression were very high (17.9%). MPES were frequently exposed to intense anger from residents and ~30% in one of the towns had left their jobs for various reasons, such as burnout. Also, nine cases of suicide among local government workers in Fukushima were reported 5 years after the disaster.²⁹ Notably, even though this survey was conducted more than 10 years after the Fukushima disaster, 101 MPES (13.0%) had severe psychological distress. Furthermore, 501 participants (65%) were hired after the disaster, which given the usual employment system of public workers in Japan (permanent employment), is a significantly high turnover rate.

The prevalence rate of 13.0% is ~2.1 times that reported in the Fukushima Prefecture Health Management Survey* (6.1%), which is the annual survey of affected residents in the heavily damaged coastal districts of Fukushima Prefecture in 2021,³⁰ and 4.8 times the percentage (2.7%) in the National Survey of Living Standards† in 2022.³¹ Previous studies have shown that MPES in affected areas are more likely to have mental health problems than the general affected population^{20,32} and the present study found the same result. In other

*The Fukushima Prefecture Health Management Survey. The survey is conducted to ascertain the physical and mental health of people in Fukushima with regard to radiation effects caused by the Fukushima Daiichi Nuclear Power Plant accident, with the aim to prevent, promptly detect, and properly treat medical conditions of all sorts. The Mental Health and Lifestyle Survey is conducted annually for evacuated residents.

†National Survey of Living Standards. The Ministry of Health, Labor and Welfare (MHLW) takes the lead in this annual survey of the lives of Japanese citizens, including health, medical care, welfare, pension, and income. Mental health is added to the survey items in the large-scale survey conducted once every 3 years.

**TABLE 2** Factors related to mental health (K6 score).

	β	SE	95% CI	<i>p</i> -value ^a
<i>Basic characteristics</i>				
Sex (reference: women)				
Men	0.096	0.035	0.028–0.165	0.01
Age group (years, reference: > 29)				
30–39	–0.042	0.063	–0.167 to 0.082	0.51
40–49	–0.118	0.074	–0.263 to 0.026	0.11
50–59	–0.284	0.076	–0.434 to –0.135	<0.001
>60	–0.258	0.085	–0.426 to –0.092	0.00
Place of residence at the time of disaster (reference: outside Fukushima)				
Coastal areas of Fukushima	0.065	0.061	–0.055 to 0.185	0.29
Inland areas of Fukushima	–0.006	0.065	–0.134 to 0.121	0.92
Working at the time of disaster (reference: same workplace as now)				
Different workplace	0.139	0.051	0.039–0.238	0.01
Student or unemployed	0.141	0.064	0.015–0.265	0.03
Employment (reference: informal employment)				
Formal employment	0.062	0.049	–0.033 to 0.157	0.21
Other (e.g. dispatch)	0.099	0.074	–0.046 to 0.243	0.18
<i>Experiences and effects of the disaster</i>				
Damage/loss of dwelling (reference: unselected)				
Yes	–0.068	0.038	–0.141 to 0.006	0.07
Evacuation (reference: unselected)				
Yes	0.014	0.048	–0.079 to 0.109	0.76
Unemployment (reference: unselected)				
Yes	0.077	0.062	–0.045 to 0.197	0.21
Terrifying experience at work (reference: unselected)				
Yes	0.026	0.035	–0.043 to 0.094	0.46
Bereavement (reference: unselected)				
Yes	–0.118	0.042	–0.201 to –0.035	0.01
Deterioration of health (reference: unselected)				
Yes	0.318	0.036	0.248–0.389	<0.001
Deterioration of relationships with family members and others (reference: unselected)				
Yes	0.133	0.037	0.060–0.206	<0.001
<i>Job-related stress and buffering factors</i>				
Staff shortages and increasing workload (reference: unselected)				
Yes	0.052	0.044	–0.035 to 0.139	0.24

TABLE 2 (Continued)

	β	SE	95% CI	p-value ^a
Unaccustomed work (reference: unselected)				
Yes	0.194	0.036	0.123–0.265	<0.001
Difficulty in getting rest and holidays (reference: unselected)				
Yes	0.10	0.038	0.022–0.172	0.01
Deterioration of relationships within the workplace (reference: unselected)				
Yes	0.302	0.038	0.227–0.378	<0.001
Uncertainty about the future (reference: unselected)				
Yes	0.172	0.036	0.102–0.242	<0.001
Frustrations with organizational policies (reference: unselected)				
Yes	0.034	0.036	–0.036 to 0.104	0.34
Life–work balance conflicts (reference: unselected)				
Yes	0.066	0.036	–0.004 to 0.136	0.06
Complaints and criticisms from residents (reference: unselected)				
Yes	–0.005	0.038	–0.078 to 0.069	0.90
Helping each other in the workplace (reference: unselected)				
Yes	–0.205	0.037	–0.277 to –0.133	<0.001
Opportunities to develop occupational skills (reference: unselected)				
Yes	–0.146	0.036	–0.216 to –0.076	<0.001
Mental health impact of subsequent disasters (reference: unselected)				
Yes	0.245	0.032	0.183–0.307	<0.001

Abbreviations: β , Standardized partial regression coefficient; SE, standard error; 95% CI, 95% confidence interval.

^aOf the 775 participants, 749 were analyzed after removing missing values for the independent variables. Poisson regression analysis was used.

words, MPES in disaster areas are at higher risk for mental health problems than general disaster survivors over a longer period.

When we try to understand such long-term mental health crises among MPES following disasters, we may need to distinguish between the common problems in natural disasters and those specific to nuclear disasters. First, it can be considered that common issues include (1) the extent of damage faced by MPES themselves during a disaster (e.g., difficulties in daily life, personal trauma, and feelings of loss),^{20,21,24,25,33} (2) the burden experienced due to carrying out a huge amount of restoration tasks on top of one's regular tasks,^{17,19,20,22,32} (3) stress managing tasks they had never experienced before,^{20,34} (4) poor workplace communication,^{17,19,20} (5) exposure to affected people's anger and complaints,^{17,19,32} (6) secondary traumatization (=compassion fatigue) when supporting affected people,^{26,35} and (7) work–life role conflict caused when workers are significantly affected by disasters.²⁵ The participants in this survey also faced work–life role conflict about whether they should prioritize their job role or family role. For example, in some cases they had to prioritize their jobs over taking care of their family members affected by the disaster. Regardless of the type of disaster, these issues can be an added burden for MPES. However, in natural disasters, the psychological distress on MPES can usually be expected

to be alleviated, as the affected people's daily lives and health problems gradually settle down.^{35,36}

On the other hand, the situation and course of the Fukushima disaster were quite different.³⁷ MPES had additional burdens due to the nuclear disaster, as shown in Table 4. At the beginning of the disaster, extremely intense and angry feelings were directed at MPES from the residents.²⁸ Also, many MPES themselves were repeatedly evacuated and relocated.¹⁵ Even in this situation, they had to deal with rebuilding the lives of affected people, who had scattered all over Japan due to anxieties about radiation. The proportion of survivors with mental health problems was much higher than that of people affected by natural disasters.³⁸ Additionally, several years after the disaster, many residents had newly moved into the district as pioneers.³⁹ In most natural disasters, the goal is to rebuild the original community, but in the Fukushima disaster, an entirely new community had to be created. According to the survey conducted by the Reconstruction Agency in 2024, the population of FD was ~20% of the previous population before the GEJE, and the aging population has increased significantly.³⁹ Approximately half of the evacuees decided they would not return, and many of the other half were debating whether they should go back or not.⁴⁰ In some areas, essential facilities such as hospitals, schools, and shops have barely

TABLE 3 Odds ratio (OR) and 95% confidence intervals of current problems for mental health distress.

	OR	95% CI	p-value ^a
Fatigue	12	5.85–26.80	< 0.001
Sleep disturbance	2.1	1.18–3.65	0.01
Dietary problems	2.0	1.10–3.68	0.02
Can't rely on others	2.5	1.42–4.44	0.00
Less laughing	2.7	1.50–4.74	< 0.001
Working too much	0.4	0.21–0.89	0.03
Lack of mental capacity due to work	2.1	1.12–3.97	0.02

Abbreviation: 95% CI, 95% confidence interval.

^aLogistic regression analysis was used ($n = 775$).

TABLE 4 Risk factors among municipal public employees (MPes) in disasters.

Common risk factors in all disasters

- Long-term overwork
- Dual burdens of regular work and reconstruction work
- MPes themselves could be affected by the disaster directly
- Secondary traumatization
- Poor workplace communication
- Work–life role conflict

Additional risk factors specific to nuclear disasters

- Unexpected long-term evacuation
- Exposure to affected people's extreme anger
- Tasks to deal with numerous widely scattered evacuated people
- Delayed return to the original community
- Large number of survivors with deteriorating mental health
- Additional tasks for many new residents as well as affected people
- Unclear future of communities

begun to be built even now.⁴¹ For these reasons, it is expected that the heavy workload of MPes of FD is likely to continue without interruption, both now and for a while. There is also the risk that another disaster could occur in the future, like previous typhoons and the COVID-19 pandemic. Since there were only a few resources available to offer long-term support to MPes after the disasters, it is even more necessary to create a system to prevent the deterioration of MPes' health and to provide appropriate mental health care from a long-term perspective. The logistic regression analysis showed that MPes in the HRG had the following current issues: "fatigue," "sleep disturbance," "dietary problems," "can't rely on others," "less laughing," "working too much," and "lack of mental capacity due to work." It is important to become aware of these issues early and encourage the person at risk to receive individual psychiatric medical care in the workplace. Especially for the 54 participants with both high psychological distress and suicidal ideation, immediate psychiatric intervention is needed.

In the results of this study, we found several factors related to the mental health of MPes. Males, people in their 20s, not working

(students or unemployed) at the time of GEJE, deterioration of one's own health and/or family members' health, deterioration of relationships with others, and the effects from the subsequent disasters were individual factors related to HRG. Especially in the Fukushima disaster, evacuation caused heavy distress for the people affected, resulting in an increase in the number of disaster-related deaths,⁴² and the stress of MPes experiencing evacuation had been tremendous. In addition, various psychosocial problems related to the nuclear accident were reported, such as separation of family members, ambiguous loss of the hometown, social stigma, post-traumatic stress responses, chronic anxiety related to radiation, and distress caused by prolonged evacuation.³⁷ The risk of adverse outcomes increasing for young people in times of disaster has been reported,⁴³ which would suggest that the mental health of young MPes should be given more attention in the workplace.

Also, there were some job-related factors associated with mental health status, such as unaccustomed work, difficulty in getting rest and holidays, deterioration of relationship with others in the workplace, and uncertainty about the future. Generally, women are viewed as more vulnerable to threats than men, and their mental health can easily deteriorate after disasters.^{44,45} However, the results of this study indicate that the mental health issues of MPes were more serious in males. Male participants answered "working too much" and "lack of mental capacity due to work" significantly more frequently than female participants. In previous studies, difficulty in getting rest and holidays, the increase in overtime at work, complaints and criticisms from affected residents, and lack of communication in the workplace were factors related to the poor mental health of MPes in the acute phase during the GEJE.^{19,22} This means the stressful and busy work environment in the acute phase of the GEJE is ongoing in FD even now and it has been particularly serious for male MPes.

On the other hand, there were some buffering factors for the HRG in this study, including bereavement, helping each other in the workplace, and opportunities to develop work-related skills. In the initial phase after disasters, bereavement is indicated as a risk factor for mental health,¹⁹ but the result from this study showed the opposite. Paradoxically, since bereavement is known as an experience that may promote post-traumatic growth,⁴⁶ we consider that the experience of loss could have worked as a resilience factor after the disaster. Also, lately it has been recommended to workplaces exposed to disasters that they take measures focusing not only on the psychological distress of the affected workers, but also on resilience factors and the post-traumatic growth emerging from their experiences of disaster.^{47,48} Indeed, taking these points into consideration, we have started to cooperate with the municipalities, providing individual support for MPes at higher risk and holding training sessions for workers.

This study identified the prevalence of long-term mental health problems and associated factors among MPes who were severely affected after the GEJE. The results could offer significant suggestions on future nuclear accidents relevant to other countries, and not only to the traditional public service system and job style in Japan.

Regarding nuclear emergencies, the World Health Organization concluded in the framework published in 2020 that radiation emergencies may have a long-lasting impact on affected communities.⁴⁹ Long-term psychological effects were also reported after the nuclear disasters at Chernobyl and Three Mile Island.⁵⁰ However, it is difficult for local municipalities alone to finance the long-term reconstruction of communities and support for affected people. In recent years, the importance of monitoring the health of relief workers and establishing support systems has been emphasized in the acute phase of disasters,¹⁴ but there has been no attention given to long-term support for MPes. In Japan, disasters tend to occur frequently due to the topography of the country, and there is a high risk of nuclear disasters along with such disasters. Recently, there has also been a significant increase in the number of rain-related disasters caused by the effects of global warming. In these days of frequent disasters, MPes must respond to recurring disasters and the mental health impact on them will be enormous, especially in nuclear disasters. Keeping this consideration in mind, we believe that it is an urgent task for national and local governments to work together to prepare for future nuclear disasters and to establish a support system for MPes in disasters.

STUDY LIMITATIONS AND FUTURE ISSUES

This study is a cross-sectional study and does not show longitudinal data on mental health over the long period of disaster. Additionally, there is a limit to what can be understood about the effects of the disaster and all the issues faced in workplaces based on this survey alone. We think it will be important to conduct further long-term longitudinal studies and carry out a survey focusing not only on mental health issues but also on resilience.

AUTHOR CONTRIBUTIONS

Noriko Setou, Yutaka Matsui, and Masaharu Maeda conceived and designed this study. Noriko Setou, Tomoyuki Kobayashi, Yutaka Matsui, and Masaharu Maeda acquired funding. Noriko Setou and Yutaka Matsui designed the questionnaire and conducted the survey. Yui Takebayashi, Tomoyuki Kobayashi, and Noriko Setou conceptualized the study methodologically and analyzed the data in the study. Noriko Setou wrote a draft of the manuscript and Masaharu Maeda supervised it. All authors contributed to the revision of the manuscript and agreed to the final version of the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the first author, Noriko Setou, upon reasonable request.

ETHICS APPROVAL STATEMENT

This study was conducted in accordance with the Declaration of Helsinki as revised in 2013 and approved by the Ethics Committee of Fukushima Medical University (Certification Number: General 2021-074 approved on June 2021). For ethical considerations, the questionnaire clearly stated participation in the survey was voluntary, participants could withdraw from the study at any time, there was no disadvantage after withdrawal, and personal information was confidential. Participants gave prior agreement to participate in the survey.

PATIENT CONSENT STATEMENT

All the participants were informed of the purpose of the study and that their participation was anonymous and voluntary. They provided their written informed consent to participate in this study.

CLINICAL TRIAL REGISTRATION

N/A.

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APPENDIX 1

ITEMS OF PARTICIPANTS' EXPERIENCES DURING/AFTER THE DISASTER

- (1) Total collapse of a house or a house washed away
- (2) Partial collapse of a house or partial wash away
- (3) Loss of their home due to radiation
- (4) Total collapse of workplace or workplace washed away
- (5) Death or missing status of a close person/people
- (6) Death of a close person/people due to other reasons
- (7) Separation from close people (other than death)
- (8) Loss of work due to the disaster
- (9) Frightening experiences associated with the disaster
- (10) Frightening experiences of family members associated with the disaster
- (11) Evacuation
- (12) Living separately from family members
- (13) Deterioration of own health

- (14) Deterioration of family member's health
- (15) Deterioration of relationships with family members
- (16) Deterioration of relationships with other people
- (17) Harassment

APPENDIX 2

PARTICIPANTS' JOB-RELATED STRESS AND BUFFERING FACTORS DURING/AFTER THE DISASTER

- (1) Shortage of manpower
- (2) Busyness
- (3) Increase in unaccustomed work
- (4) Leave of absence
- (5) Resignation
- (6) Change of occupation
- (7) Difficulty in getting rest and holidays
- (8) Frightening experiences related to work
- (9) Deterioration of relationships with others in the workplace
- (10) Uncertainty about the future
- (11) Differences in enthusiasm for the disaster recovery work between the colleagues
- (12) Dissatisfaction with the organization's policy
- (13) Loss of self-confidence at work
- (14) Decrease in motivation
- (15) Difficulty with life-work balance
- (16) Responding to suffering residents and sharing their painful experiences
- (17) Helping each other in the workplace
- (18) Opportunities to develop work-related skills

APPENDIX 3

PARTICIPANTS' CURRENT PROBLEMS

- (1) I'm very tired (= fatigue)
- (2) I don't exercise enough (= lack of exercise)
- (3) I don't have enough sleep, or my sleep pattern is not normal (= sleep disturbance)
- (4) I am not eating properly (= dietary problems)
- (5) I don't have enough time to spend with my family and friends (= lack of time with family and friends)
- (6) I cannot rely on anyone (= can't rely on others)
- (7) I hardly laugh any more (= less laughing)
- (8) I am working too much (= working too much)
- (9) I feel guilty when I take a rest or holidays (= guilt over taking a break)
- (10) I prioritize the needs of disaster survivors over my own needs (= priority to others' needs)
- (11) I don't have enough mental capacity due to work (= lack of mental capacity due to work)
- (12) I lack the confidence to continue in this work (= no confidence to continue work)