

BMJ Open Association between continued residence in temporary prefabricated housing and musculoskeletal pain in survivors of the Great East Japan Earthquake: a longitudinal study

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ABSTRACT

Objective Prolonged periods of living in prefabricated houses (PHs) may increase the risk of musculoskeletal (MSK) symptoms; however, the association is not clear. This study aimed to investigate the association between continued residence in PHs and MSK pain in a population affected by a natural disaster, the Great East Japan Earthquake (GEJE) survivors.

Design, setting and participants A panel study was conducted including 1059 and 792 survivors at 2 and 4 years, respectively, after the GEJE, using a self-reported questionnaire. Those with no response on living status and those who did not live in a PH were excluded. Participants were classified into two groups by living status: continued residence in a PH (lived in a PH during both periods) or moving out of a PH (lived in a PH in the first period and did not live in a PH in the second).

Primary outcome measure MSK pain included lower back, shoulder, knee, hand or foot, and neck pain. Changes in the occurrence of MSK pain during the two periods were assessed and defined as 'new-onset' and 'continuing' MSK pain. Multiple logistic regression analysis was used to examine the influence of continued residence in a PH on new-onset and continuing MSK pain.

Results Continued residence in a PH was significantly associated with new-onset MSK pain, even after adjustment for covariates (adjusted OR 2.18, 95% CI 1.25 to 3.79, $p=0.006$). Participants who continued living in a PH had higher rates of continuing MSK pain than those who moved out; however, the difference was not significant (adjusted OR 1.69, 95% CI 0.94 to 3.05, $p=0.079$).

Conclusion Continued residence in a PH was associated with new-onset MSK pain among survivors. Public support should be provided to such people to ensure a more comfortable life.

INTRODUCTION

The Great East Japan Earthquake (GEJE) and the tsunami that followed occurred in the northeastern coast of Japan on 11

Strengths and limitations of this study

- This is a longitudinal study examining the association between continued residence in prefabricated houses and musculoskeletal pain after a natural disaster.
- A panel study has been ongoing among survivors of the Great East Japan Earthquake (aged ≥ 18 years) who lived in Ogatsu district, Oshika district in Ishinomaki city or Wakabayashi ward in Sendai city, in Miyagi prefecture, which were severely affected by the earthquake and tsunami.
- The pathology and severity of pain as well as disabilities caused by the pain were not assessed.

March 2011 and caused enormous damage to personnel and property.¹ Furthermore, the Fukushima Dai-ichi Nuclear Power Plant underwent major damage due to the tsunami, leading to radiation leaks and contamination. According to government reports, approximately 345 000 people were forced to evacuate due to the loss of their homes or radiation exposure avoidance.² The evacuees then moved into small temporary prefabricated houses (PHs), public housing estates or relatives' homes.³ Although 8 years have elapsed since the disaster, more than 50 000 people have not moved back to their own homes.² Residential relocation following major disasters negatively affects the mental health and social capital of survivors.^{4 5} However, the influence of prolonged residential relocation for refugees was not well known. In a previous study, the rate of psychological distress among evacuees increased with longer duration of residing in a PH.⁶ Most PHs are smaller than the former homes of evacuees, have poor isolation, thin internal walls and lower

soundproof effect, which leads to health problems.⁷ PHs are not suitable for long-term living; long-term residence in them could have negative effects. However, many evacuees are forced to continue living in PHs due to delays in the reconstruction of their homes.⁸

Numerous studies have reported on the physical and mental health problems that are observed following natural disasters.^{4 9–13} Following the GEJE, the development of musculoskeletal (MSK) symptoms, both acute and chronic, has been a major concern among survivors.¹⁴ The most commonly observed MSK symptoms following the GEJE are knee, shoulder and lower back pain, with several reports indicating that these are related to multiple factors.^{3 10–15} Survivors are susceptible to psychological and social influences, due to having lost their friends, families and homes, as well as social isolation.¹⁵ In addition, subjective economic hardship is also related to shoulder, neck and lower back pain.^{3 13 16} Prolonged periods of residence in PHs may affect the development of MSK symptoms; however, its association is not clarified in previous study. The purpose of the present study was to investigate the influence of continued residence in a PH on MSK pain among GEJE survivors.

MATERIALS AND METHODS

Participants

We have been conducting a panel study among survivors of the GEJE (aged 18 years or older) who lived in Ogatsu district, Oshika district in Ishinomaki city or Wakabayashi ward in Sendai city, in Miyagi prefecture, which were severely affected by the earthquake and tsunami. Every 6 months since 2011, medical health check-ups and self-administered questionnaire surveys were being conducted among the survivors. The questionnaire was described in detail in a previous report.¹² The questionnaire requested the following information from each participant: the condition of house before and after the GEJE, health condition, lifestyle, working status, amount of activities, psychological distress, quality of sleep and social capital (online supplementary file 1). During our study period, the questionnaire and a document of informed consent were mailed to participants, and the returned questionnaires were collected and analysed longitudinally from the fourth phase (November 2012 to February 2013, 2 years after the GEJE) to the eighth phase (November 2014 to February 2015, 4 years after the GEJE).

Outcome variables

It included items on the locations of pain, such as the lower back, shoulders, knees, hand or feet, and neck (multiple choices were allowed). MSK pain was defined as the presence of pain in at least one of these locations. The outcomes of interests were 'new-onset' and 'continuing' MSK pain. New-onset MSK pain was defined as the absence of MSK pain in the first period (November 2012 to February 2013) and its presence in the second period (November 2014 to February 2015). Continuing MSK

pain was defined as the presence of MSK pain during both periods.

Exposures

The questionnaire included surveys on present living status, and participants chose an answer from the following options: same house as before the earthquake, temporary PH, rental house, relative's house, newly established house, public funded rental accommodation or other. Participants who had lived in a PH during the first period were investigated to identify if they lived in the PH in the second period too. Living status was accordingly classified as continued residence in a PH (lived in a PH in both periods) or moving out of PH (lived in a PH in the first period and did not live in one in the second).

Covariates

The following were included in the analyses as covariates because they were considered as potential confounding factors^{3 10–13 16}: sex, body mass index (BMI), age, living areas, smoking habits, drinking habits, chronic conditions (hypertension, diabetes mellitus, myocardial infarction and cerebral stroke), working status, walking time per day, subjective economic hardship, psychological distress (Kessler Psychological Distress Scale, K6),¹⁷ quality of sleep (Athens Insomnia Scale, AIS)¹⁸ and social capital (Lubben Social Network Scale, LSNS-6).¹⁹ The following continuous variables were divided into categories according to distribution or clinical significance when necessary: BMI ($<18.5 \text{ kg/m}^2$, 18.5 to $<25 \text{ kg/m}^2$ or $\geq 25 \text{ kg/m}^2$), age (<65 years or ≥ 65 years) and drinking habits (non-drinker, $<45.6 \text{ g}$ or $\geq 45.6 \text{ g}$ of alcohol per day). Questions pertaining to drinking habits included: "Do you drink alcoholic beverages? If yes, please describe the kind and amount of beverage consumed per day". We calculated the amount of alcohol consumed and divided the consumption level into the three categories described above. Higher psychological distress was defined as a score ≥ 10 points in the K6.²⁰ Sleep disturbance was defined as a score ≥ 6 in the AIS.²¹ Lower social capital was defined as a score <12 in the LSNS-6.²⁰ Pre-coded questions included those on living area (Ogatsu, Oshika or Wakabayashi), smoking habits (smoker or non-smoker), working status (unemployed or employed), walking time per day ($<30 \text{ min}$, 30 min to $<1 \text{ hour}$ or $\geq 1 \text{ hour}$) and subjective economic hardship (normal, a little hard, hard or very hard).

Statistical analysis

Categorical variables were presented as numbers and percentage (%). We performed crude and multiple logistic regression analyses to examine the influence of continued residence in a PH on new-onset and continuing MSK pain. The ORs and their 95% CIs for new-onset and continuing MSK pain, according to living status, were calculated after simultaneous adjustment for covariates. Covariates included sex (male or female), BMI ($<18.5 \text{ kg/m}^2$, 18.5 to $<25 \text{ kg/m}^2$, $\geq 25 \text{ kg/m}^2$ or unknown),

age (<65 or ≥65 years), living area (Ogatsu, Oshika or Wakabayashi), smoking habits (smoker, non-smoker or unknown), drinking habits (non-drinker, <45.6g, ≥45.6g of alcohol per day or unknown), chronic conditions (hypertension, diabetes mellitus, myocardial infarction and cerebral stroke), working status (unemployed, employed or unknown), walking time per day (<30min, 30min to <1 hour, ≥1 hour or unknown), subjective economic hardship (normal, a little hard, hard, very hard or unknown), K6 score (<10 or ≥10, or unknown), AIS score (<6 or ≥6, or unknown) and LSNS-6 score (≥12 or <12, or unknown). Further, we performed stratified analyses according to age (<65 or ≥65 years), and the crude and adjusted OR (95% CI) for new-onset and continuing MSK pain were assessed in the same way as mentioned above. For the stratified analyses, we examined for the interactions between age and living in PH, tested by Wald test. All statistical analyses were performed with IBM SPSS Statistics V.24.0 (SPSS Japan, Tokyo, Japan). All tests were two-tailed, and a p value <0.05 was considered statistically significant.

Patient and public involvement

The patients and public were not involved in the development of the research questions, outcome measures or study design. The patients were also not involved in the recruitment and performance of the study. We will disseminate the final results to the participants after the results are published in a peer-reviewed journal.

RESULTS

Two years after the GEJE, we invited a total of 6283 survivors to participate in this study. Of these, 2412 (38.4%, 2412/6283) responded and 2286 (94.8%, 2286/2412) provided consent to participate. We excluded 82 participants with no responses on living status and 1145 participants who did not live in a PH in the first period. The follow-up rate in the second period was 75.7% (802/1059), and 10 participants who did not enter responses pertaining to living status were excluded. The final study population comprised 792 participants (figure 1). Of the 792 participants, 231 had moved out of the PH in the second period (newly established house, 137; public-funded rental accommodation, 38; the same house as before the earthquake, 38; rental house, 7; relative's house, 4; others, 7) and 561 participants continued residence in a PH. The baseline characteristics of the participants are shown in table 1. A total of 51.9% of the participants who had moved out of the PH and 53.5% of those who continued residence in PHs were female. The mean age of the participants was 60.4 years (range, 18–91 years).

The number of participants who had MSK pain during the fourth phase was 323 (40.8%), and the prevalence of pain for each body sites was as follows: lower back, 24.7%; shoulders, 9.8%; knees 11.4%; hands or feet, 12.0%; neck, 21.5%. The number of participants who had MSK

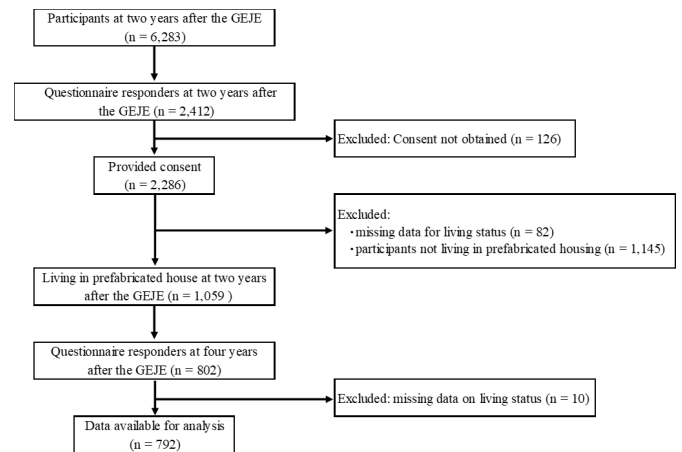


Figure 1 Study flow chart. GEJE, the Great East Japan Earthquake.

pain during eighth phase was 346 (43.7%), and the prevalence of pain for each body sites was as follows: lower back, 24.7%; shoulders, 9.8%; knees, 16.3%; hands or feet, 14.0%; neck, 19.7%. Of the 469 participants without MSK pain in the first period, 130 (27.7%) had new-onset MSK pain in the second period. The crude and adjusted ORs (95% CI) for new-onset MSK pain according to living status are shown in table 2. Continued residence in a PH was significantly associated with new-onset MSK pain, even after adjustment for covariates (adjusted OR 2.18, 95% CI 1.25 to 3.79, p=0.006). Further, of the 323 participants with MSK pain in the first period, 216 (66.9%) had continuing MSK pain in the second period. The crude and adjusted ORs (95% CI) for continuing MSK pain, according to living status, are shown in table 3. Participants with continued residence in a PH had higher rates of MSK pain than those who moved out of the PH; however, the difference was not significant (adjusted OR, 1.69 (0.94 to 3.05), p=0.079). There were no significant associations between new-onset or continuing pain for each body site and living status.

The results of the stratified analyses are shown in table 4. Among the younger participants (age <65 years), continued residence in a PH was significantly associated with new-onset MSK pain (adjusted OR 2.70 (1.03 to 7.09), p=0.044). However, there was no significant association between continued residence in a PH and continuing MSK pain. Among the older participants (age ≥65), continued residence in a PH was significantly associated with both new-onset MSK pain (2.27 (1.03 to 5.02), p=0.042) and continuing MSK pain (4.17 (1.52 to 11.45), p=0.006). There were statistically significant interactions between age and living in PH.

DISCUSSION

This study revealed that continued residence in a PH was significantly associated with new-onset MSK pain among GEJE survivors. Further, although there was no significant association between continued residence in a PH

Table 1 Baseline characteristics of participants

	Living in PH			P value
	Total 792	Moving out 231 (29.2)	Continued residence 561 (70.8)	
Sex				
Male	372 (47.0)	111 (48.1)	261 (46.5)	0.70
Female	420 (53.0)	120 (51.9)	300 (53.5)	
BMI (kg/m ²)				
18.5 to <25	421 (53.2)	134 (58.0)	287 (51.2)	0.021
<18.5	24 (3.0)	3 (1.3)	21 (3.7)	
≥25	313 (39.5)	90 (39.0)	223 (39.8)	
Age (years)				
<65	430 (54.3)	120 (51.9)	310 (55.3)	0.40
≥65	362 (45.7)	111 (48.1)	251 (44.7)	
Living area				
Ogatsu	294 (37.1)	60 (26.0)	234 (41.7)	<0.001
Oshika	190 (24.0)	45 (19.5)	145 (25.8)	
Wakabayashi	308 (38.9)	126 (54.5)	182 (32.4)	
Smoking habits				
Smoker	148 (18.7)	38 (16.5)	110 (19.6)	0.015
Non-smoker	606 (76.5)	189 (81.8)	417 (74.3)	
Drinking habits				
Non-drinker	454 (57.4)	139 (60.2)	315 (56.3)	0.57
<45.6g of alcohol per day	176 (22.3)	52 (22.5)	124 (22.1)	
≥45.6g of alcohol per day	81 (10.2)	21 (9.1)	60 (10.7)	
Chronic conditions				
Hypertension	316 (39.3)	95 (41.1)	221 (39.4)	0.65
Diabetes mellitus	81 (10.2)	26 (11.3)	55 (9.8)	0.54
Myocardial infarction	56 (7.1)	20 (8.7)	36 (6.4)	0.26
Cerebral stroke	16 (2.0)	8 (3.5)	8 (3.5)	0.064
Working status				
Unemployed	411 (51.9)	125 (54.1)	286 (51.0)	0.38
Employed	367 (46.3)	104 (45.0)	263 (46.9)	
Walking time per day				
<30 min	283 (35.7)	84 (36.4)	199 (35.5)	0.58
30 min to <1 hour	285 (36.0)	79 (34.2)	206 (36.7)	
≥1 hour	211 (26.6)	66 (28.6)	145 (25.8)	
Subjective economic hardship				
Normal	276 (34.8)	81 (35.1)	195 (34.8)	0.019
A little hard	219 (27.7)	81 (35.1)	138 (24.6)	
Hard	183 (23.1)	44 (19.0)	139 (24.8)	
Very hard	98 (12.4)	21 (9.1)	77 (13.7)	
K6 score				
<10	639 (80.7)	186 (80.5)	453 (80.7)	0.16
≥10	129 (16.3)	34 (14.7)	95 (16.9)	
Athens Insomnia Scale score				
<6	477 (60.2)	138 (59.7)	339 (60.4)	

Continued

Table 1 Continued

	Living in PH			P value
	Total 792	Moving out 231 (29.2)	Continued residence 561 (70.8)	
≥6	308 (38.9)	88 (38.1)	220 (39.2)	0.047
Lubben Social Network Scale 6 score				
≥12	558 (70.5)	168 (72.7)	390 (69.5)	0.60
<12	233 (29.4)	63 (27.3)	170 (30.3)	

As each item had a limited number of respondents, the actual number is not necessarily in accordance with the total.

22.8g of alcohol amounts to '1 go' or traditional unit of sake (180 mL), which also approximates to two glasses of wine (200 mL) or beer (500 mL) in terms of alcohol content.

BMI, body mass index; K6, Kessler 6-item Psychological Distress Scale; PH, prefabricated temporary housing.

and continuing MSK pain among younger survivors, the association was significant among older survivors.

Survivors of natural disasters are usually forced to move to unfamiliar environments owing to a loss of dwelling or for refuge from the disaster. The GEJE and accompanying tsunami severely damaged the coastal areas of Japan. PHs were required for survivors for the protection of their security and privacy, but these had minimum-comfort conditions,²² and the survivors desired to move out from the provided emergency shelters as soon as possible.²³ After the GEJE, over 50 000 PHs were built and the occupancy rate was over 90% until several years after the disaster.²⁴

PHs were originally built for short-term purposes and not for long-term living. While the numbers of refugees and PHs have been gradually decreasing, 40%–50% of the refugees reluctantly continued residing in PHs at 2 or 3 years after the GEJE.²⁵ In our previous study, about 70% (561/792) of the participants who lived in PHs at 2 years after the GEJE continued residence in a PH at 4 years after the disaster. Possible reasons for the high rate of continued residence in a PH are economic poverty,⁵ lack of public housing or loss of motivation to move out.⁷

A previous study reported that prolonged PH stays were associated with physical dysfunction and psychological distress.^{6 7 26} Ishii *et al* indicated that most PHs were built

in areas that were separated from the local communities in which survivors previously lived, and did not include commercial areas; therefore, refugees tended to confine themselves to their own PHs, leading to physical inactivity,²⁶ which is considered to be related to MSK pain.²⁷ However, there was no significant association between walking time and living status in this study, meaning that staying indoors may not be a reason for the association of prolonged PH stays and MSK pain. PHs comprise only one dining area and kitchen (about 30 m² in size) and tend to be smaller than survivors' former homes.⁵ Living in a small house may lead to bad posture or immobility.¹⁶ Incorrect posture limits the joint movement and gives excessive load on the body.²⁸ Physical inactivity is linked to inflammation through the mechanism of immune response and causes many chronic diseases including MSK disorders.²⁷ These conditions may result in MSK pain, especially among vulnerable refugees. On the other hand, we expected that residence in a PH led to the sustenance of pre-existing MSK pain; however, the association was not significant. The chronicity of MSK pain has been linked to numerous factors including physical, psychological and sociological problems.²⁹ Once MSK pain occurs, it may be difficult to improve the resulting pain even if evacuees move out of the PH because the participant's circumstances may not have changed dramatically to allow for such conveniences.

Table 2 Influence of changes in living status on new-onset MSK pain

	Living in PH		P value
	Moving out	Continued residence	
Participants without MSK pain at 2 years after the GEJE	138	331	
New-onset MSK pain			
n (%)	25 (18.1)	105 (31.7)	
Crude OR (95% CI)	1.00	2.10 (1.29 to 3.43)	0.003
Adjusted OR (95% CI)	1.00	2.18 (1.25 to 3.79)	0.006

Adjusted for sex, body mass index, age, living area, smoking habits, drinking habits, chronic conditions (hypertension, diabetes mellitus, myocardial infarction and cerebral stroke), working status, walking time per day, subjective economic hardship, K6 score, AIS score and LSNS-6 score.

AIS, Athens Insomnia Scale; GEJE, Great East Japan Earthquake; K6, Kessler 6-item Psychological Distress Scale; LSNS-6, Lubben Social Network Scale; MSK, musculoskeletal; PH, prefabricated temporary housing.

Table 3 Influence of changes in living status on continuing MSK pain

	Living in PH		P value
	Moving out	Continued residence	
Participants with MSK pain at 2 years after the GEJE	93	230	
Continuing MSK pain			
n (%)	56 (60.2)	160 (69.6)	
Crude ORs (95% CI)	1.00	1.51 (0.92 to 2.49)	0.11
Adjusted ORs (95% CI)	1.00	1.69 (0.94 to 3.05)	0.079

Adjusted for sex, body mass index, age, living area, smoking habits, drinking habits, chronic conditions (hypertension, diabetes mellitus, myocardial infarction and cerebral stroke), working status, walking time per day, subjective economic hardship, K6 score, AIS score and LSNS-6 score.

AIS, Athens Insomnia Scale; GEJE, Great East Japan Earthquake; K6, Kessler 6-item Psychological Distress Scale; LSNS-6, Lubben Social Network Scale; MSK, musculoskeletal; PH, prefabricated temporary housing.

The results of our stratified analysis showed that continued residence in a PH was associated with new-onset MSK pain among both younger and older survivors. However, the association between continued residence in a PH and continuing MSK pain was different between the two. The age-related differences we observed can be attributed to activity levels. Younger survivors had a greater number of opportunities to go out for work or shopping, shortening the time spent

staying inside the PH. However, older survivors tended to be isolated from society and were homebound easily.³⁰ Additionally, the areas in which the PHs were located were often far away from the survivors' previous homes, leading to isolation from their local communities.²⁶ The resulting loss of social relationships led to evacuees being homebound. Attention should be paid to survivors, especially elderly people, with extended stays in PHs.

Table 4 Stratified analysis for each age group

	Living in PH		P value	P interaction
	Moving out	Continued residence		
New-onset MSK pain				0.87
Younger (age <65 years)				
n (%)	10 (14.5)	44 (30.3)		
Crude ORs (95% CI)	1.00	2.57 (1.20 to 5.49)	0.013	
Adjusted ORs (95% CI)	1.00	2.70 (1.03 to 7.09)	0.044	
Older (age ≥65 years)				
n (%)	15 (21.7)	61 (32.8)		
Crude ORs (95% CI)	1.00	1.76 (0.92 to 3.36)	0.086	
Adjusted ORs (95% CI)	1.00	2.27 (1.03 to 5.02)	0.042	
Continuing MSK pain n (%)				0.11
Younger (age <65 years)				
n (%)	30 (71.4)	71 (67.0)		
Crude ORs (95% CI)	1.00	0.81 (0.37 to 1.77)	0.60	
Adjusted ORs (95% CI)	1.00	1.03 (0.37 to 2.87)	0.95	
Older (age ≥65 years)				
n (%)	26 (51.0)	89 (71.8)		
Crude ORs (95% CI)	1.00	2.45 (1.25 to 4.80)	0.008	
Adjusted ORs (95% CI)	1.00	4.17 (1.52 to 11.45)	0.006	

Adjusted for sex, body mass index, living area, smoking habits, drinking habits, chronic conditions (hypertension, diabetes mellitus, myocardial infarction and cerebral stroke), working status, walking time per day, subjective economic hardship, K6 score, AIS score and LSNS-6 score.

AIS, Athens Insomnia Scale; GEJE, Great East Japan Earthquake; K6, Kessler 6-item Psychological Distress Scale; LSNS-6, Lubben Social Network Scale; MSK, musculoskeletal; PH, prefabricated temporary housing.

By Japanese law, PHs must be used within 2 years⁶; however, the period was unavoidably extended in the case of the GEJE. After the Great Hanshin Awaji Earthquake in Japan in 1995, it took 5 years for all evacuees to move out of the PHs.³¹ The GEJE caused more serious damage, so we assumed that there were greater delays in reconstruction, resulting in prolonged PH stays. Although no study has focused on the relationship between accommodation and MSK pain among survivors, the results of the present study suggest that prolonged stays in a PH may lead to an undesirable MSK state; it may be better to shorten the lengths of redundant PH stay. Public-funded accommodation should be provided to survivors as early as possible after a disaster. Additionally, while survivors are forced to reside in PHs, lifestyle and exercise-related guidance should be provided to improve physical activity levels and prevent MSK pain.

This study had several limitations. First, the response rate to the questionnaire was not high as the questionnaire was mailed to the survivors. Some of them may have been evacuated to other locations; therefore, it was difficult to conduct a follow-up of the participants' living status. Second, the responders may have been more concerned about maintaining a healthy lifestyle, and the occurrence of pain may be less common among them than among non-responders. Third, we assessed for pain using only the self-administered survey responses of the survivors. The severity or pathology of the pain, and disabilities caused by the pain were not assessed because we needed to make the questionnaire simple to enhance the collection rate. Further, the pain was assessed at two periods only, and changes at other points were not assessed, which meant that the chronicity of the pain was not evaluated. Finally, reverse causality could not be ruled out.

In conclusion, continued residence in a PH was associated with new-onset MSK pain among survivors. Public support and guidance are required for symptom management.

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Contributors YaS participated in the design of the study and statistical analysis of the data and wrote the manuscript. YH is the corresponding author of this study. YH participated in the design of the study and helped to draft and edit the manuscript. YY and TS participated in the design of the study. YuS and MT participated in data collection and helped to analyse the data and draft the manuscript. MK, NI, SY, TY and EI helped to draft the manuscript. IT conceived the study, collected the data, and helped to analyse the data and draft and edit the manuscript. All authors read and approved the final manuscript.

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Competing interests None declared.

Patient consent for publication Obtained.

Ethics approval The study protocol was reviewed and approved by the Ethics Committee of Tohoku University Graduate School of Medicine (no. 201192).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available in a public, open-access repository.

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