Original Contribution

Does Type of Residential Housing Matter for Depressive Symptoms in the Aftermath of a Disaster? Insights From the Great East Japan Earthquake and Tsunami

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The 2011 Great East Japan Earthquake and Tsunami resulted in widespread property destruction and over 250,000 displaced residents. We sought to examine whether the type of housing arrangement available to the affected victims was associated with a differential incidence of depressive symptoms. In this prospective cohort study, which comprised participants aged ≥65 years from Iwanuma as a part of the Japan Gerontological Evaluation Study, we had information about the residents' mental health both before the disaster in 2010 and 2.5 years afterward. The Geriatric Depression Scale was used. Type of accommodation after the disaster was divided into 5 categories: no move, prefabricated housing (temporary housing), existing private accommodations (temporary apartment), newly established housing, and other. Poisson regression analysis was adopted, with and without multiple imputation. Among the 2,242 participants, 16.2% reported depressive symptoms at follow-up. The adjusted rate ratio for depressive symptoms among persons moving into prefabricated housing, compared with those who did not, was 2.07 (95% confidence interval: 1.45, 2.94). Moving into existing private accommodations or other types of accommodations was not associated with depression. The relationship between living environment and long-term mental health should be considered for disaster recovery planning.

depression; disasters; housing; mental health; older adults; stress; survivors

Abbreviations: GDS, Geriatric Depression Scale; JAGES, Japan Gerontological Evaluation Study; MI, multiple imputation.

Natural disasters are increasing in frequency (1–3). Growing research has shown an association between natural disasters and mental health problems (4–8). Depression commonly co-occurs with posttraumatic stress disorder in exposed victims (9, 10). Mental health problems following natural disasters tend to continue for several years and affect the cognitive and behavioral functions of the survivors (11–13).

Abrupt changes in living environment are hypothesized to contribute to persistent mental health problems among victims. Moreover, psychological trauma is associated with property damage/loss and forced relocation that uproots residents from their communities, thereby severing local social ties and contributing to social isolation. Previous studies have confirmed the influence of disaster-related relocation experience on depressive symptoms (14–16).

However, to our knowledge, no studies have examined whether a specific type of accommodation following relocation predicts the onset and persistence of depressive symptoms. For example, it is not known whether housing displaced victims in existing private accommodations is better than providing them with temporary housing (similar to the trailer parks built by the US Federal Emergency Management Agency in the wake of Hurricane Katrina) (15) while more permanent accommodations are being built. In addition, few studies have been able to document the mental health status of displaced victims prior to the disaster (16). Recall of predisaster mental states by victims

is undoubtedly subject to information bias. Furthermore, most studies on mental health after disasters have reported on short-term outcomes (14, 17).

Understanding the possible influence of residential type on mental health after a disaster can potentially assist policymakers when they need to provide housing after a disaster. We took advantage of a unique "natural experiment" in which we had information about the mental health status of community-dwelling seniors 7 months before the 2011 Great East Japan Earthquake and Tsunami. Taking advantage of this design, we examined the association between type of accommodation after the disaster and the subsequent emergence of depressive symptoms among older survivors.

METHODS

Study design and participants

The Japan Gerontological Evaluation Study (JAGES) was established in 2010 as a nationwide, population-based prospective cohort study of older community-dwelling Japanese adults (18–20). This longitudinal study used panel data from 2 surveys. The baseline survey was conducted between August 2010 and January 2012 among 141,452 older people (ages ≥65 years). Self-administered questionnaires were mailed to the entire population of 10 municipalities, and for 14 municipalities, the questionnaires were mailed to randomly selected members of the population, sampled from the official residential registers. A total of 92,272 people responded to the questionnaire (response rate = 65.2%) (20). The follow-up survey was conducted between October and December 2013. A total of 62,438 individuals completed both the 2010 and 2013 questionnaires (20).

One of the original JAGES field sites was Iwanuma City, located approximately 80 km west of the 2011 earthquake epicenter (16, 21). On the day of the disaster, 180 residents of the city were killed, while 48% (29 km^2) of the land was inundated by seawater (22). Approximately 5,000 houses in the city were completely or partially destroyed by the disaster, and large numbers of survivors were forced to relocate (23). Questionnaires were mailed to all residents of the city aged 65 years or older in August 2010 (i.e., 7 months before the disaster) and again after the disaster in October 2013. The rate of response to the baseline survey was 59.0% (n = 4,957) (Figure 1). Of these individuals, 34 people lost their lives on the day of the disaster, and an additional 400 people had died of natural causes by the time of the follow-up survey. After exclusion of people who moved out of the area (n = 92), were lost to follow-up with no known forwarding address (n = 17), or were too sick to be recontacted (n = 34), a total of 4,380 people were eligible for the follow-up survey. Among them, 3,594 people responded to the second survey (response rate = 82.1%). After exclusion of invalid consent forms, 3,567 people participated in both surveys in 2010 and 2013, and the participation rate was 81.4% (21) (Figure 1).

For our analysis, we excluded participants who reported limitations in Activities of Daily Living, were receiving public long-term care insurance benefits, or had already experienced depressive symptoms (as defined by Geriatric Depression Scale (GDS) score ≥5 at the time of the baseline survey in 2010) in order to identify newly developed depressive symptoms during the follow-up period. Approximately 2.5 years after the disaster, we carried out a follow-up survey. Among the 3,567 participants, 3,464 answered 7 or more questions on the GDS at baseline and follow-up. From these individuals, our analytical sample comprised 2,242 participants who reported being free of depressive symptoms at baseline.

Outcome variable: onset of depressive symptoms following disaster

Our primary outcome was the incidence of depressive symptoms as measured by the Japanese short version of the GDS, which has been previously validated as a screening instrument for major depressive disorder (sensitivity = 0.97, specificity = 0.95, Cronbach's α = 0.80) (24, 25). It has also been found to be a good predictor of health status, including cognitive function and dementia (26, 27). Following the previous research, we imputed the overall score based on the average of the available items for handling the missing values (16). Participants were classified into 2 groups in the follow-up survey: no depressive symptoms (GDS score <5) and having depressive symptoms (GDS score ≥5) (18, 25, 28–31).

Predictor variable: type of residential accommodation after the disaster

In the follow-up survey, each participant was asked about his/her experience of relocation and the type of accommodation provided after the disaster with the question "Did you move to a new residence after the earthquake?," for which the possible responses were: 1) no; 2) moved into prefabricated housing; 3) moved into existing private accommodations, either paid for by the survivor or subsidized by the government; 4) purchased or built a new home; and 5) other. From these responses, 2 models were established for considering the relationship between the "move" per se and the type of accommodation (models A and B). In model A, the responses were categorized as "no move" or "moved" (combining responses 2–5), while model B broke out the different types of accommodations.

Covariates: sociodemographic characteristics and disaster damage

We adjusted for sociodemographic characteristics and disaster damage in the analyses. Information on age and sex was obtained from the government register. Information on educational level, living status (alone or not alone), and self-rated health was obtained from the self-report questionnaire at baseline. Household income was equivalized to adjust for differences in household size—that is, to correct for the fact that 2 households at the same level of income can have different standards of living depending on the number of people in the household. We used the standard procedure of dividing gross household income by the square root of the number of people in the household (32). Housing damage was assessed by asking respondents to evaluate the extent of property damage on a scale from "not affected" to "minor damage," "major damage," or "total collapse." These categories were themselves based on an individual inspection made by 2 assessors for the purpose of government compensation. Participants were asked about loss of relationships due to the disaster, with multiple possible answers, and results were
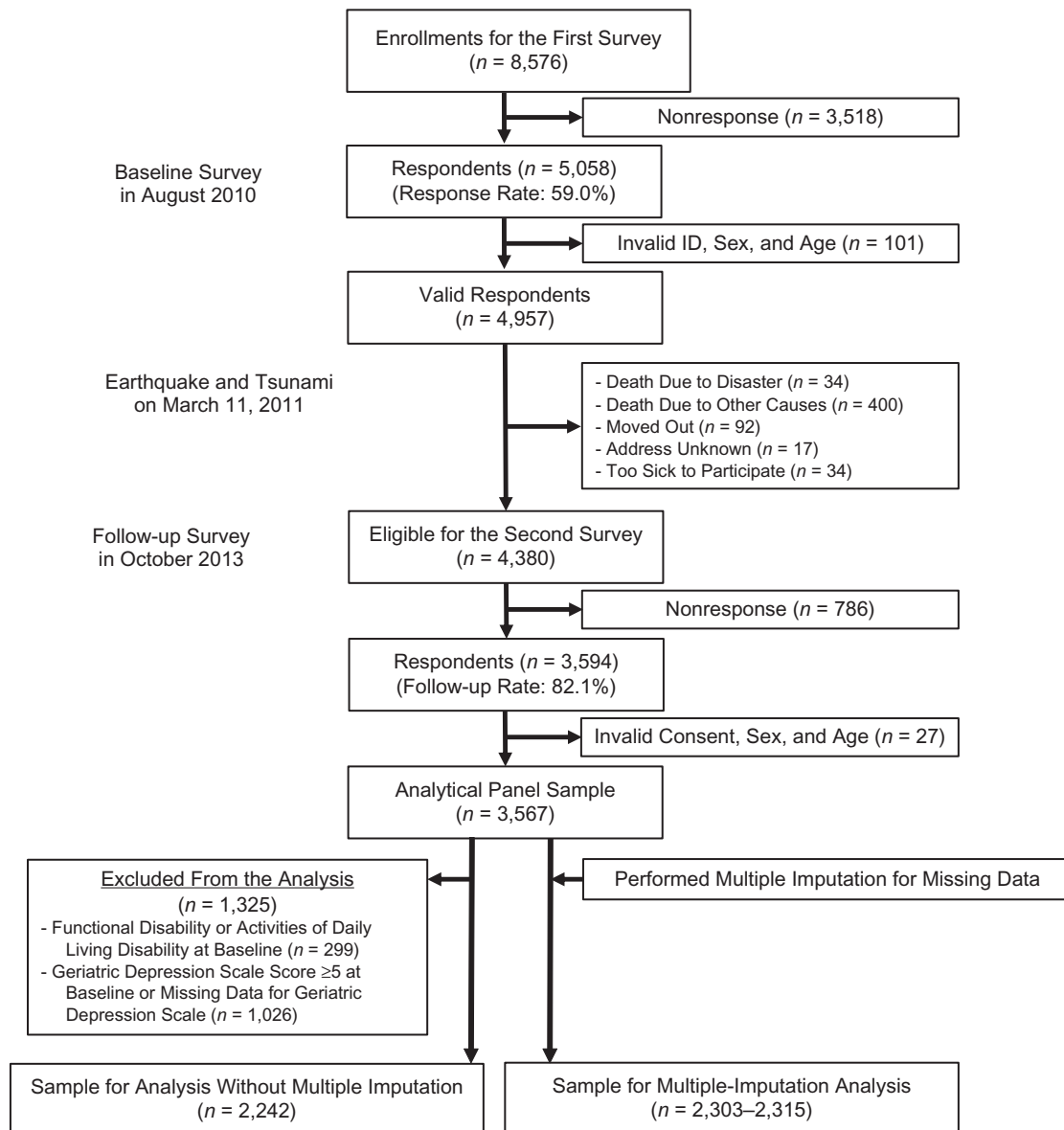
Figure 1.   Selection of participants for a study (with and without multiple imputation analysis) of the association between housing type and depressive symptoms after the 2011 Great East Japan Earthquake and Tsunami, Iwanuma, Japan, 2010–2013. ID, identification.

categorized as 1) losing close relatives or not and 2) losing close friends or not.

Statistical analysis

We first determined participants' sociodemographic characteristics. We then performed multiple imputation (MI) with multivariate normal regression and generated 20 imputed data sets for the multiple regression analysis. Because the cumulative incidence rate of depressive symptoms was over 10%, odds ratios obtained by means of ordinary logistic regression might have overestimated the risk (19, 33). Therefore, we used Poisson regression analysis with a robust error variance to estimate crude

and adjusted rate ratios for the association between type of accommodation and the presence of depressive symptoms (34, 35).

Results are presented with and without MI. Based on the 2 ways of classifying exposure (models A and B), the following 3 models were constructed: Models A1 and B1 adjusted the results for age and sex; models A2 and B2 additionally adjusted for self-rated health, educational level, equivalized income, and living status; and models A3 and B3 further adjusted for the experience of disaster damage. Tables 2 and 3 show results from the crude and final models. We used IBM SPSS Statistics 23 (SPSS Inc., Chicago, Illinois) and STATA14 (StataCorp LP, College Station, Texas) for statistical analyses and set the statistical significance level at $P < 0.05$.

Ethical consideration

The survey protocol was approved by the human subjects committee of the Harvard T.H. Chan School of Public Health, as well as those of Tohoku University, Nihon Fukushi University, and Chiba University. Informed consent was obtained at the time of data collection.

RESULTS

The average age of participants was 73 years (Table 1). Among the eligible 2,242 participants, 363 experienced depressive symptoms at follow-up (cumulative incidence of depressive symptoms = 16.2%). The majority of participants did not move after the disaster (93%), while 1.9%, 0.8%, and 1.6% moved into prefabricated housing, existing private accommodations, and newly established housing, respectively. The distribution of sociodemographic variables in the MI data was close to that in the original data, although the rate of moving into prefabricated housing was slightly higher in the former (see Web Table 1, available at https://academic.oup.com/aje).

Table 2 shows the association between type of accommodation after the disaster and the presence of depressive symptoms with MI. In the final model (model A3), participants who moved into new accommodations were around 1.5 times more likely to report depressive symptoms than those who did not move (adjusted rate ratio = 1.51, 95% confidence interval: 1.14, 2.00). When type of accommodation was considered, moving into prefabricated housing had about a 30% stronger association with depressive symptoms than any other type of relocation (in the final model, adjusted rate ratio = 2.07, 95% confidence interval: 1.45, 2.94).

Table 3 shows the results obtained without MI. Although the point estimates of the parameters were different from those of the results with MI due to the difference in the variable distribution between the original and multiply imputed data sets (Web Table 1), similar trends as those obtained with the MI data set emerged.

DISCUSSION

This cohort study, in which we had information on both pre- and postdisaster mental health status, enabled us to determine that 16% of the JAGES participants affected by the earthquake and tsunami in Iwanuma City developed symptoms of depression. Regarding the representativeness of our data, the percentages of survivors who moved into prefabricated housing (1.9%) or existing private market accommodations (0.8%) were quite comparable to those of the population surveillance carried out in Iwanuma City (2.0% and 0.7%, respectively) (36–38). This comparison supports the representativeness of our data.

Older survivors who are affected by natural disasters have a higher risk of developing depressive symptoms than those in other age groups, as has been shown in previous studies (39–41). Our finding further supports the hypothesis that relocation after a natural disaster is associated with the development of depressive symptoms, and that furthermore the type of accommodation matters. Although the point estimates were fairly similar among persons who moved into existing private accommodations, newly established housing, or other arrangements, moving into prefabricated housing was significantly associated with a higher level of depressive symptoms. Even in the analysis restricted to people who relocated, those who moved into prefabricated housing had a greater risk of depressive symptoms than those who moved into the other types of accommodations (Web Table 2).

Our study included participants who did not move into new accommodations despite housing damage after the disaster. Housing damage after natural disasters is known to be a risk factor for depressive symptoms (16). Our study included such participants in the reference group: the nonrelocation group. If none of the survivors in the reference group experienced housing damage, the proportion of depressive symptoms among those who did not move might be lower than the result obtained in this study. Thus, the association between the onset of depressive symptoms and relocation might have been underestimated in this study.

We can put forward 3 potential explanations for the ciation between moving into prefabricated housing and increased depressive symptoms: 1) physical environmental factors (such as noise due to thin walls); 2) social factors (such as lack of privacy in conjunction with feeling socially isolated); 3) and psychological factors (such as uncertainty about the future).

A previous study showed that housing quality significantly influenced mental health status (42). Prefabricated housing units provided by the local government after the 2011 earthquake and tsunami were similar in construction to Federal Emergency Management Agency trailers; that is, they were container-shaped units that had 1 dining area and 1 kitchen (around 30 m^2) with a toilet and private bath. An air conditioner was also installed in the room (43). A wall separated each unit from the adjoining unit and afforded residents some privacy. These units also provided survivors with a space for returning to their normal daily activities, such as cooking, housekeeping, working, socializing, and storing belongings (44–46). In Iwanuma City, basic amenities such as grocery stores and health facilities also tended to be conveniently accessible from these locations.

In addition, we assessed social participation by asking whether residents participated in any type of organization, including political, industry/trade, religious, volunteer, sports, and hobby groups, neighborhood associations, and senior citizens' clubs (47, 48). The rate of participation in these groups was higher among persons who moved into prefabricated housing than among those who moved into existing private accommodations (83.3% vs. 72.2%) (data not shown). This tendency was also seen in the official government reports that investigated social participation among residents living in prefabricated housing versus existing private accommodations (49).

On the other hand, the design of prefabricated housing emphasizes structural safety and fast production. These types of housing units may fail to meet the real needs and expectations of survivors who live in them for long periods of time (46). Local government reports documented residents' complaints about living conditions in the prefabricated housing units, such as lack of adequate lighting, heating, ventilation, space, privacy, a bathtub, etc. (50). Living in prefabricated housing for a prolonged period of time, therefore, may have contributed to the development of depressive symptoms. People who moved into prefabricated housing were more likely to experience stress

Table 1. Sociodemographic Characteristics of Participants in a Study of the Association Between Housing Type and Depressive Symptoms After the 2011 Great East Japan Earthquake and Tsunami ($n = 2,242$[a]), Iwanuma, Japan, 2010–2013

Variable	No. of Persons	%
GDS score at follow-up in 2013		
<5	1,879	83.8
≥5	363	16.2
Type of residence after earthquake		
No move	2,084	93.0
Prefabricated housing	42	1.9
Existing private accommodations	19	0.8
Newly established housing	36	1.6
Other	10	0.4
Missing data	51	2.3
Age, years[b]	73 (5.8)	
Sex		
Male	1,039	46.3
Female	1,203	53.7
Self-rated health		
Good	351	15.7
Relatively good	1,661	74.1
Relatively bad	198	8.8
Bad	16	0.7
Missing data	16	0.7
Education, years		
≥13	501	22.3
10–12	993	44.3
6–9	669	29.8
<6	18	0.8
Missing data	61	2.7
Equivalized income[c]		
High	213	9.5
Middle	869	38.8
Low	812	36.2
Missing data	348	15.5
Living status		
Not alone	2,039	90.9
Alone	158	7.0
Missing data	45	2.0
Bereavement		
Loss of close relative(s)		
No loss	1,639	73.1
Loss	603	26.9
Loss of close friend(s)		
No loss	1,880	83.9
Loss	362	16.1

Table continues

Table 1. Continued

Variable	No. of Persons	%
Housing damage[d]		
No damage	931	41.5
Damage	1,268	56.6
Missing data	43	1.9

Abbreviation: GDS, Geriatric Depression Scale.

[a] Participants with limitations in performing Activities of Daily Living (i.e., independent walking, bathing, and, toileting) and participants receiving public long-term care insurance benefits were excluded. Participants who had mild or more severe depression (GDS score ≥5) in the baseline survey of 2010 were also excluded.

[b] Value is expressed as mean (standard deviation).

[c] Household income was equivalized to adjust for differences in household size. We used the standard procedure of dividing gross household income by the square root of the number of people in the household (32).

[d] Housing damage was assessed by asking respondents to evaluate the extent of property damage on a scale from "not affected" to "minor damage," "major damage," or "total collapse."

stemming from the perceived overcrowded housing conditions (51). On the other hand, existing private accommodations obtained through the open market may provide a better living environment than prefabricated housing, since survivors who move into them can select their residence and have better chances to live in well-structured residences than those who move into prefabricated housing. Previous studies have indicated that forced relocation itself is a stressful event, while voluntary relocation is less stressful, and that people who have some choice in selecting their accommodations are less likely to be stressed than those who do not (14, 52). Thus, there is a possibility that survivors who moved into existing private accommodations were better able to afford the rent and therefore had some choice in their accommodation compared with those who moved into prefabricated housing.

Furthermore, participants who live alone may be more likely to move into prefabricated housing due to its smaller space. As for the participants' age, the likelihood of living in prefabricated housing may increase with age, since it is difficult for people of an advanced age to obtain a home mortgage loan. These factors are known to be risk factors for depression (53–56), and we adjusted for these variables. We also compared persons who did not change their residence with those who moved into different types of accommodations following property damage (Web Table 3). With regard to sociodemographic characteristics, participants who moved into prefabricated housing were more likely to have a low income (62.2%) and to live alone (10%) compared with those who did not move (41.8% and 7.3%, respectively) or those who moved into existing private accommodations (50.0% and 0%, respectively). Although our analyses controlled for these observed differences, the influence of such confounding variables may not have been completely removed.

Table 2. Risk of Depressive Symptoms According to Housing Type and Other Factors (Multivariate Poisson Regression With Multiple Imputation) After the 2011 Great East Japan Earthquake and Tsunami (n = 2,303–2,315[a]), Iwanuma, Japan, 2010–2013

Variable	Model							
	Crude Results				**Adjusted Results**			
	Model A[b]		Model B[c]		Model A3[b]		Model B3[c]	
	RR	95% CI	RR	95% CI	ARR	95% CI	ARR	95% CI
Relocation after the earthquake								
No move	1	Referent	N/A	N/A	1	Referent	N/A	N/A
Move	1.91	1.47, 2.48	N/A	N/A	1.51	1.14, 2.00	N/A	N/A
Type of residence after earthquake								
No move	N/A	N/A	1	Referent	N/A	N/A	1	Referent
Prefabricated housing	N/A	N/A	2.51	1.79, 3.52	N/A	N/A	2.07	1.45, 2.94
Existing private accommodations	N/A	N/A	1.88	0.92, 3.85	N/A	N/A	1.49	0.73, 3.06
Newly established housing	N/A	N/A	1.24	0.62, 2.50	N/A	N/A	0.80	0.37, 1.69
Other	N/A	N/A	2.07	0.82, 5.21	N/A	N/A	1.40	0.55, 3.57
Age, years					1.03	1.01, 1.04	1.03	1.01, 1.04
Sex								
Male					1	Referent	1	Referent
Female					0.94	0.78, 1.14	0.94	0.77, 1.14
Self-rated health								
Good					1	Referent	1	Referent
Relatively good					1.51	1.09, 2.10	1.50	1.08, 2.09
Relatively bad					2.40	1.62, 3.55	2.40	1.62, 3.55
Bad					4.18	2.13, 8.20	4.94	2.58, 9.43
Education, years								
≥13					1	Referent	1	Referent
10–12					1.03	0.79, 1.34	1.03	0.79, 1.34
6–9					1.22	0.92, 1.62	1.23	0.92, 1.63
<6					1.59	0.74, 3.41	1.61	0.75, 3.44
Equivalized income								
High					1	Referent	1	Referent
Middle					1.11	0.74, 1.67	1.09	0.73, 1.63
Low					1.37	0.91, 2.05	1.36	0.91, 2.03
Living status								
Not alone					1	Referent	1	Referent
Alone					1.31	0.95, 1.80	1.29	0.94, 1.77
Bereavement								
Loss of close relative(s)								
No loss					1	Referent	1	Referent
Loss					1.24	1.01, 1.51	1.24	1.01, 1.52
Loss of close friend(s)								
No loss					1	Referent	1	Referent
Loss					0.96	0.74, 1.25	0.99	0.76, 1.28
Housing damage								
No damage					1	Referent	1	Referent
Damage					1.29	1.05, 1.58	1.27	1.03, 1.56

Abbreviations: ARR, adjusted rate ratio; CI, confidence interval; N/A, not available; RR, rate ratio.

[a] Numbers of multiple-imputation estimates.

[b] Model A combined the responses "prefabricated housing," "existing private accommodations," "newly established housing," and "other" with "move."

[c] Model B used responses as they were.

Table 3.   Risk of Depressive Symptoms According to Housing Type and Other Factors (Multivariate Poisson Regression Without Multiple Imputation) After the 2011 Great East Japan Earthquake and Tsunami (*n* = 2,242), Iwanuma, Japan, 2010–2013

Variable	Model							
	Crude Results				Adjusted Results			
	Model A[a]		Model B[b]		Model A3[a]		Model B3[b]	
	RR	95% CI	RR	95% CI	ARR	95% CI	ARR	95% CI
Relocation after the earthquake								
No move	1	Referent	N/A	N/A	1	Referent	N/A	N/A
Move	1.16	1.08, 1.24	N/A	N/A	1.09	1.01, 1.19	N/A	N/A
Type of residence after earthquake								
No move	N/A	N/A	1	Referent	N/A	N/A	1	Referent
Prefabricated housing	N/A	N/A	1.28	1.16, 1.42	N/A	N/A	1.26	1.13, 1.41
Existing private accommodations	N/A	N/A	1.14	0.97, 1.34	N/A	N/A	1.09	0.90, 1.32
Newly established housing	N/A	N/A	1.04	0.93, 1.16	N/A	N/A	0.89	0.79, 1.00
Other	N/A	N/A	1.13	0.91, 1.41	N/A	N/A	0.95	0.74, 1.22
Age, years					1.01	1.00, 1.01	1.01	1.00, 1.01
Sex								
Male					1	Referent	1	Referent
Female					0.99	0.96, 1.02	0.99	0.96, 1.02
Self-rated health								
Good					1	Referent	1	Referent
Relatively good					1.03	1.00, 1.07	1.04	0.99, 1.07
Relatively bad					1.13	1.06, 1.21	1.13	1.07, 1.21
Bad					1.34	1.10, 1.64	1.41	1.18, 1.70
Education, years								
≥13					1	Referent	1	Referent
10–12					1.01	0.98, 1.05	1.01	0.98, 1.04
6–9					1.04	0.99, 1.08	1.04	0.99, 1.08
<6					1.05	0.86, 1.29	1.05	0.85, 1.28
Equivalized income								
High					1	Referent	1	Referent
Middle					1.01	0.96, 1.05	1.00	0.96, 1.05
Low					1.03	0.99, 1.08	1.03	0.99, 1.08
Living status								
Not alone					1	Referent	1	Referent
Alone					1.05	0.99, 1.11	1.04	0.98, 1.10
Bereavement								
Loss of close relative(s)								
No loss					1	Referent	1	Referent
Loss					1.04	1.00, 1.07	1.04	1.00, 1.07
Loss of close friend(s)								
No loss					1	Referent	1	Referent
Loss					1.02	0.98, 1.06	1.03	0.99, 1.07
Housing damage								
No damage					1	Referent	1	Referent
Damage					1.04	1.01, 1.07	1.04	1.01, 1.07

Abbreviations: ARR, adjusted rate ratio; CI, confidence interval; N/A, not available; RR, rate ratio.

[a] Model A combined the responses "prefabricated housing," "existing private accommodations," "newly established housing," and "other" with "move."

[b] Model B used responses as they were.

Another possible mechanism which might increase the risk of developing depressive symptoms is that survivors living in prefabricated housing might be more concerned about their future, especially regarding their future housing and living costs, since they tend to have a low income and to live alone. Further investigation is needed to elucidate the association between concerns about the future and the development of depressive symptoms among older survivors living in temporary housing.

This study had 2 key strengths that contributed to understanding of the development of depressive symptoms after a disaster. First, our study design minimized recall bias by using predisaster information about mental health status. Second, we focused on the long-term consequences of the disaster, because understanding the type of accommodation influencing mental health outcomes over longer time periods is critical to supporting survivors by improving social resilience. Previous studies have focused only on short-term outcomes immediately after a disaster (14).

This study also had several limitations that must be considered. As with any study that relies on self-reporting, there is a possibility that individuals whose depressive symptoms increased during the time between the 2 surveys were also more likely to recall personal experiences of damage selectively (16). Furthermore, there was a 7-month lag between the baseline survey and the disaster. This might have resulted in some inflation of the perceived effect of the disaster on the incidence of depressive symptoms.

Second, the data did not reveal how long participants stayed in temporary housing. A previous study indicated that people who stay in temporary housing longer are more likely to be depressed (57). Information about the duration of residence in temporary housing is important in order to develop efficacious programs for preventing depression. Thus, this factor warrants further research.

Third, our estimates were based on a relatively small number of participants who relocated after the disaster. Although this small number of participants may have contributed to the difference in point estimates when the original data set was compared with multiply imputed data sets, we judged the data to be missing at random given the similar variable distributions in both data sets (Web Table 1).

Finally, the generalizability of these results may be debated because the present analyses used data from healthy older adults who responded to both the baseline and follow-up surveys. This suggests that our sample might have underrepresented participants who were more vulnerable to depressive symptoms, which may have led us to underestimate the relationship between postdisaster residential status and depressive symptoms. However, since the number of individuals who dropped out at follow-up in our data set was quite low (11.6%) due to the Japanese compulsory system of domiciliary registration—wherein all residents are required to notify authorities of address changes—the extent of bias induced by loss to follow-up might have been small (16). Given the number of residual confounding factors, our results should be interpreted with some caution.

This study has various implications. Whether relocation is a risk factor for the development of depressive symptoms among older disaster survivors seems to depend on the type of accommodation. Large-scale utilization of existing private accommodations or planned housing constructed for future disasters may contribute to maintaining the mental health of older survivors who relocate. Government policy-makers might consider giving vouchers to survivors to rent existing private accommodations—that is, provide subsidies to residents to move into existing private accommodations—although this may not be practical in every situation, depending on housing availability and the local housing supply. Moreover, the ease or difficulty of social interactions with neighbors ought to be considered when moving into existing private accommodations, given that these units can be scattered throughout a city (58).

In conclusion, we found that after the 2011 Great East Japan Earthquake and Tsunami, older survivors who moved into prefabricated housing experienced higher levels of depressive symptoms than those who did not move or moved into other types of residences. The long-term consequences of living environment on disaster survivors should be considered in strategic planning for future disasters.

REFERENCES

1. Ryan B, Franklin RC, Burkle FM Jr, et al. Identifying and describing the impact of cyclone, storm and flood related disasters on treatment management, care and exacerbations of non-communicable diseases and the implications for public health. *PLoS Curr*. 2015;7: ecurrents.dis.62e9286d152de04799644dcca47d9288. (Edition 1, September 28, 2015).
2. O'donnell ML, Forbes D. Natural disaster, older adults, and mental health—a dangerous combination. *Int Psychogeriatr*. 2016;28(1):9–10.
3. Working Group II, Intergovernmental Panel on Climate Change. *Climate Change 2001: Impacts, Adaptation, and Vulnerability*. Cambridge, United Kingdom: Cambridge University Press; 2001. http://www.ipcc.ch/ipccreports/tar/ wg2/pdf/wg2TARfrontmatter.pdf. Accessed May 29, 2016.
4. Fergusson DM, Horwood LJ, Boden JM, et al. Impact of a major disaster on the mental health of a well-studied cohort. *JAMA Psychiatry*. 2014;71(9):1025–1031.
5. Frankenberg E, Friedman J, Gillespie T, et al. Mental health in Sumatra after the tsunami. *Am J Public Health*. 2008;98(9): 1671–1677.
6. Kumar MS, Murhekar MV, Hutin Y, et al. Prevalence of posttraumatic stress disorder in a coastal fishing village in Tamil Nadu, India, after the December 2004 tsunami. *Am J Public Health*. 2007;97(1):99–101.
7. van Griensven F, Chakkraband ML, Thienkrua W, et al. Mental health problems among adults in tsunami-affected areas in southern Thailand. *JAMA*. 2006;296(5):537–548.
8. Parker G, Lie D, Siskind DJ, et al. Mental health implications for older adults after natural disasters—a systematic review and meta-analysis. *Int Psychogeriatr*. 2016;28(1):11–20.
9. Bryant R. The impact of natural disasters on mental health. *InPsych: Bull Aus Psychol Soc*. 2009;31(2):Article 1.
10. Galea S, Nandi A, Vlahov D. The epidemiology of post-traumatic stress disorder after disasters. *Epidemiol Rev*. 2005; 27(1):78–91.
11. Zhang B, Zhang F, Wang L, et al. A cross-sectional study on the current prevalence of posttraumatic stress disorder in adults orphaned by Tangshan Earthquake in 1976. *Chin Ment Health J*. 2008;(6):469–473.
12. van der Velden PG, Wong A, Boshuizen HC, et al. Persistent mental health disturbances during the 10 years after a disaster: four-wave longitudinal comparative study. *Psychiatry Clin Neurosci*. 2013;67(2):110–118.
13. Zhang LP, Zhao Q, Luo ZC, et al. Prevalence and risk factors of posttraumatic stress disorder among survivors five years after the "Wenchuan" earthquake in China. *Health Qual Life Outcomes*. 2015;13:75.
14. Lamond JE, Joseph RD, Proverbs DG. An exploration of factors affecting the long term psychological impact and deterioration of mental health in flooded households. *Environ Res*. 2015;140:325–334.
15. Singelmann J, Schafer M. Dislocation and depression: social consequences of Hurricanes Katrina and Rita. *Soc Nat Resour*. 2010;23(10):919–934.
16. Tsuboya T, Aida J, Hikichi H, et al. Predictors of depressive symptoms following the Great East Japan earthquake: a prospective study. *Soc Sci Med*. 2016;161:47–54.
17. Norris FH. *Methods for Disaster Mental Health Research*. New York, NY: Guilford Press; 2006.
18. Tani Y, Sasaki Y, Haseda M, et al. Eating alone and depression in older men and women by cohabitation status: the JAGES longitudinal survey. *Age Ageing*. 2015;44(6):1019–1026.
19. Tani Y, Fujiwara T, Kondo N, et al. Childhood socioeconomic status and onset of depression among Japanese older adults: the JAGES prospective cohort study. *Am J Geriatr Psychiatry*. 2016;24(9):717–726.
20. Koyama S, Aida J, Saito M, et al. Community social capital and tooth loss in Japanese older people: a longitudinal cohort study. *BMJ Open*. 2016;6(4):e010768.
21. Hikichi H, Aida J, Tsuboya T, et al. Can community social cohesion prevent posttraumatic stress disorder in the aftermath of a disaster? A natural experiment from the 2011 Tohoku Earthquake and Tsunami. *Am J Epidemiol*. 2016;183(10): 902–910.
22. Ishigaki A, Higashi H, Sakamoto T, et al. The Great East-Japan Earthquake and devastating tsunami: an update and lessons from the past Great Earthquakes in Japan since 1923. *Tohoku J Exp Med*. 2013;229(4):287–299.
23. Miyagi Prefectural Government. Situation of emergency temporary housing in Miyagi Prefecture—responses to the Great East Japan Earthquake [in Japanese]. http://dl.ndl.go.jp/info:ndljp/ pid/6009973. Published 2012. Accessed October 24, 2016.
24. Yesavage JA, Brink TL, Rose TL, et al. Development and validation of a geriatric depression screening scale: a preliminary report. *J Psychiatr Res*. 1982–1983;17(1):37–49.
25. Nyunt MS, Fones C, Niti M, et al. Criterion-based validity and reliability of the Geriatric Depression Screening Scale (GDS-15) in a large validation sample of community-living Asian older adults. *Aging Ment Health*. 2009;13(3):376–382.
26. Meara J, Mitchelmore E, Hobson P. Use of the GDS-15 geriatric depression scale as a screening instrument for depressive symptomatology in patients with Parkinson's disease and their carers in the community. *Age Ageing*. 1999; 28(1):35–38.
27. Allan LM, Rowan EN, Firbank MJ, et al. Long term incidence of dementia, predictors of mortality and pathological diagnosis in older stroke survivors. *Brain*. 2011;134(12):3716–3727.
28. Murata C, Kondo K, Hirai H, et al. Association between depression and socio-economic status among community-dwelling elderly in Japan: the Aichi Gerontological Evaluation Study (AGES). *Health Place*. 2008;14(3):406–414.
29. Schreiner AS, Hayakawa H, Morimoto T, et al. Screening for late life depression: cut-off scores for the Geriatric Depression Scale and the Cornell Scale for Depression in Dementia among Japanese subjects. *Int J Geriatr Psychiatry*. 2003;18(6): 498–505.
30. Tani Y, Kondo N, Nagamine Y, et al. Childhood socioeconomic disadvantage is associated with lower mortality in older Japanese men: the JAGES cohort study. *Int J Epidemiol*. 2016;45(4):1226–1235.
31. Kurlowicz L, Greenberg SA. The Geriatric Depression Scale (GDS). *Am J Nurs*. 2007;107(10):67–68.

32. Kawachi I, Kennedy BP. The relationship of income inequality to mortality: does the choice of indicator matter? *Soc Sci Med*. 1997;45(7):1121–1127.

33. Zhang J, Yu KF. What's the relative risk? A method of correcting the odds ratio in cohort studies of common outcomes. *JAMA*. 1998;280(19):1690–1691.

34. Institute for Digital Research and Education, University of California, Los Angeles. Poisson regression | Stata data analysis examples. http://stats.idre.ucla.edu/stata/dae/poisson-regression/. Accessed November 15, 2016.

35. Zou G. A modified Poisson regression approach to prospective studies with binary data. *Am J Epidemiol*. 2004;159(7): 702–706.

36. Statistics Bureau of Japan. *Population Census 2010. Population and Households in Iwanuma City* [in Japanese]. Tokyo, Japan: Statistics Bureau of Japan; 2011. https://www.city.iwanuma.miyagi.jp/shisei/tokei/joho/documents/1kinrinjinnkou.pdf. Accessed January 15, 2017.

37. Japan Overseas Cooperative Association and Iwanuma City. *Smile Support Center in Iwanuma City* [in Japanese]. Tokyo, Japan: Japan Overseas Cooperative Association; 2016. www.joca.or.jp/upload/item/2503/File/brochure_160513.pdf. Accessed January 15, 2017.

38. Japan Overseas Cooperative Association. *"SATONOMORI" Support Center in Iwanuma City* [in Japanese]. Tokyo, Japan: Japan Overseas Cooperative Association; 2013. www.pref.miyagi.jp/uploaded/attachment/219840.pdf. Accessed January 15, 2017.

39. Parker G, Lie D, Siskind DJ, et al. Mental health implications for older adults after natural disasters—a systematic review and meta-analysis. *Int Psychogeriatr*. 2016;28(1):11–20.

40. Ticehurst S, Webster RA, Carr VJ, et al. The psychosocial impact of an earthquake on the elderly. *Int J Geriatr Psychiatry*. 1996;11(11):943–951.

41. Jia Z, Tian W, Liu W, et al. Are the elderly more vulnerable to psychological impact of natural disaster? A population-based survey of adult survivors of the 2008 Sichuan earthquake. *BMC Public Health*. 2010;10:172.

42. Pan Y, Zhou TJ, Zhang HB, et al. Are rural residents' mental health influenced by the new countryside construction? An investigation in Chongqing, China. *Rev Cercet Interv Soc*. 2015;51:135–149.

43. Watanabe M. Living in emergency temporary housing [in Japanese]. *Tokyo Shinbun*. August 28, 2015:P4.

44. Johnson C, Lizarralde G, Davidson CH. A systems view of temporary housing projects in post-disaster reconstruction. *Constr Manage Econ*. 2006;24(4):367–378.

45. Johnson C. Strategic planning for post-disaster temporary housing. *Disasters*. 2007;31(4):435–458.

46. Félix D, Monteiro D, Branco JM, et al. The role of temporary accommodation buildings for post-disaster housing reconstruction. *J Hous Built Environ*. 2015;30(4):683–699.

47. Yazawa A, Inoue Y, Fujiwara T, et al. Association between social participation and hypertension among older people in Japan: the JAGES Study. *Hypertens Res*. 2016;39(11):818–824.

48. Aida J, Hanibuchi T, Nakade M, et al. The different effects of vertical social capital and horizontal social capital on dental status: a multilevel analysis. *Soc Sci Med*. 2009;69(4):512–518.

49. Miyagi Prefectural Government. Health survey for residents living in temporary housing [in Japanese]. http://www.pref.miyagi.jp/soshiki/kensui/oukyuukasetsujyutaku.html. Accessed October 15, 2016.

50. Ministry of Health, Labour and Welfare, Japan. Report on the living environment in temporary housing after the 2011 Great East Japan Earthquake and Tsunami [in Japanese]. http://www.mhlw.go.jp/stf/houdou/2r9852000001pw1l.html. Published 2011. Accessed October 15, 2016.

51. Chambers EC, Fuster D, Suglia SF, et al. Depressive symptomology and hostile affect among Latinos using housing rental assistance: the AHOME study. *J Urban Health*. 2015; 92(4):611–621.

52. Saito T, Lee H, Kai I. Health and motivation of elderly relocating to a suburban area in Japan. *Arch Gerontol Geriatr*. 2007;45(2):217–232.

53. Lorant V, Deliège D, Eaton W, et al. Socioeconomic inequalities in depression: a meta-analysis. *Am J Epidemiol*. 2003;157(2):98–112.

54. Hoebel J, Maske UE, Zeeb H, et al. Social inequalities and depressive symptoms in adults: the role of objective and subjective socioeconomic status. *PLoS One*. 2017;12(1):e0169764.

55. Xiu-Ying H, Qian C, Xiao-Dong P, et al. Living arrangements and risk for late life depression: a meta-analysis of published literature. *Int J Psychiatry Med*. 2012;43(1):19–34.

56. Zhao KX, Huang CQ, Xiao Q, et al. Age and risk for depression among the elderly: a meta-analysis of the published literature. *CNS Spectr*. 2012;17(3):142–154.

57. Nagata S, Matsunaga A, Teramoto C. Follow-up study of the general and mental health of people living in temporary housing at 10 and 20 months after the Great East Japan Earthquake. *Jpn J Nurs Sci*. 2015;12(2):162–165.

58. Saito Y. *Temporary Housing and Community Organization During a Disaster: Experiences Before and After the Great East Japan Earthquake*. Chiba, Japan: Japan Association of Regional and Community Studies; 2016.