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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.

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 km²) 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 participants 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
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 citation 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 m²) 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...
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 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 = 2,242a), Iwanuma, Japan, 2010–2013

| Variable | No. of Persons | % |
|----------|----------------|---|
| 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, yearsb | 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 incomec | | |
| 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 1. Continued

| Variable | No. of Persons | % |
|----------|----------------|---|
| Housing damage | | |
| 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.”
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 ($n = 2,303–2,315\text{a}$), Iwanuma, Japan, 2010–2013

| Variable                                      | Model Crude Results | Model Adjusted Results |
|-----------------------------------------------|---------------------|------------------------|
|                                               | 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 N/A | N/A N/A 1 Referent N/A |
| 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.

\(\text{a}\) Numbers of multiple-imputation estimates.

\(\text{b}\) Model A combined the responses “prefabricated housing,” “existing private accommodations,” “newly established housing,” and “other” with “move.”

\(\text{c}\) Model B used responses as they were.

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### 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      | Model B        | Model A3         | Model B3 |
|                                 | RR 95% CI    | RR 95% CI      | ARR 95% CI       | ARR 95% CI |
| Relocation after the earthquake |              |                |                  |          |
| No move                         | 1 Referent   | N/A            | 1 Referent       | N/A      |
| Move                            | 1.16 1.08,1.24 | N/A            | 1.09 1.01,1.19   | N/A      |
| Type of residence after earthquake |          |                |                  |          |
| No move                         | N/A          | N/A            | N/A              | 1 Referent |
| Prefabricated housing           | N/A          | 1.28 1.16,1.42 | N/A              | 1.26 1.13,1.41 |
| Existing private accommodations  | N/A          | 1.14 0.97,1.34 | N/A              | 1.09 0.90,1.32 |
| Newly established housing       | N/A          | 1.04 0.93,1.16 | N/A              | 0.89 0.79,1.00 |
| Other                           | N/A          | 1.13 0.91,1.41 | 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       | 0.99 0.96,1.02 |
| Female                          |              |                |                  | 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 | 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       | 0.99 1.04 |
| 10–12                           | 1.01 0.98,1.05 | 1.01 0.96,1.05 |                  |          |
| 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       | 0.96,1.05 |
| 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       | 0.98,1.10 |
| 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       | 1 Referent |
| Loss                            | 1.04 1.00,1.07 | 1.04 1.00,1.07 | 1.00 1.07 |
| Bereavement                     |              |                |                  |          |
| Loss of close friend(s)         |              |                |                  |          |
| No loss                         | 1 Referent   |                | 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       | 1 Referent |
| Damage                          | 1.04 1.01,1.07 | 1.04 1.01,1.07 | 1.01 1.07 |

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

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

* 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 post-disaster 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.

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