

# BMJ Open Moving from prefabricated temporary housing to public reconstruction housing and social isolation after the Great East Japan Earthquake: a longitudinal study using propensity score matching

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## ABSTRACT

**Objectives** After the Great East Japan Earthquake (GEJE) of 2011, many survivors have been forced to live in prefabricated temporary housing, which is uncomfortable and insufficiently durable for permanent living. Public reconstruction housing has been built to improve their living conditions; however, those moving have to rebuild personal relationships and adapt to a new environment. This study examined whether survivors moving to public reconstruction housing became more socially isolated than those remaining in prefabricated temporary housing.

**Design, setting and participants** Self-report questionnaire data collected in 2015 (4 years after the GEJE) were used as the baseline for follow-up surveys in 2016 and 2017, as many survivors moved from prefabricated temporary housing to public reconstruction housing from 2015. We analysed longitudinal data from 393 survivors, distinguishing those who moved to public reconstruction housing during the 5th year after the disaster from those who remained in prefabricated temporary housing. Participants were assessed using the Lubben Social Network Scale-6 (LSNS-6) in all three surveys, with social isolation defined by a score of <12/30. To reduce the effect of selection bias, propensity score analysis was performed (178 of 393 participants were retained). We used a generalised estimated equation to evaluate the association between moving from prefabricated temporary housing to public reconstruction housing and changes in social isolation over 2 years.

**Results** LSNS-6 scores of the reconstruction housing group were worse than those of the prefabricated housing group between 4 and 6 years after the GEJE ( $P=0.006$ ). Over the same period, social isolation worsened in the reconstruction housing group but improved in the prefabricated housing group ( $P=0.002$ ).

**Conclusions** Social isolation should be monitored while supporting survivors who moved to public reconstruction housing, and further longitudinal research is needed to clarify the risk of social isolation.

## Strengths and limitations of this study

- This is the first study to examine the association between moving to public reconstruction housing and social isolation after a natural disaster.
- This study used a longitudinal design, requiring protracted efforts from the researchers and survivors to undertake surveys in the aftermath of a disaster.
- To minimise the differences between the two groups' characteristics, participants were matched using propensity scores
- Among the 937 participants who lived in prefabricated temporary housing, the analysed population of 393 (41.9%) was relatively small.
- The participants had all lived in prefabricated temporary housing for at least 4 year, consequently, the results might suffer from overestimation.

## INTRODUCTION

Social isolation is associated with a higher risk of various physical and psychological problems, including stroke,<sup>1</sup> coronary heart disease,<sup>2 3</sup> depression,<sup>4-6</sup> mortality<sup>7 8</sup> and suicide.<sup>9</sup> Survivors of natural disasters are at higher risk of social isolation due to the death of family or friends, and evacuation from their home community. Several recent studies have focused on the importance of social networks in the recovery process after natural disasters.<sup>10 11</sup>

The Great East Japan Earthquake (GEJE), which was followed by a devastating tsunami, struck the northeastern coastal area of Japan on March 11, 2011, leaving approximately 18 500 people dead or missing.<sup>12</sup> Because the GEJE and tsunami destroyed over 390 000 houses, Japanese municipal governments began to build prefabricated temporary

housing during the acute phase after the calamity.<sup>13</sup> Approximately 120 000 survivors were forced to live in this housing.<sup>14</sup> As the coastal areas are at a higher risk of future tsunamis, local governments have prevented the rebuilding of towns where survivors previously lived, insisting instead that new towns be developed for them on mountainsides or at a higher elevation along the coast.<sup>13</sup> Due to the length of time required to accomplish these recovery plans,<sup>15</sup> many survivors have been forced to live in prefabricated temporary housing for several years after the GEJE.<sup>14</sup>

Public reconstruction housing plays an important role in providing permanent houses for the survivors of natural disasters, as demonstrated after the Hanshin-Awaji Earthquake in 1995.<sup>16</sup> From around 4 years after the disaster, many survivors who were initially accommodated in prefabricated temporary housing started to move to public reconstruction housing.<sup>17</sup> Their new surroundings require them to rebuild personal relationships and to adapt to a different environment. An increase in suicide and dying alone (*kodoku-shi*, in Japanese) was highlighted among residents of public reconstruction housing during the recovery phase following the Hanshin Awaji Earthquake.<sup>18</sup> Therefore, it is crucial to monitor such psychosocial issues following the GEJE. However, no study has yet focused on the social isolation of GEJE survivors relocated to public reconstruction housing. This study aims to examine whether survivors who moved to public reconstruction housing became more socially isolated compared with those who remained in prefabricated temporary housing after the GEJE.

## METHODS

### Study design and participants

Study participants comprised GEJE survivors (aged 18 or over) who lived in the severely damaged coastal areas of Ogatsu and Oshika in Ishinomaki city, and Wakabayashi ward in Sendai city, all situated in Miyagi Prefecture.<sup>19</sup> The design of this panel study was reported in detail elsewhere.<sup>20</sup> Health surveys involving an interview questionnaire and health check-up were conducted from June to November 2011, and ongoing questionnaire surveys have been repeated every 6 months thereafter. A self-report questionnaire and form for obtaining informed consent were mailed to all participants in the surveys analysed in his study.

Data from the questionnaire survey completed from November 2014 to February 2015 (4 years after the GEJE) were used as baseline data in this study, because many residents initially accommodated in prefabricated temporary housing have moved to public reconstruction housing. Approximately 30% of the survivors had been living in prefabricated temporary housing 4 years after the GEJE. The proportion has decreased gradually (21% and 10.4% after 5 and 6 years after the GEJE); on the contrary, the proportion of the survivors who lived in public reconstruction housing has increased (2.1%,

9.0%, and 13.1% after 4, 5 and 6 years after the GEJE). Among the 2762 individuals who responded to the questionnaire, 937 lived in prefabricated temporary housing at that time. We excluded one participant who did not respond to questions concerning social isolation. Among the 936 remaining participants, we excluded 117 who did not respond to the questionnaire survey conducted from November 2015 to January 2016 (1 year after baseline; 5 years after the GEJE). We then excluded a further 11 who did not respond to questions on their living environment, and 123 who did not live in either prefabricated housing or public reconstruction housing. Among the 688 participants who lived in prefabricated temporary housing (555) or public reconstruction housing (133), 72 did not respond to the questionnaire survey conducted from November 2016 to January 2017 (2 years after baseline; 6 years after the GEJE), and so were excluded. We then excluded eight who did not respond to questions on their living environment, 115 who no longer lived in prefabricated temporary housing or public reconstruction housing, 99 who moved house between the questionnaire surveys conducted 5 and 6 years after the GEJE, and one who did not respond to the LSNS-6 questions. Thus, a total of 393 participants were included in the analysis (figure 1).

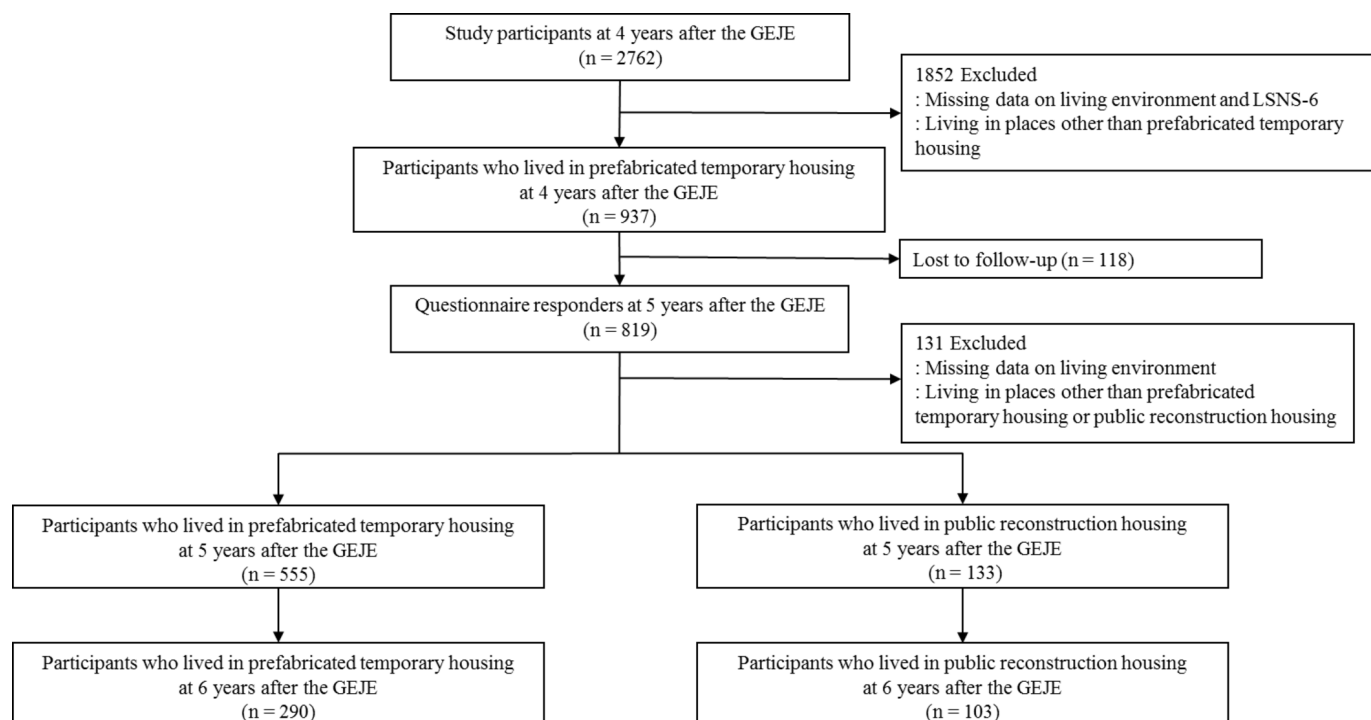
## Measurements

### Exposure: moving to public reconstruction housing

Local governments around the GEJE-affected areas recruited survivors whose houses were completely destroyed, and who were unable to rebuild their houses, to live in public reconstruction housing, allowing the survivors to decide for themselves. Participants' living environment at 4, 5 and 6 years after the GEJE was determined through a self-report questionnaire. We divided the participants into two groups: survivors who moved from prefabricated temporary housing to public reconstruction housing during the 5th year after the GEJE ('the reconstruction housing group') and those who continued to live in prefabricated temporary housing ('the prefabricated housing group').

### Outcome: social isolation

The Lubben Social Network Scale (LSNS-6) has been widely used to assess social integration and to screen for social isolation.<sup>21</sup> The reliability and validity of the Japanese version of LSNS-6 has previously been confirmed.<sup>22</sup> The measure comprises a set of three questions that evaluate family ties and a comparable set of three questions that evaluate friendship ties: (1) 'How many relatives do you see or hear from at least once a month?'; (2) 'How many relatives do you feel close to such that you could call on them for help?'; (3) 'How many relatives do you feel at sufficient ease with to talk about private matters?'; (4) 'How many of your friends do you see or hear from at least once a month?' (5) 'How many friends do you feel close to such that you could call on them for help?' or (6) 'How many friends do you feel sufficiently at ease with to



**Figure 1** Flow diagram of the participants. GEJE, Great East Japan Earthquake; LSNS-6, Lubben Social Network Scale-6.

talk about private matters?’ The possible responses and their scores are: ‘none’ (0 points), ‘one’ (one point), ‘two’ (two points), ‘three or four’ (three points), ‘five to eight’ (four points) and ‘nine or more’ (five points). The total score thus ranges from 0 to 30. As suggested by Lubben *et al.*,<sup>21</sup> we classified individuals with scores of less than 12 as being socially isolated.

### Covariates

The following variables at baseline (4 years after the GEJE) were included in the analysis as covariates: sex, age, body mass index (BMI; calculated using self-reported height and weight values), working status, drinking habits, smoking habits, physical activity (walking time per day), complications (hypertension, myocardial infarction, diabetes mellitus, or cerebral stroke), number of families living together, subjective economic hardship and psychological distress. Subjective economic hardship was assessed by the question: ‘How do you feel about the current state of your household economy?’ Available responses were ‘fair’, ‘poor’, ‘poorer’ and ‘poorest’.<sup>14 23</sup> Psychological distress was defined by a score of  $\geq 10/24$  on the Kessler Psychological Distress Scale-6 (K6).<sup>24</sup>

### Statistical analysis

To determine the impact of moving into public reconstruction housing and to reduce the effect of selection bias, propensity score analysis was performed using the following algorithm.<sup>25</sup> Possible confounders were chosen for their potential association with the outcome based on clinical knowledge. Propensity scores were estimated using a logistic regression model with the following variables: sex (male or female), age ( $<65$  years

old or  $\geq 65$  years old), BMI ( $<18.5$ ,  $18.5$  to  $25$ , or  $\geq 25$ ), working status (unemployed or employed), drinking habits (non-drinker,  $<45.6$  g of alcohol/day, or  $\geq 45.6$  g of alcohol/day), smoking habits (non-smoker or smoker), walking time per day ( $<30$  min/day,  $30$  min to  $<1$  hour/day or  $\geq 1$  hour/day), complications (hypertension, myocardial infarction, diabetes mellitus and/or cerebral stroke), number of families living together ( $1$ ,  $2$ ,  $3$  to  $4$  or  $\geq 5$ ), subjective economic hardship (fair, or poor to poorest), psychological distress (K6 score:  $<10$  or  $\geq 10$ ). For cases with missing values for a confounding variable, we created a separate missing category and included this in the model. The variables to be inserted into the multivariate models to calculate propensity scores were determined after screening for multicollinearity. According to their propensity scores, participants were matched in a 1-to-1 manner using the greedy nearest neighbour method. The area under the curve (AUC) and the Hosmer-Lemeshow test were calculated to respectively assess the model’s performance and calibration.

Categorical variables were summarised as percentages. Continuous variables were summarised as means with SD. A  $\chi^2$  test for categorical variables and Student t-test for continuous variables were conducted to compare baseline characteristics between the groups. A generalised estimated equation (GEE) was used to evaluate the association between moving from prefabricated temporary housing to public reconstruction housing and changes in social isolation. This model takes into account the relationship between repeated measurements for each individual. To gain a clearer picture of the association between moving to public reconstruction housing and

any change in social isolation, we considered the LSNS-6 as (1) continuous (total scores of the LSNS-6), and (2) binary (socially isolated or not socially isolated) variables. Furthermore, the internal consistency of the LSNS-6 and K6 was assessed using Cronbach's alpha coefficient.

All statistical analyses were performed using SPSS V.24.0 (SPSS Japan Inc., Tokyo, Japan). A *p* value of <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 disseminated the final results to the participants after the results are published in a peer-reviewed journal.

## RESULTS

### Propensity score matching and baseline

Of the 393 participants, 103 (26.2%) were in the reconstruction housing group and 290 (73.8%) were in the prefabricated housing group (figure 1). Participants' characteristics before propensity score matching are shown in table 1. Before matching, the participants in

**Table 1** Baseline characteristics according to changes in living environment before matching (n=393)

Living environment	Baseline*	Prefabricated temporary housing		P values
	Follow-up†	Prefabricated temporary housing 290	Public reconstruction housing 103	
Sex (%)	Male	47.2	47.6	0.95
	Female	52.8	52.4	
Age (continuous)		62.1 (16.5)	60.0 (15.3)	0.27
Age (%)	<65 years old	43.1	52.4	0.1
	≥65 years old	56.9	47.6	
BMI (continuous)		24.3 (3.8)	23.7 (3.8)	0.86
BMI (%)	<18.5	2.5	3	0.73
	18.5–24.9	57.7	61.6	
	≥25	39.8	35.4	
Working status (%)	Unemployed	53.7	53.9	0.97
	Employed	46.3	46.1	
Drinking habits (%)	Non-drinker	65.9	66.7	0.13
	<45.6 g of alcohol/day	23.9	29.3	
	≥45.6 g of alcohol/day	10.2	4.0	
Smoking habits (%)	Non-smoker	77.8	77.1	0.88
	Smoker	22.2	22.9	
Walking time/day (%)	<30 min	32.8	38.8	0.54
	30 min–1 hour	36.6	33.0	
	≥1 hour	30.7	28.2	
Complications (%)	presence	15.5	22.3	0.12
Subjective economic status (%)	Fair	25.8	26.2	
	Poor to poorest	74.2	73.8	0.049
Families live together (%)	1	14.7	12.6	
	2	37.9	44.7	
	3–4	34.0	38.8	
	≥5	13.3	3.9	
Psychological distress (%)	K6 scores:<10	83.9	78.4	0.22
	K6 scores:≥10	16.1	21.6	

\*Baseline: 4 years after the GEJE. The study participants had lived prefabricated temporary housing up to 4 years after the GEJE.

†Follow-up: 5 and 6 years after the GEJE.

BMI, body mass index; GEJE, Great East Japan Earthquake.



**Table 2** Baseline characteristics according to changes in living environment after matching (n=178)

Living environment	Baseline*	Prefabricated temporary housing		P values
	Follow-up†	Prefabricated temporary housing 89	Public reconstruction housing 89	
Sex (%)	Male	51.7	46.1	0.55
	Female	48.3	53.9	
Age (continuous)		61.1 (17.3)	60.7 (15.4)	0.35
Age (%)	<65 years old	47.2	49.4	0.88
	≥65 years old	52.8	50.6	
BMI (continuous)		24.3 (4.2)	23.7 (3.8)	0.37
BMI (%)	<18.5	1.2	2.4	0.95
	18.5–24.9	61.6	61.6	
	≥25	37.2	36.0	
Working status (%)	Unemployed	57.3	54.5	0.57
	Employed	42.7	44.9	
Drinking habits (%)	Non-drinker	65.5	68.2	0.92
	<45.6g of alcohol/day	31.0	27.1	
	≥45.6g of alcohol/day	3.5	4.7	
Smoking habits (%)	Non-smoker	79.3	79.6	0.85
	Smoker	20.7	20.4	
Walking time/day (%)	<30 min	36.0	38.2	0.73
	30 min–1 hour	38.2	32.6	
	≥1 hour	25.8	29.2	
Complications (%)	presence	24.7	21.3	0.72
Subjective economic status (%)	Fair	23.6	24.7	0.86
	Poor to poorest	76.4	75.3	
Families live together (%)	1	12.4	14.6	0.89
	2	48.3	43.8	
	3–4	33.7	37.1	
	≥5	5.6	4.5	
Psychological distress (%)	K6 score:<10	77.0	81.8	0.62
	K6 score:≥10	23.0	18.2	

\*Baseline: 4 years after the GEJE. The study participants had lived prefabricated temporary housing up to 4 years after the GEJE.

†Follow-up: 5 and 6 years after the GEJE.

BMI, body mass index; GEJE, Great East Japan Earthquake.

the reconstruction housing group were more likely to be living with five and more families than those in the prefabricated housing group. Participants in the reconstruction housing group tended to be younger than those in the prefabricated housing group, with no statistical significance. To minimise the differences between the two groups' baseline characteristics, participants were matched using propensity scores. The AUC was 0.70, and the Hosmer-Lemeshow test was 0.23. Finally, 178 out of 393 participants remained in the analysis. Among these participants, there were no significant differences in the baseline characteristics, nor any statistical differences in the covariates between the two groups (table 2).

### Longitudinal analysis: changes in social isolation between the reconstruction housing and prefabricated housing groups

The two groups' LSNS-6 scores across the three data collection points (4, 5 and 6 years after the GEJE) are shown in table 3. At the baseline (4 years post-GEJE), mean LSNS-6 scores did not differ significantly between the reconstruction housing and prefabricated housing groups (table 3). However, the GEE analysis showed that, over the subsequent 2 years, LSNS-6 scores worsened in the reconstruction housing group but slightly improved in the prefabricated housing group (table 3).

The rate of social isolation (LSNS-6 scores <12/30) across the three data collection points are shown in

**Table 3** Association between moving to public reconstruction housing and the Lubben Social Network Scale after the Great East Japan Earthquake

Living environment	Baseline	Prefabricated temporary housing		$\beta$	95% CI	P values
	Follow-up	Prefabricated temporary housing	Public reconstruction housing			
LSNS-6		89	89			
Baseline*		14.01 (5.9)	14.0 (5.5)	−0.966	−1.66 to −0.27	0.006
1-year follow-up†		14.4 (6.1)	13.3 (5.7)			
2-year follow-up‡		14.3 (5.7)	12.4 (5.9)			

Data presented are mean scores (SD).

\*Baseline: 4 years after the GEJE.

†1year follow-up: 5 years after the GEJE.

‡2year follow-up: 6 years after the GEJE.

GEJE, Great East Japan Earthquake; LSNS-6, Lubben Social Network Scale-6.

**table 4.** At the baseline, the rate of social isolation did not differ significantly between the public housing and prefabricated housing groups (**table 4**). However, the GEE analysis showed, over the subsequent 2years, social isolation of the reconstruction housing group worsened whereas it improved in the prefabricated housing group (**table 4**).

In order to check robustness of the results, non-matched data analysis was conducted in the same manner. There were no significant differences found between the results of matched and non-matched data (online supplementary tables S1 and S2). The Cronbach's alpha coefficient for LSNS-6 ranged from 0.71 to 0.74, and that for K6 ranged from 0.88 to 0.89 during the 2-year study period.

## DISCUSSION

In the present study, we examined the changes in social isolation between survivors who moved to public reconstruction housing during the 5th year after the GEJE and those who continued to live in temporary prefabricated

housing. LSNS-6 scores deteriorated more among the former than the latter group, and the social isolation rate (LSNS-6 score <12) also increased more in the former group.

Sone *et al* previously reported that 24.9% and 26.0% of survivors were socially isolated at 1 and 3years, respectively, after the GEJE. They also found a longitudinal association between social isolation and psychological distress.<sup>24</sup> Compared with their study, our data show a higher prevalence of social isolation at 4years after the GEJE (34.3%). One likely cause of this difference is the participants' living environment: our study focused on survivors who had lived in prefabricated temporary housing for at least 3years; however, the previous study analysed the living environment data of all survivors, without any limitations.<sup>24</sup> Our study's participants would have been forced to live in prefabricated temporary housing of similar areas for longer periods than participants of the previous study; therefore, the rate of social isolation at 4years after the GEJE was higher than that of the previous study.

**Table 4** Relation between moving to public reconstruction housing and the proportion of social isolation after the Great East Japan Earthquake

Living environment	Baseline	Prefabricated temporary housing		OR	95% CI	P values
	Follow-up	Prefabricated temporary housing	Public reconstruction housing			
Social isolation		89	89			
Baseline*		36.0%	32.6%	1.67	1.22 to 2.29	0.002
1-year follow-up†		27.0%	40.4%			
2-year follow-up‡		24.7%	43.8%			

\*Baseline, 4 years after the GEJE.

†1year follow-up: 5 years after the GEJE.

‡2year follow-up: 6 years after the GEJE.

GEJE, Great East Japan Earthquake.

There are several possible explanations for the apparent association between moving to public reconstruction housing and increased social isolation. First, the survivors participating in this study had continued to live in temporary housing for more than 3 years due to the high risk of future tsunamis affecting coastal areas. A one-level prefabricated temporary house consists of five to 10 units, with one or two rooms in each unit. Such houses are likely smaller than the survivors' former residences,<sup>14</sup> which can give them greater chances of seeing each other, resulting in the nurturing of interpersonal relationships. For those survivors subsequently relocated to public reconstruction housing, relationships built after the GEJE were destroyed, requiring them to again build new personal relationships. This could cause social isolation to increase. Second, residential forms differ substantially between public reconstruction housing and prefabricated temporary housing. Prefabricated temporary housing, which is designed for the practical purpose of fast erection, takes the form of a relatively small shelter, which could be conducive to the formation of relationships among survivors.<sup>14</sup> By contrast, public reconstruction housing, which is intended to be permanent, takes the form of an apartment or a detached house. While inherently a more secure and stable form of housing, survivors occupying these properties may find it more difficult to build relationships within their neighbourhood. Third, the aims of public reconstruction housing and temporary housing differ. Since the main purposes of the former include promoting self-reliance among survivors, social support and social events held by volunteer groups and/or local governments might be weakened among survivors living in public reconstruction housing. Some strategies might be useful to eliminate social isolation, such as collective relocation and early moving plan. However, there would be several issues such as land acquisition, location condition, project funds and culture adaptation during the planning process.

Several studies have demonstrated that the strength of social networks can aid both short-term and long-term disaster recovery.<sup>26–28</sup> Koyama *et al* concluded that the method of moving to temporary housing is an important predictor of access to social support.<sup>13</sup> Our study suggested that moving to public reconstruction housing could put people at risk of having less social support in an ordinary manner after the GEJE. The approach for survivors who have been moved to public reconstruction housing should be more intense and thoroughly focused on improving disaster recovery to reduce suicide and dying alone, which were highlighted after the Hanshin Awaji Earthquake.<sup>18</sup>

This study has several strengths. First, it is the first to examine the association between moving to public reconstruction housing and social isolation among survivors of a natural disaster. Second, this study used a longitudinal design, requiring protracted efforts from the researchers and survivors to undertake surveys in the aftermath of the GEJE. Conversely, our study has several limitations. First, in absolute terms, our sample size of 393 was relatively

small. Second, as a proportion of the 937 participants who lived in prefabricated temporary housing at 4 years after the GEJE, the analysed population of 393 (41.9%) was relatively small, so our findings could be influenced by the healthy participant effect. Third, the participants had all lived in prefabricated temporary housing for at least 4 years. Since they had lived in the similar area, this study might overestimate their social ties existing in the GEJE-affected area. The survivors have been recruited by local governments to live in public reconstruction housing and decided to move to public reconstruction housing. There were some prioritisations (eg, aged households, families with children and with disabilities) to move to public reconstruction housing. Furthermore, low-income, vulnerable and older populations are often excluded from permanent housing programmes and choose to stay in temporary housing,<sup>29</sup> which could lead to overestimation. However, the proportions of participants with social isolation (LSNS-6 <12) between the analysed and excluded participants did not differ substantially (34.3% vs 32.1%).

## CONCLUSION

Survivors who moved from prefabricated temporary housing to public reconstruction housing during the 5th year after the GEJE suffered greater social isolation compared with those who continued to live in prefabricated temporary housing. Although public reconstruction housing is important for providing permanent and safe housing to survivors of natural disasters, it is also necessary to consider the reconstruction of social and interpersonal ties. Continuous social care should be provided to survivors relocated to public reconstruction housing.

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**Patient consent for publication** Obtained.

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