



Living in temporary housing and later psychological distress after the Great East Japan Earthquake of 2011: A cross-lagged panel model

Ryo Morishima^a, Satoshi Usami^b, Shuntaro Ando^{a,c}, Tomoki Kiyono^a, Masaya Morita^a, Shinya Fujikawa^a, Tsuyoshi Araki^{a,*}, Kiyoto Kasai^a

^a The Department of Neuropsychiatry, Graduate School of Medicine, The University of Tokyo, Tokyo, Japan

^b The Graduate School of Education, University of Tokyo, Tokyo, Japan

^c The Department of Psychiatry and Behavioral Science, Tokyo Metropolitan Institute of Medical Science, Tokyo, Japan

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ABSTRACT

Living in temporary housing is a risk factor for psychological distress after a natural disaster. As temporary housing is an essential resource for those affected by disasters, investigation of factors which potentially mediate living in temporary housing and psychological distress is needed. This is a cohort study in general population of areas affected by the Great East Japan Earthquake in 2011. Data were obtained from self-report questionnaires in annual health checks between 2014 and 2016 regarding residential situation (e.g., prefabricated or privately-rented temporary housing), psychological distress, sleep disturbances, social support, and covariates. Mediation effects of sleep disturbances and social support on the relationship between temporary housing and psychological distress were evaluated using a cross-lagged panel model during three time points. Among 3,116 participants in 2014, approximately 12% lived in prefabricated or privately-rented temporary housing. Living in prefabricated ($\beta = 0.046$, $p = 0.031$) and privately-rented temporary housing ($\beta = 0.043$, $p = 0.042$) predicted later psychological distress. There was no mediation effect by sleep disturbances (prefabricated temporary housing: $\beta = 0.001$, $p = 0.620$; privately-rented temporary housing: $\beta = -0.001$, $p = 0.467$) or social support (prefabricated temporary housing: $\beta < 0.001$, $p = 0.748$; privately-rented temporary housing: $\beta < 0.001$, $p = 0.435$). CLPM also showed no relationship between living in temporary housing and increased sleep problems or decreased social support. Mental health support may be required for residents who lived in prefabricated or privately-rented temporary housing three years after a natural disaster, whereas support focusing only on sleep disturbances or social support in residents who lived in temporary housing may not be enough to contribute to reducing psychological distress.

1. Introduction

Natural disasters influence mental health (Ando et al., 2017; Tang et al., 2014), and living in temporary housing has been identified as a risk factor for psychological distress after a natural disaster (Ito et al., 2016; Morishima et al., 2019; Murakami et al., 2017; Sasaki et al., 2018). The Great East Japan Earthquake occurred on March 11, 2011, off the Pacific coast of northeastern Japan. About 90,000 residents lived in prefabricated or privately-rented temporary housing for six years following the earthquake (Reconstruction Agency, 2017), suggesting that these major types of temporary housing are essential resources for those affected by natural disasters over the long-term. Addressing factors which mediate living in temporary housing and psychological

distress may be effective for prevention of long-term psychological distress in those living in areas affected by natural disasters.

While no study has investigated mediators on the relationship between temporary housing and psychological distress, sleep disturbances and insufficient social support may mediate this relation. Residents who lived in temporary housing were more likely to experience sleep disturbances and social isolation than those who lived in other situation such as same house as before the earthquake or reconstructed housing (Ito et al., 2016; Murakami et al., 2017; Yabe et al., 2018), and in turn these predicted later psychological distress (Chou et al., 2007; Kanehara et al., 2016; Matsuyama et al., 2016). However, a bidirectional rather than unidirectional model may be suitable for a statistical estimation of the relationships between psychological distress, sleep disturbance, and

* Corresponding author. 7-3-1 Hongo, Bunkyo-ku, Tokyo, 113-8655, Japan.
E-mail address: taraki-tyk@umin.ac.jp (T. Araki).

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insufficient social support. Some previous studies on areas affected by natural disasters suggested associations of psychological distress with sleep disturbances or poor social interaction (Geng et al., 2019, 2018; Hikichi et al., 2017; Lowe et al., 2015). These findings suggested another possibility that sleep disturbances and poor social support for residents who lived in temporary housing might be explained by underlying psychological distress.

Furthermore, the type of temporary housing may be associated with further increased psychological distress. Temporary housing in affected areas is classified broadly as either prefabricated or privately-rented temporary housing. Evacuees who could not continue to live in their own house could move into either type of temporary housing. Evacuees could choose either of the two options: 1) individual relocation or 2) group relocation with members of the same community, considering factors such as housing type, family size, or convenience. Prefabricated temporary housing is a free-rent and simple structure house, built based on the Disaster Relief Act. Privately-rented temporary housing is a system to provide evacuees with normal private rental housing located outside the affected area, and paid for by the government (or subsidized by the government while the evacuees looked for rental housing) during two years after relocated. In many cases, residents in privately-rented temporary housing settled in a community where non-victimized people were dominant. Both types of temporary housing were associated with psychological distress in the residents (Morishima et al., 2019), while some studies reported that residents who lived in one type of temporary housing had higher psychological distress than those in another type of housing (Murakami et al., 2017; Ito et al., 2016; Kusama et al., 2019). Promoting temporary housing residents' mental health may thus necessitate considering the effect of the type of temporary housing on psychological distress.

The present study aimed to evaluate the effects of candidate mediators such as sleep disturbances and social support on the relationship between temporary housing and psychological distress in an area affected by the Great East Japan Earthquake. In addition, the effect of the type of temporary housing on psychological distress was evaluated. We used a cross-lagged panel model (CLPM) to investigate the reciprocal relationship between sleep disturbances, social support, and psychological distress. We hypothesized that the relationship between living in prefabricated or privately-rented temporary housing and subsequent psychological distress would be partially mediated by sleep disturbances and social support.

2. Methods

2.1. Study design

The present study used data of a cohort study starting at 2012 and collecting from annual health checks in Higashi-Matsushima city, Miyagi prefecture. The city is located in the coastal area of northeastern Japan, and suffered serious damage during the Great East Japan Earthquake in 2011. Approximately 65% of the area was flooded by the huge tsunami caused by the earthquake, and more than 1,000 of 40,000 residents lost their lives. Time 1 (T1) in the present study was three years after the disaster (between May 15 and June 16, 2014), and time 2 (T2) and time 3 (T3) were conducted on around the same dates in 2015 and 2016, respectively. Because the start of data collection regarding residential situations was in 2014, we used data from 2014 to 2016.

Data were collected using self-report questionnaires. An investigation letter and self-report questionnaire were delivered to city residents who were eligible for the annual health check conducted by the city. Those who received the health check filled out the questionnaire and brought it to the health check venue.

2.2. Participants

The eligibility criteria for the participants was residents in the

Higashi-Matsushima city who were 19 years or older, and who were enrolled in either national health insurance or late stage elderly medical insurance. Those who matched the eligibility criteria were invited for the health checks. National health insurance in Japan is designed for people who are not eligible for any employment-based health insurance program (e.g., self-employed workers, part-time workers). Late stage elderly medical insurance in Japan is designed for individuals aged 75 and older, and for those between 65 and 74 years of age recognized as having a designated level of disability. Therefore, the participation rate for annual health checks was high in older individuals.

A total of 10,937, 10,469, and 10,215 residents, who had met the eligibility criteria, were invited for the health checks in 2014, 2015, and 2016, respectively, of which 3321 (30.4%), 3364 (32.1%), and 3347 (32.8%) participated in each survey. A total of 5,347 residents participated in at least one survey between 2014 (T1) and 2016 (T3).

We collaborated with the municipal government of Higashi-Matsushima and the public health center, and the center provided follow-up support for residents who had serious mental health problems and required care.

2.3. Measurements

2.3.1. Psychological distress

Psychological distress was measured for all time points using the Kessler 6 scale (K6), a six-item screening measure for nonspecific psychological distress during the past 30 days (Kessler et al., 2002). The participants rated the items (e.g., "During the past 30 days, about how often did you feel so depressed that nothing could cheer you up?") on a five-point Likert-type scale ranging from "none of the time" (0) to "all of the time" (4). The score was calculated by summing all responses, with a possible range of 0 to 24. Higher scores indicated more severe psychological distress. People who scored more than 20 received at least one follow-up telephone call and/or visit by community health nurses from the public health center.

2.3.2. Residential situation

Residential situation at T1 and T2 was assessed by participants selecting from the following list: "prefabricated temporary housing," "privately-rented temporary housing," "disaster public housing (which is an independent house built for disaster victims)," "own home," or "others."

2.3.3. Sleep disturbance

Sleep disturbances were measured for all time points by four dichotomous questions regarding current sleep problems including difficulty falling asleep, nocturnal awakening, early morning awakening, and daytime sleepiness. Total scores for sleep disturbances ranged from 0 to 4. Higher scores indicated having a higher number of current sleep problems.

2.3.4. Social support

Social support was assessed at all time points using two questions. First, to assess if participants had access to an individual who could offer consultation on mental health issues, they were asked a dichotomous question (Yes/No): "Do you have anyone for consulting about your mental health?" Individuals who answered "yes" were coded as 1 (defined as presence of a person to consult about mental health); whereas those who answered "no" were coded as 0.

If participants responded "Yes," they were also asked the following multiple-choice question: "Please choose those who consult about your mental health." The multiple choices were as follows: (1) family, (2) friends, (3) colleagues, (4) welfare commissioners (social workers), (5) staff of support centers for affected people, (6) public health nurses or psychological care support staff, (7) medical institution staff, and (8) others. Presence of any person consulting about mental health was defined as "1", and each response was summed up yielding the total

score of social support ranged from 0 to 8. Higher scores indicated having more person who consult about present mental health.

2.3.5. Covariates

Covariates obtained at T1 of this study included age, sex, presence of cohabitants (Yes/No), working status, and house damage. Working status was categorized into “working 4 days or more in a week,” “working 1 to 3 days in a week,” or “others.” Participants who were unemployed, homemakers, or students were classified as “other.” Self-rated damage to participants’ house was evaluated using a five-point Likert-type scale (“total collapse,” “extensive collapse,” “partial collapse,” “partial damage,” and “no damage”), and was treated as a continuous variable. Higher scores indicated more severe house damage caused by the disaster. In addition, loss of family or relative (Yes/No) due to the disaster was obtained at T3.

2.4. Statistical analysis

Descriptive statistics of variables were first calculated. Analysis of variance (ANOVA) and a Bonferroni post hoc test were used to evaluate mean differences in psychological distress between residential situations at baseline (T1).

Mediation analysis using a cross lagged panel model (CLPM) was conducted to examine the direct effects of prefabricated and privately-rented temporary housing, indirect effects mediated by sleep disturbances and social support (total score), and total effects on subsequent psychological distress (Fig. 1). CLPM, usually estimated by structural equation modeling, can simultaneously examine the effects of the potential mediators on reciprocal relationships between variables over time. Structural equation modeling is generally considered to be a useful tool if one is interested in uncovering a wide range of different effects and pathways across an entire set of variables for several different outcomes (VanderWeele, 2012). Under the assumption of missing at random in the main analysis, the parameters in the CLPM were estimated using the full information maximum likelihood (FIML) method, a popular approach for structural equation modeling to account for missing data (Schafer & Graham, 2002). This method can provide

unbiased estimates for the hypothesized model if data are missing at random (MAR; the probability of missing depends on observed quantities), by setting a likelihood function for each individual based on the variables that were actually observed. We evaluated model fit using the comparative fit index (CFI) and root mean square error of approximation (RMSEA). Criteria of CFI >0.9 and RMSEA <0.1 were used to evaluate the adequacy of model fit (Hu & Bentler, 1999; MacCallum et al., 1996).

For the purpose of the present study, we created two dummy variables from the residential situation to indicate whether the participants were living in prefabricated temporary housing (1) or not (0), and whether they were living in privately-rented temporary housing (1) or not (0). Both dummy variables were simultaneously included in the model to contrast the effects of having lived in the prefabricated or privately-rented temporary housing with other residential situations (i. e., reference group) (Suits, 1957). The direct effect is the effect of living in each temporary housing at T1 on psychological distress at T3 in the model (path c in Fig. S1). The indirect effect is the product (path a x path b in Fig. S1) of the coefficient of living in temporary housing at T1 on a mediator (sleep disturbance or social support) at T2 (path a in Fig. S1), and the coefficient of the mediator at T2 on psychological distress at T3 (path b in Fig. S1). Total effect is the sum of the direct effects and the indirect effects.

We conducted three sensitivity analyses to assess the robustness of the obtained results, according to the choice of the analytical approaches. First, the total score of social support in the CLPM was replaced by binary items from each question: the presence of a person to consult about mental health (Yes/No), and the person to consult about mental health (e.g., family).

Second, to assess a potential effect of analytical approaches, multi-variable regression analyses were conducted. In the analyses, residential situation was categorized into three levels: “non-temporary housing” (i. e., disaster public housing, own home, and others) = 0 (reference), “prefabricated temporary housing” = 1, and “privately-rented temporary housing” = 2. Four steps of the multivariable regression analyses on the relationship between residential situation at T1 and psychological distress at T3 were conducted as follows: (1) adjusted for covariates (age, gender, without cohabitants, working status, and house damage)

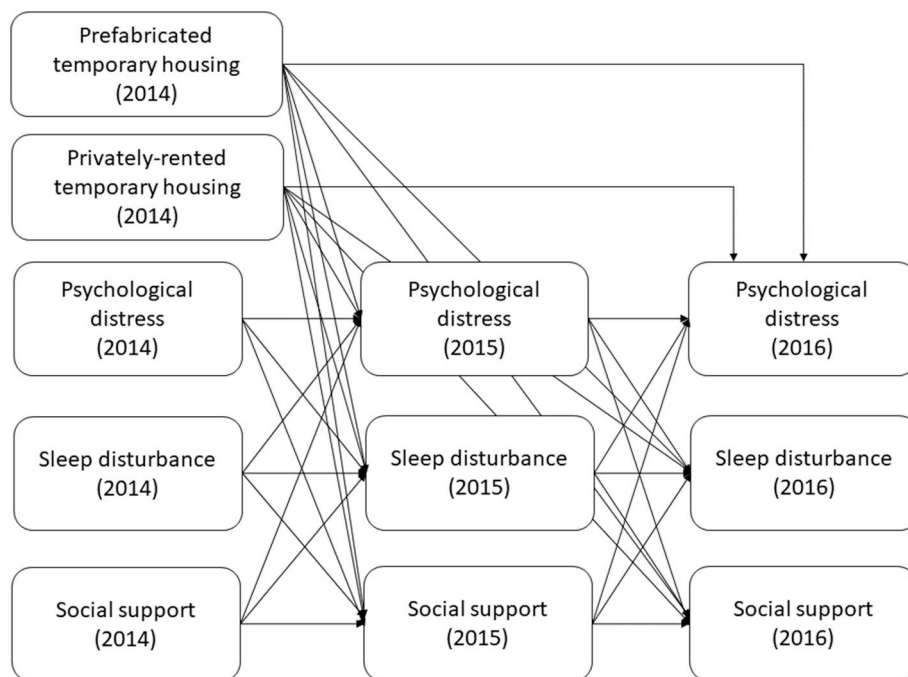


Fig. 1. Cross-lagged panel model of the relationship between prefabricated/privately-rented temporary housing, sleep disturbance, social support, and psychological distress. Paths of covariances between exogenous variables and of residual covariances, and residuals are omitted from the figure.

Table 1
Descriptive statistics of the study participants (Total N = 5347).

			missing/number of participants in each survey
Age, mean (sd)	65.3	(12.7)	22/3321
Female Sex, N (%)	1812	(54.9)	21/3321
Type of housing, N (%)			205/3321
Prefabricated temporary housing	268	(8.6)	
Privately-rented temporary housing	98	(3.1)	
Disaster public housing	24	(0.8)	
Own home	2640	(84.7)	
Other	86	(2.8)	
House damage at the disaster, mean (sd)	3.7	(1.2)	304/3321
House damage at the disaster, N (%)			304/3321
Total collapse	1093	(36.2)	
Extensive collapse	676	(22.4)	
Partial collapse	636	(21.1)	
Partial damage	459	(15.2)	
No damage	153	(5.1)	
Without Cohabitants, N (%)	274	(8.7)	162/3321
Working Status, N (%)			1241/3321
4 days and above	676	(32.5)	
1 to 3 days	158	(7.6)	
Other	1246	(59.9)	
Loss of family or relative (2016), N (%)	1094	(36.5)	348/3347
Psychological distress in 2014, mean score (sd)	3.3	(4.0)	178/3321
Psychological distress in 2015, mean score (sd)	3.0	(3.8)	153/3364
Psychological distress in 2016, mean score (sd)	3.2	(3.9)	172/3347
Sleep disturbance in 2014, mean number (sd)	1.3	(1.0)	0/3321
Sleep disturbance in 2015, mean number (sd)	1.3	(1.0)	0/3364
Sleep disturbance in 2016, mean number (sd)	1.3	(1.0)	0/3347
Social support in 2014, mean number (sd)	1.1	(0.9)	0/3321
Social support in 2015, mean number (sd)	1.2	(0.9)	0/3364
Social support in 2016, mean number (sd)	1.2	(0.9)	0/3347

and psychological distress at T2, (2) adjusted for the variables in model 1 and sleep disturbance at T2, (3) adjusted for the variables in model 1 and social support at T2, (4) adjusted for the variables in model 1, and sleep disturbance and social support at T2. If the estimated effect was largely different from the previous model, the adjusted variables could be viewed as changing the results. Missing data were handled using listwise deletion in these sensitivity analyses. Because missing often occurred in covariates such as presence of cohabitants or not, working status, house

Table 2
Estimation results of direct, indirect, and total effects of prefabricated/privately-rented temporary housing in 2014 on psychological distress in 2016.

mediators	β	b	SE	p-value	Lower 95% CI	Upper 95% CI
<i>Prefabricated temporary housing</i>						
Total	0.047	0.669	0.305	0.029	0.070	1.268
Direct	0.046	0.660	0.305	0.031	0.061	1.258
Indirect						
Sleep disturbance in 2015	0.001	0.010	0.021	0.620	-0.031	0.052
Social support in 2015	0.000	-0.002	0.005	0.748	-0.011	0.008
<i>Privately-rented temporary housing</i>						
Total	0.041	0.950	0.484	0.050	0.001	1.899
Direct	0.043	0.985	0.484	0.042	0.036	1.934
Indirect						
Sleep disturbance in 2015	-0.001	-0.023	0.032	0.467	-0.087	0.040
Social support in 2015	0.000	-0.011	0.014	0.435	-0.039	0.017

β , standardized regression coefficient; b, regression coefficient; SE, standard error; CI, confidence interval. Bold text represents statistical significance.

damage, and loss of family or relative (Table 1), the multivariable regression models were further conducted after we imputed such missing data (Table S12).

Third, to assess whether the direct effects of living in each temporary housing at T1 on psychological distress at T3 could be explained by the long stay at temporary housing or not, multivariable regression analyses were conducted. In these models, four groups were defined using the dummy variables of prefabricated or privately-rented temporary housing at T1 and T2 as follows: (1) individuals who had not lived in each temporary housing at either T1 or T2 (“continued non-temporary housing”) were coded as “1”, (2) individuals who had lived in each temporary housing only at T1 (“prefabricated/privately-rented temporary housing in 2014 only”) were coded as “2”, (3) individuals who had lived in each temporary housing only at T2 (“prefabricated/privately-rented temporary housing in 2015 only”) were coded as “3”, and (4) individuals who had lived in each temporary housing at both time points (“continued prefabricated/privately-rented temporary housing”) were coded as “4”. These four groups were used as a single categorical variable and individuals who were classified as “continued non-temporary housing” (coded as “1”) were used as a reference group. Missing data were also handled by listwise deletion. Further multivariable regression models were also conducted using imputed covariates (Table S12).

A significance level was set to $\alpha = 0.05$ for all analyses. All statistical analyses were conducted using R version 3.6.1 (R Foundation for Statistical Computing, Vienna, Austria), and CLPM was fit to the data using the lavaan package in R.

3. Results

3.1. Subject characteristics

Descriptive statistics of study participants and the amount of missing data in each survey per number of participants in each survey are shown in Table 1. The mean age was 65.3 years (standard deviation, $sd = 12.7$), and 54.9% of participants were female. Approximately 12% of participants lived in prefabricated or privately-rented temporary housing at T1. The mean scores of K6 and number of sleep disturbances and social support for participants were almost unchanged from T1 to T3.

The mean scores of psychological distress at T1 were 4.86 ($sd = 4.63$), 4.04 ($sd = 4.20$), 3.91 ($sd = 3.60$), 3.05 ($sd = 3.87$), and 3.85 ($sd = 4.52$) in prefabricated temporary housing, privately-rented temporary housing, disaster public housing, own home, and other, respectively. The one-way ANOVA revealed a significant effect of residential situation at T1 on psychological distress at T1 ($F(4,2954) = 13.615, p < 0.001$). The Bonferroni post hoc test showed that residents in prefabricated temporary housing scored significantly higher on psychological distress than those in their own home ($p < 0.001$).

Table 3
Estimation results in the cross-lagged panel model.

	<i>B</i>	<i>b</i>	SE	<i>p</i> -value	Lower 95% CI	Upper 95%CI
Psychological distress (2016)						
Psychological distress (2015)	0.666	0.688	0.017	0.000	0.654	0.721
Sleep disturbance (2015)	0.071	0.275	0.064	0.000	0.150	0.401
Social support (2015)	-0.014	-0.065	0.073	0.373	-0.208	0.078
Prefabricated temporary housing	0.046	0.660	0.305	0.031	0.061	1.258
Privately-rented temporary housing	0.043	0.985	0.484	0.042	0.036	1.934
Sex	0.014	0.111	0.148	0.452	-0.178	0.401
Age	0.034	0.011	0.008	0.204	-0.006	0.027
House damage	0.040	0.129	0.066	0.051	-0.001	0.259
Without cohabitant	0.031	0.439	0.274	0.110	-0.099	0.977
Working Status	0.040	0.172	0.119	0.146	-0.060	0.405
Loss of family or relative	0.031	0.255	0.129	0.048	0.002	0.507
Sleep disturbance (2016)						
Psychological distress (2015)	0.093	0.025	0.005	0.000	0.014	0.035
Sleep disturbance (2015)	0.475	0.471	0.018	0.000	0.436	0.507
Social support (2015)	-0.033	-0.039	0.021	0.066	-0.081	0.003
Prefabricated temporary housing	-0.003	-0.011	0.083	0.896	-0.173	0.151
Privately-rented temporary housing	0.011	0.063	0.130	0.628	-0.191	0.317
Sex	-0.004	-0.008	0.042	0.841	-0.091	0.074
Age	0.034	0.003	0.002	0.238	-0.002	0.007
House damage	0.020	0.016	0.019	0.385	-0.020	0.053
Without cohabitant	0.004	0.015	0.076	0.841	-0.134	0.164
Working Status	0.092	0.103	0.033	0.002	0.039	0.167
Loss of family or relative	0.026	0.055	0.036	0.123	-0.015	0.126
Social support (2016)						
Psychological distress (2015)	-0.080	-0.018	0.005	0.000	-0.027	-0.009
Sleep disturbance (2015)	-0.019	-0.016	0.016	0.317	-0.048	0.016
Social support (2015)	0.472	0.475	0.018	0.000	0.440	0.510
Prefabricated temporary housing	0.056	0.176	0.072	0.014	0.036	0.317
Privately-rented temporary housing	-0.008	-0.039	0.112	0.726	-0.259	0.181
Sex	0.075	0.133	0.036	0.000	0.061	0.204
Age	0.006	0.000	0.002	0.842	-0.004	0.004
House damage	-0.004	-0.003	0.016	0.866	-0.034	0.029
Without cohabitant	-0.051	-0.160	0.065	0.014	-0.288	-0.032
Working Status	0.022	0.021	0.028	0.450	-0.034	0.077
Loss of family or relative	0.027	0.049	0.031	0.120	-0.013	0.110
Psychological distress (2015)						
Psychological distress (2014)	0.674	0.638	0.015	0.000	0.608	0.668
Sleep disturbance (2014)	0.074	0.283	0.063	0.000	0.160	0.406
Social support (2014)	-0.026	-0.116	0.069	0.094	-0.252	0.020
Prefabricated temporary housing	-0.012	-0.172	0.250	0.491	-0.661	0.317
Privately-rented temporary housing	0.009	0.200	0.377	0.595	-0.538	0.938
Sex	0.039	0.305	0.124	0.014	0.063	0.548
Age	-0.059	-0.018	0.007	0.009	-0.031	-0.005
House damage	0.004	0.013	0.055	0.815	-0.095	0.121
Without cohabitant	0.005	0.068	0.220	0.758	-0.364	0.500
Working Status	0.014	0.059	0.102	0.561	-0.141	0.259
Loss of family or relative	0.026	0.213	0.141	0.131	-0.063	0.489
Sleep disturbance (2015)						
Psychological distress (2014)	0.113	0.029	0.005	0.000	0.019	0.039
Sleep disturbance (2014)	0.486	0.495	0.019	0.000	0.459	0.532
Social support (2014)	-0.028	-0.033	0.021	0.121	-0.075	0.009
Prefabricated temporary housing	0.010	0.038	0.077	0.619	-0.112	0.188
Privately-rented temporary housing	-0.014	-0.085	0.115	0.459	-0.310	0.140
Sex	-0.016	-0.033	0.038	0.395	-0.108	0.043
Age	0.046	0.004	0.002	0.074	0.000	0.008
House damage	0.016	0.013	0.017	0.437	-0.020	0.046
Without cohabitant	0.005	0.019	0.067	0.774	-0.113	0.151
Working Status	0.048	0.054	0.031	0.076	-0.006	0.115
Loss of family or relative	0.044	0.095	0.042	0.025	0.012	0.177
Social support (2015)						
Psychological distress (2014)	-0.054	-0.011	0.004	0.010	-0.020	-0.003
Sleep disturbance (2014)	-0.019	-0.016	0.017	0.342	-0.049	0.017
Social support (2014)	0.438	0.441	0.018	0.000	0.405	0.477
Prefabricated temporary housing	0.008	0.024	0.068	0.728	-0.110	0.158
Privately-rented temporary housing	0.034	0.171	0.102	0.094	-0.029	0.372
Sex	0.088	0.155	0.034	0.000	0.088	0.222
Age	0.037	0.003	0.002	0.172	-0.001	0.006
House damage	0.058	0.041	0.015	0.006	0.012	0.070
Without cohabitant	-0.032	-0.099	0.060	0.096	-0.216	0.018
Working Status	0.002	0.002	0.026	0.946	-0.050	0.053
Loss of family or relative	-0.025	-0.046	0.038	0.229	-0.121	0.029

β , standardized regression coefficient; *b*, regression coefficient; SE, standard error; CI, confidence interval. Bold text represents statistical significance.

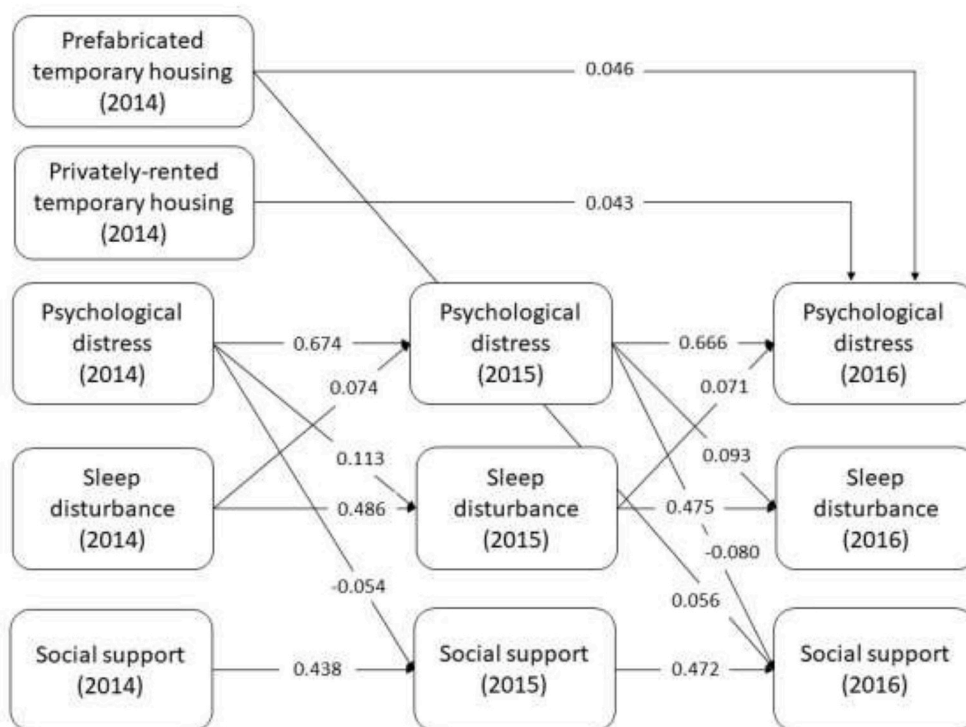


Fig. 2. Significant path coefficients of estimation results in the cross-lagged panel model. Paths of covariances between exogenous variables and of residual covariances, and residuals are omitted from the figure.

3.2. Results of mediation analysis and cross-lagged panel model

The results of mediation analysis using the CLPM are presented in Table 2. CFI and RMSEA in this model were 0.943 and 0.099, indicating acceptable model fit to the data. Direct effects of living in prefabricated as well as privately-rented temporary housing at T1 were significantly associated with increased psychological distress at T3. There was no evidence of indirect effect mediated by sleep disturbances or social support at T2.

Estimated path coefficients in the CLPM are shown in Table 3, and Fig. 2 showed significant path coefficients of estimation results in the CLPM. Estimation results of residual (co)variances are omitted here due to space limitation. Results showed the reciprocal relationship between sleep disturbance and psychological distress during three time points. Psychological distress predicted later decreased social support, whereas social support was not associated with later psychological distress. In addition, living in temporary housing at T1 was not related with psychological distress at T2, but predicted psychological distress at T3.

3.3. Sensitivity analysis

In the sensitivity analysis of CLPM using a dichotomous question of social support, almost of all results did not change (Table S1; Table S2). In this model, CFI (0.936) was acceptable level of fit to the data, but RMSEA was 0.105 indicating beyond criteria of adequacy. Further CLPM using the dichotomous question about the person to consult about mental health (e.g., family) also showed similar estimated results, whereas the direct effects of privately-rented temporary housing on subsequent psychological distress were marginally significant in some models (Tables S3–S10).

Approximately 96% of those in the non-temporary housing group in the three level variable of residential situation consisted of residents who lived in their own home (Table 1). In the multivariable regression analyses, living in prefabricated or privately-rented temporary housing at T1 was not at all or marginally related to psychological distress at T3

(Table S11). In the multivariable regression analyses with imputed covariates, living in prefabricated or privately-rented temporary housing marginally or significantly predicted psychological distress (Table S13). The effects of living in prefabricated and privately-rented temporary housing were almost unchanged from model 1 to model 4.

Multivariable regression analyses showed that continued privately-rented temporary housing group had marginally higher psychological distress than continued non-temporary housing group, while there was no significant difference between continued prefabricated temporary housing group and the reference group (model 1 in Table S14). In multivariable regression analyses with imputed covariates, compared to continued non-temporary housing group, continued prefabricated or privately-rented temporary housing group had marginally or significantly, higher psychological distress (model 2 in Table S14).

4. Discussion

To the best of our knowledge, this is the first study to evaluate the indirect effects of sleep disturbances and social support as candidate mediators on the relationship between living in temporary housing and psychological distress. We found direct effects of living in prefabricated as well as privately-rented temporary housing in 2014 on psychological distress in 2016; however, we did not find indirect effects mediated by sleep disturbances or social support in 2015. Sensitivity analyses supported these results by multivariable regression analyses, and added views that long stay of temporary housing may lead subsequent psychological distress.

Living in prefabricated as well as privately-rented temporary housing was found to be associated with later psychological distress, controlling for covariates and candidate mediators such as sleep disturbances and social support. This finding mainly focused on a comparison in the mental health condition of those living in temporary housing versus own home, because approximately 96% of “non-temporary housing group” consisted of residents who lived in their own home. There are some plausible explanations. First, loss of resources (e.g., own home, property,

social status, displacement from a familiar place) may be associated with increased psychological distress in residents of both types of temporary housing (Fussell et al., 2014; Hobfoll et al., 1989; Kiliç et al., 2006; Tang et al., 2014). Second, being unable to have future housing prospects may lead psychological distress (Nakaya et al., 2016). Perceived lack of future resource including housing may also be associated with onset of distress (Hobfoll et al., 1989). Third, for prefabricated temporary housing, poor housing structure may increase psychological distress. The Ministry of Health, Labor and Welfare in Japan reported some housing structural problems (e.g., inadequate indoor climate, neighborhood noise and less privacy due to thin wall) in prefabricated temporary housing (Ministry of Health, Labour and Welfare, Japan, 2011). A previous study focusing on low- and middle-income families in areas of the United States not affected by natural disaster indicated a relationship between such housing structural problems and psychological distress (Evans et al., 2000). Forth, for privately-rented temporary housing, economic burden may also lead to increased psychological distress. Individuals who lived in privately-rented temporary housing were shown to be more likely to have economic burdens than those who lived in other residential situations, including prefabricated temporary housing (Murakami et al., 2017; Orui et al., 2017), maybe due to the end of rent subsidy payments. In addition, living in temporary housing at 2014 was not related with psychological distress at 2015, but predicted increased psychological distress at 2016 in CLPM. Many participants who lived in temporary housing at T1, continued living in the same housing at T2, and had higher distress than others (Table S14). This finding was consistent with a previous study indicating that residents who were long stay (more than four years) of prefabricated temporary housing had higher psychological distress than those who were short to middle stay (four years or less) (Tanji et al., 2018). Residents who were long stay (more than four years) in prefabricated as well as privately-rented temporary housing might be at risk of having mental health problems.

We did not find indirect effects mediated by sleep disturbances or social support in both main analysis and sensitivity analyses. In the results of the CLPM (Table 3; Fig. 2), we did not find a relationship between living in temporary housing and increased sleep problems or decreased social support. This is not in line with the previous studies indicating the relationship between living in temporary housing and sleep disturbances or social isolation without controlling for concurrent psychological distress (Ito et al., 2016; Murakami et al., 2017; Yabe et al., 2018). The difference may be due to depending on whether those studies controlled for psychological distress. The present study examined the association between living in temporary housing in 2014 and sleep disturbances or social support in 2015, controlling for psychological distress in 2014. Additionally, some clinical support from local government was provided to residents who lived in temporary housing (Orui et al., 2017). No relationship between living in temporary housing and sleep disturbance or insufficient social support found in the present study might represent presence of clinical support being provided to participants such as staffs of public health center in the affected area. Furthermore, sleep problems in residents who lived in temporary housing might remit because they got used to the environment, while being unable to have future housing prospects which could lead psychological distress may be remained.

Additionally, the analysis of CLPM revealed a reciprocal relationship between sleep disturbances and psychological distress (Table 3; Fig. 2). This was consistent with previous studies indicating bidirectional relationships between sleep disturbances and depressive or anxiety symptoms in adolescents during a 2.5 year span following a natural disaster (Geng et al., 2018; 2019). The present study applied this bidirectional relationship to an adult sample during a five-year span in an area affected by natural disaster. Sleep disturbance and psychological distress may influence each other bidirectionally, regardless of age, residential situation, or degree of exposure to disaster. We also found that psychological distress predicted later decreased social support, but

that social support was not associated with subsequent psychological distress (Table 3; Fig. 2). These results share the same direction with some previous findings indicating the association of psychological distress with poor social interaction (Hikichi et al., 2017; Lowe et al., 2015). In areas affected by natural disasters, prevention or intervention of social isolation might be effective for focusing on residents who suffered from mental illness.

A strength of the present study is that it examined the relationship between living in temporary housing and psychological distress using a large cohort from annual health check data. The current analysis of CLPM that adequately controls covariates in inferring bidirectional relationships between sleep disturbances, social support, and psychological distress can be considered as a procedure that is effective for causal inference. Despite these strengths, some methodological limitations should be noted. First, generalizability of this study might be limited, as the participation rates at the annual health checks were not high (30.4%–32.8%). Further, an older age group was more likely to be invited to attend the health checks than a younger age group. Second, the results of CLPM with FIML should be interpreted with caution because the estimated parameters were based on the assumption that the data were missing at random, and because the hypothesized paths on the structural equation modeling would be making a strong assumption and require high statistical power. The amount of missing data for the working status variable at T1 was high, making it suspect regarding its violation of the missing at random assumption. However, working status was only used as a covariate in the present study, and the amount of missingness for the exposure, mediator, and outcome variables were low (about 6% or less) in each survey. In addition, while CLPM was used to investigate the reciprocal relationship between the mediator and outcome in the present study, the lack of any indirect effects for sleep disturbances or social support in CLPM might be due to the insufficient power of these models which generally comes at the cost of assumptions (VanderWeele, 2012). However, we did conduct these analyses using a large sample of more than 5,000 participants and perform sensitivity analyses using traditional regression-based approaches that avoid the assumption of missing at random. These analyses support the robustness of the obtained results on CLPM. Third, the measurement items for sleep disturbance and social support were not validated. Forth, the item of social support in the present study was also limited to support for mental health, and did not include other aspects, such as economic or objective support. Fifth, we also did not control for socio-economic status such as household income and educational level.

We can take several implications from the present study. Long-term mental health support may be required for those who still live in both prefabricated and privately-rented temporary housings three years after a natural disaster. Especially, the present study suggested that residents who lived in both types of temporary housing more than four years should be assessed mental health problems. Given the results of our mediation analysis, support focusing only on sleep disturbances or social support may not be enough to contribute to reducing psychological distress. Further research, with validated measurements, is needed to examine whether other potential factors (e.g., loss of resources, housing structural problems, economic burden) explain the relationship between living in temporary housing and subsequent psychological distress.

5. Conclusions

This study evaluated the mediation effects of sleep disturbances and social support on the relationship between living in prefabricated and privately-rented temporary housing and psychological distress. Living in both types of temporary housing was associated with psychological distress following the disaster, although this association was not mediated by sleep disturbances or social support. Long-term mental health support may be required for individuals who lived in both types of temporary housing three years after the disaster. Further research is required to examine the effects of potential factors (e.g., loss of

resources, housing structural problems, economic burden) on the relationship between living in temporary housing and psychological distress.

Author contributions

R.M., S.U., S.A., T.K., M.M., S.F., T.A., and K.K. conceptualized and designed the study. S.A. and T.A. acquired the data. R.M. acquired funding. R.M. and S.U. conducted the statistical analyses. R.M. wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript.

Ethical approval

The present study was approved by the Ethical Committee of the Faculty of Medicine at the University of Tokyo (approval No. 3583-(2)) and the Tokyo Metropolitan Institute of Medical Science (approval No. 14–21). Written informed consent was waived by the Ethical Committee of the Faculty of Medicine and the University of Tokyo. Instead, we declared the use of the data for the purpose of the present study on our research team web page (<http://plaza.umin.ac.jp/~youth-mh/>). Additionally, the cover page of the health check questionnaire clearly stated that the anonymous data would be used for research, so that those who wanted to be excluded from the analysis could request to do so.

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Declaration of competing interest

The authors declare that they have no competing interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmph.2020.100629>.

References

- Ando, S., Kuwabara, H., Araki, T., Kanehara, A., Tanaka, S., Morishima, R., Kondo, S., & Kasai, K. (2017). Mental health problems in a community after the Great East Japan Earthquake in 2011: A systematic review. *Harvard Review of Psychiatry*, 25(1), 15–28.
- Chou, F. H., Wu, H. C., Chou, P., Su, C. Y., Tsai, K. Y., Chao, S. S., Chen, M. C., Su, T. T., Sun, W. J., & Ou-Yang, W. C. (2007). Epidemiologic psychiatric studies on post-disaster impact among Chi-Chi earthquake survivors in Yu-Chi, Taiwan. *Psychiatry and Clinical Neurosciences*, 61(4), 370–378.
- Evans, G. W., Wells, N. M., Chan, H. Y., & Saltzman, H. (2000). Housing quality and mental health. *Journal of Consulting and Clinical Psychology*, 68(3), 526–530.
- Fussell, E., & Lowe, S. R. (2014). The impact of housing displacement on the mental health of low-income parents after Hurricane Katrina. *Social Science & Medicine*, 113, 137–144.
- Geng, F., Liang, Y., Li, Y., Fang, Y., Pham, T. S., Liu, X., & Fan, F. (2019). Bidirectional associations between insomnia, posttraumatic stress disorder, and depressive symptoms among adolescent earthquake survivors: A longitudinal multiwave cohort study. *Sleep*, 42(11). pii: zsz162.
- Geng, F., Liu, X., Liang, Y., Shi, X., Chen, S., & Fan, F. (2018). Prospective associations between sleep problems and subtypes of anxiety symptoms among disaster-exposed adolescents. *Sleep Medicine*, 50, 7–13.
- Hikichi, H., Sawada, Y., Tsuboya, T., Aida, J., Kondo, K., Koyama, S., & Kawachi, I. (2017). Residential relocation and change in social capital: A natural experiment from the 2011 Great East Japan Earthquake and tsunami. *Science Advances*, 3(7), Article e1700426.
- Hobfoll, S. E. (1989). Conservation of resources: A new attempt at conceptualizing stress. *American Psychologist*, 44(3), 513–524.
- Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, 6, 1–55.
- Ito, K., Tomata, Y., Kogure, M., Sugawara, Y., Watanabe, T., Asaka, T., & Tsuji, I. (2016). Housing type after the Great East Japan Earthquake and loss of motor function in elderly victims: A prospective observational study. *BMJ Open*, 6(11), Article e012760.
- Kanehara, A., Ando, S., Araki, T., Usami, S., Kuwabara, H., Kano, Y., & Kasai, K. (2016). Trends in psychological distress and alcoholism after the Great East Japan Earthquake of 2011. *SSM Population Health*, 2, 807–812.
- Kessler, R. C., Andrews, G., Colpe, L. J., Hiripi, E., Mroczek, D. K., Normand, S. L., Walters, E. E., & Zaslavsky, A. M. (2002). Short screening scales to monitor population prevalences and trends in non-specific psychological distress. *Psychological Medicine*, 32(6), 959–976.
- Kiliç, C., Aydın, I., Taşkıntuna, N., Özçürümez, G., Kurt, G., Eren, E., Lale, T., Ozel, S., & Zileli, L. (2006). Predictors of psychological distress in survivors of the 1999 earthquakes in Turkey: Effects of relocation after the disaster. *Acta Psychiatrica Scandinavica*, 114(3), 194–202.
- Kusama, T., Aida, J., Sugiyama, K., Matsuyama, Y., Koyama, S., Sato, Y., Yamamoto, T., Igarashi, A., Tsuboya, T., & Osaka, K. (2019). Does the type of temporary housing make a difference in social participation and health for evacuees of the Great East Japan Earthquake and tsunami? A cross-sectional study. *Journal of Epidemiology*, 29(10), 391–398.
- Lowe, S. R., & Willis, M. (2015). Trajectories of perceived social support among low-income female survivors of Hurricane Katrina. *Journal of Social and Personal Relationships*, 32(8), 1034–1055.
- MacCallum, R. C., Browne, M. W., & Sugawara, H. M. (1996). Power analysis and determination of sample size for covariance structure modeling. *Psychological Methods*, 1, 130–149.
- Matsuyama, Y., Aida, J., Hase, A., Sato, Y., Koyama, S., Tsuboya, T., & Osaka, K. (2016). Do community- and individual-level social relationships contribute to the mental health of disaster survivors?: A multilevel prospective study after the Great East Japan Earthquake. *Social Science & Medicine*, 151, 187–195.
- Ministry of Health, Labour and Welfare, Japan. (2011). *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/2r985200001pw11.html> (accessed 22 June 2019).
- Morishima, R., Ando, S., Araki, T., Usami, S., Kanehara, A., Tanaka, S., & Kasai, K. (2019). The course of chronic and delayed onset of mental illness and the risk for suicidal ideation after the Great East Japan Earthquake of 2011: A community-based longitudinal study. *Psychiatry Research*, 273, 171–177.
- Murakami, A., Sugawara, Y., Tomata, Y., Sugiyama, K., Kaiho, Y., Tanji, F., & Tsuji, I. (2017). Association between housing type and γ -GTP increase after the Great East Japan Earthquake. *Social Science & Medicine*, 189, 76–85.
- Nakaya, N., Nakamura, T., Tsuchiya, N., Narita, A., Tsuji, I., Hozawa, A., & Tomita, H. (2016). Prospect of future housing and risk of psychological distress at 1 year after an earthquake disaster. *Psychiatry and Clinical Neurosciences*, 70(4), 182–189.
- Orui, M., Harada, S., Hayashi, M., & Disaster Mental Health Team of the Sendai City Mental Health and Welfare Center. (2017). Practical report on long-term disaster mental health services following the Great East Japan Earthquake: Psychological and social background of evacuees in Sendai city in the mid- to long-term post-disaster period. *Disaster Medicine and Public Health Preparedness*, 11(4), 439–450.
- Reconstruction Agency. (2017). *Current status of recovery*. http://www.reconstruction.go.jp/topics/main-cat1/sub-cat1-1/20170310_genjou.pdf (accessed 4 October 2018).
- Sasaki, Y., Aida, J., Tsuji, T., Miyaguni, Y., Tani, Y., Koyama, S., Matsuyama, Y., Sato, Y., Tsuboya, T., Nagamine, Y., Kameda, Y., Saito, T., Kakimoto, K., Kondo, K., & Kawachi, I. (2018). Does type of residential housing matter for depressive symptoms in the aftermath of a disaster? Insights from the Great East Japan Earthquake and tsunami. *American Journal of Epidemiology*, 187(3), 455–464.
- Schafer, J. L., & Graham, J. W. (2002). Missing data: Our view of the state of the art. *Psychological Methods*, 7, 147–177.
- Suits, D. B. (1957). Use of dummy variables in regression equations. *Journal of the American Statistical Association*, 52(280), 548–551.
- Tang, B., Liu, X., Liu, Y., Xue, C., & Zhang, L. (2014). A meta-analysis of risk factors for depression in adults and children after natural disasters. *BMC Public Health*, 14, 623.
- Tanji, F., Tomata, Y., Sekiguchi, T., & Tsuji, I. (2018). Period of residence in prefabricated temporary housing and psychological distress after the Great East Japan Earthquake: A longitudinal study. *BMJ Open*, 8, Article e018211.
- VanderWeele, T. J. (2012). Invited commentary: Structural equation models and epidemiologic analysis. *American Journal of Epidemiology*, 176(7), 608–612.
- Yabe, Y., Hagiwara, Y., Sekiguchi, T., Sugawara, Y., Tsuchiya, M., Koide, M., Itaya, N., Yoshida, S., Sogi, Y., Yano, T., Tsuji, I., & Itoi, E. (2018). Sleep disturbance is associated with new onset and continuation of lower back pain: A longitudinal study among survivors of the Great East Japan Earthquake. *Tohoku Journal of Experimental Medicine*, 246(1), 9–14.