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Original Contribution

Postdisaster Changes in Social Capital and Mental Health: A Natural Experiment From the 2016 Kumamoto Earthquake

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Levels of social capital can change after a natural disaster; thus far, no study has examined how changes in social capital affect the mental health of disaster victims. In this study, we examined how predisaster social capital and its changes after a disaster were associated with the onset of mental disorders. In October 2013, we mailed a questionnaire to participants in the Japan Gerontological Evaluation Study living in Mifune, a town in Kumamoto Prefecture, Japan, and measured predisaster social capital. In April 2016, the Kumamoto earthquake struck the region. Three years after the baseline survey, postdisaster social capital and symptoms of mental disorders were measured using the Screening Questionnaire for Disaster Mental Health ($n = 828$). Multiple Poisson regression indicated that a 1-standard-deviation change in predisaster social cohesion at the community level reduced the risk of depression among women (relative risk = 0.44, 95% confidence interval: 0.24, 0.78); a decline in social capital after the disaster elevated the risk (relative risk = 2.44, 95% confidence interval: 1.33, 4.47). In contrast to social cohesion, high levels of social participation at the community level were positively associated with the risk of depression among women. Policy-makers should pay attention to sex differences and types of social capital when leveraging social capital for recovery from disasters.

depression; Kumamoto earthquake; natural disasters; natural experiments; social capital; social cohesion

Abbreviations: CI, confidence interval; JAGES, Japan Gerontological Evaluation Study; MDE, major depressive episode; PTSD, posttraumatic stress disorder; RR, relative risk; SQD, Screening Questionnaire for Disaster Mental Health.

The mental health of older people in the aftermath of natural disasters is a crucial public health issue. A meta-analysis of research in this regard showed that older adults face 2.11 and 1.73 times' higher risks of posttraumatic stress disorder (PTSD) and adjustment disorder, respectively, than young adults after natural disasters (1).

High levels of social capital, defined as "resources that are accessed by individuals as a result of their membership of a network or a group" (2, p. 291), are associated with lower risk of psychological distress after natural disasters (3). Levels of social capital can differ before and after natural disasters. Some researchers have suggested that social capital would be negatively influenced by disasters and that residents would have more difficulty in maintaining communications and social relationships than they did predisaster (4, 5). In contrast, other scholars have argued that social capital increases in the aftermath of disasters, as communities tend to cooperate when coping with difficult situations (6, 7). Despite the ongoing debate, however, no study has examined how changes in social capital affect the mental health of disaster victims, since predisaster social capital is hardly ever measured (3).

The present study made use of a unique data set comprising community-dwelling older adults in Mifune, a town in Kumamoto Prefecture, Japan. Mifune was one of the participating towns in the Japan Gerontological Evaluation Study (JAGES), and 1,432 older residents completed the baseline survey in 2013. In April 2016, 3 major earthquakes with a moment magnitude (M_w) of at least 6.0 struck Kumamoto Prefecture in succession. The town of Mifune is located

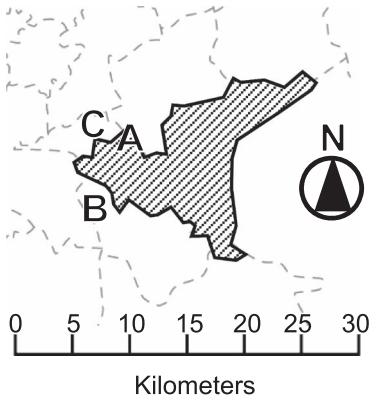

Figure 1. Map of the town of Mifune and the locations of the 2016 Kumamoto earthquakes, Mifune, Japan, 2013–2016. Point A shows the epicenter of an earthquake with a magnitude of 6.2 which occurred at 9:26 PM on April 14; point B shows the epicenter of an earthquake with a magnitude of 6.0 which occurred at 12:03 AM on April 15; and point C shows the epicenter of an earthquake with a magnitude of 7.0 which occurred at 1:25 AM on April 16.

approximately 10 km southeast of the epicenter of the main shock and was severely affected by the disaster (Figure 1); more than 196,000 people were evacuated, and 272 people lost their lives (8). The Kumamoto earthquake seriously damaged survivors' health. The number of certified disaster-related deaths from indirect causes (e.g., venous thrombosis, PTSD, and stress during evacuation, exacerbation of symptoms among hospitalized patients, and suicide) was 4 times higher than the number of deaths caused by the earthquakes directly (8). A follow-up survey was conducted in Mifune 7 months after the earthquakes. Thus, we were able to assess both pre- and postdisaster levels of social capital.

We leveraged this "natural experiment" to examine how predisaster levels of social capital and their changes after a disaster affect mental health outcomes, specifically major depressive episode (MDE) and PTSD.

METHODS

Baseline survey

The present study was a part of JAGES, an ongoing nationwide cohort study of Japanese people aged 65 years or older who are physically and cognitively independent (9). Mifune is an inland municipality in Kumamoto Prefecture and one of the JAGES study sites. In 2013, the town had a total population of 17,888, with persons aged 65 years or older comprising 27.7% (4,953 people) of the population (10). Selection of the analytical sample is shown in Figure 2. We collaborated with the municipal office of Mifune, and from a complete list of insured persons, town officials randomly sampled half of the residents aged 65 years or older who had not been certified as needing long-term public care or any support (eligibility for long-term care is determined by a municipality on the basis of assessment by a trained municipal employee (11)). The baseline survey was mailed to 2,000 eligible older persons in October 2013 and included questions on socioeconomic status, physical and functional status, mental health, and social participation (see Kondo and Rosenberg (9) for more detail). The response rate was 71.6% ($n = 1{,}432$), and 125 participants whose sex and age could not be confirmed or were reported incorrectly were excluded.

Follow-up survey

Three years after the baseline survey, the proportion of residents aged 65 years or older in Mifune had increased to 31.9% (5,649 of 17,705 people). On April 14, 2016, an earthquake of M_w 6.2 struck Kumamoto Prefecture, followed by an earthquake of M_w 6.0 on April 15 and the main shock of M_w 7.0 on April 16. There were also 3 major aftershocks measuring between M_w 5.2 and M_w 5.8 on the same day.

In November 2016, 7 months after the earthquakes, a follow-up survey including questions about experiences during the earthquakes was conducted in Mifune. The town mailed the follow-up questionnaire to all residents aged 65 years or older, excluding those who were certified as needing long-term care but including those who needed support for preventive long-term care. Persons who had died, moved to other towns, or become disabled were lost to follow-up. A total of 831 participants who had participated in the baseline survey returned questionnaires, corresponding to a follow-up rate of 63.6%. Three participants who seemed to report erroneous ages at follow-up were excluded from analysis. Our study sample ultimately comprised 828 individuals (361 men and 467 women). A comparison of characteristics between the analytical sample and nonrespondents at follow-up is presented in Web Table 1 (available at https://academic.oup.com/aje).

The study protocol was reviewed and approved by ethics committees at the University of Tokyo, Nihon Fukushi University, the National Center for Geriatrics and Gerontology, and Chiba University.

Outcome variable

In 2016, symptoms of PTSD and MDE were assessed using the Screening Questionnaire for Disaster Mental Health (SQD) (12). The SQD was developed and psychiatrically validated against the Japanese-language version of the Clinician Administered PTSD Scale (13) and the Major Depression Section of the Structured Clinical Interview for DSM-III-R (14) as gold standards among victims of the 1995 Great Hanshin-Awaji Earthquake. It was designed with a simple interview format, mindful of use among older populations, and comprises a total of 12 questions (9 items on PTSD and 6 items on MDE, with some overlap). The cutoffs were set at 6 out of 9 points for probable PTSD and 5 out of 6 points for probable MDE. In the present study, we created binary variables according to the predefined cutoff points. At baseline, we did not measure symptoms of PTSD and MDE using the SQD. However, we measured symptoms of depression using the short form of the Geriatric Depression Scale (15) and adjusted for its score.

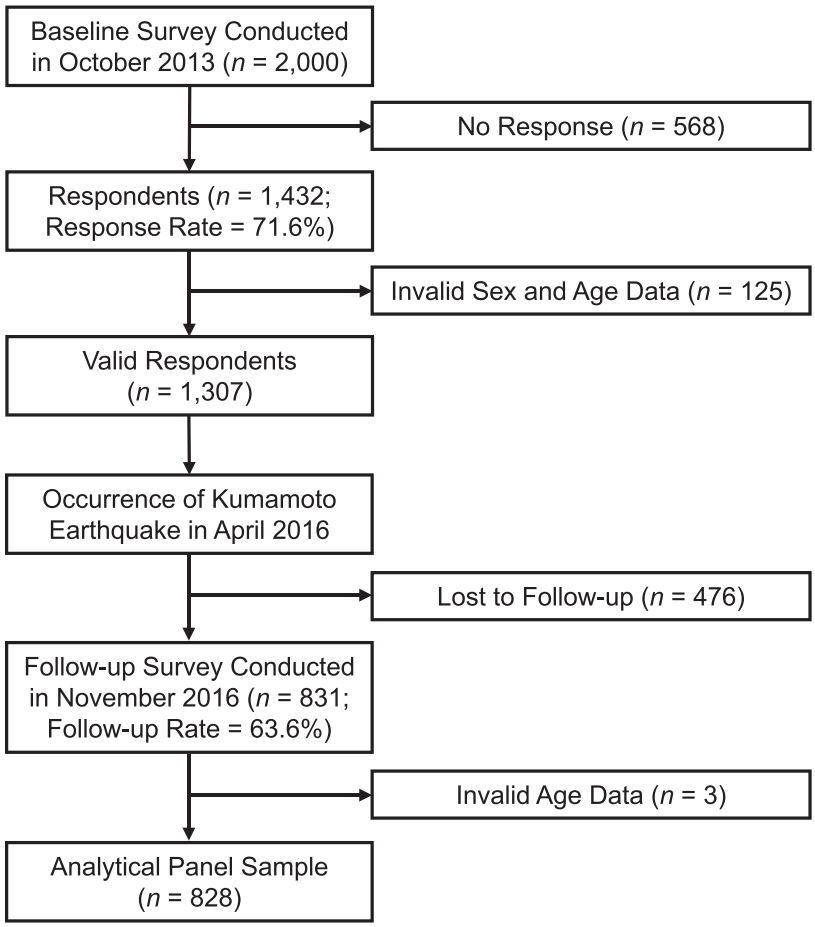

Figure 2. Selection of the analytical sample for a study of social capital before and after the 2016 Kumamoto earthquakes, Mifune, Japan, 2013–2016.

Explanatory variable

Our primary explanatory variable was social capital measured before and after the earthquakes. Hikichi et al. (16–18) developed scales on social capital representing a cognitive dimension ("social cohesion") and a structural dimension ("informal socializing and social participation"), and we applied the same scales to this study. Social cohesion was measured by means of 3 questions on trust, mutual support, and community attachment, rated on a 5-point Likert scale. Informal socializing and social participation were evaluated through 4 questions on frequency of meeting friends, number of friends met over the past month, and frequency of participation in sports and hobby groups, rated on a 5- or 6-point Likert scale. The actual questions posed are shown in the Web Appendix, and the results of confirmatory factor analysis for the social capital scales are shown in Web Figure 1. Individual-level social capital was calculated by summing the scores for all items in the subcategories, with higher scores indicating higher levels of social capital.

In addition, we added community-level social capital to our regression model, because previous studies have found that community-level variations in the prevalence of mental disorders cannot be fully explained by individual-level variations in the availability of social capital in the aftermath of disasters (16, 19). Community-level social capital was obtained as the average score of individual responses within a school district, in accordance with other literature (20, 21). A school district often represents the sociogeographic area of a former village, and community activities such as senior citizens' clubs, agricultural cooperatives, and local festivals are organized within each district. Mifune included 10 school districts in 2013, and the size of the older population in each district varied from approximately 120 to 1,600. The scores for individual- and community-level social capital were standardized to z scores to avoid multicollinearity and for ease of interpretation. In addition, we used the difference between scores for social capital measured in 2013 and 2016 (subtracting the 2016 score from the 2013 score) as an index of change in social capital.

Covariates

We adjusted for potential confounders measured at baseline, namely: sex; age (65–69, 70–74, 75–79, 80–84, or ≥85 years); educational level (≤9 years, 10–12 years, or ≥13 years); annual equivalized household income (<2.0 million or ≥2.0 million Japanese yen); family composition (living alone or with others); self-reported medical conditions (no reported illness vs. having any illness); baseline depressive symptoms (Geriatric Depression Scale score: not depressed (≤4 points), moderately depressed (5–9 points), or depressed (≥10 points)); and population density of each school district. We also controlled for whether the municipality had certified its housing as having sustained minor damage or worse damage during the earthquakes and whether the individual had moved because of the earthquakes; both were measured through the follow-up survey.

Statistical analysis

We used multiple Poisson regression with robust standard errors to examine the association between social capital (SC) and mental health outcomes (22). Our model was specified as follows:

$$\ln(\lambda_i) = \beta_0 + \beta_1 \text{indSC}_{13i} + \beta_2(\text{indSC}_{13i} - \text{indSC}_{16i}) + \beta_3 \text{comSC}_{13i} + \beta_4(\text{comSC}_{13i} - \text{comSC}_{16i}) + \mathbf{X}_i'\gamma,$$

where λ_i is the expected number of cases of MDE and PTSD in 2016, β_0 is a constant term, β_1 is a coefficient for individual-level (ind) social capital in 2013, β_2 is a coefficient for changes in individual-level social capital (2013 score minus 2016 score), β_3 is a coefficient for community-level (com) social capital in 2013, β_4 is a coefficient for changes in community-level social capital, and $\mathbf{X}_i'\gamma$ is a vector of covariates and their coefficients. We adjusted for the baseline social capital scores to examine the associations of predisaster social capital with the outcomes and to eliminate the possibility of "regression to the mean" (23). We also conducted multilevel analyses in consideration of heterogeneity across school districts. The intraclass correlation coefficient was less than 0.1%, and the estimated random effects had wide confidence intervals; therefore, we report results from pooled data without a hierarchical structure. We also adopted a multiple-membership model to take into account the duration of time that each resident had spent in different school districts, given that 19% of participants had moved because of the disaster; the results obtained were similar to those of the pooled model (Web Table 2).

To address potential bias caused by missing values, we adopted multiple imputation under the missing-at-random assumption. Missing data for incomplete variables were imputed by means of a multivariate normal model using all of the variables as explanatory variables: sex, age, years of education, equivalized household income, family composition, self-reported medical conditions, Geriatric Depression Scale score, the 7 social capital items, housing damage, relocation, and the 12 SQD items. We created 20 imputed data sets, and the estimates were combined. All analyses were performed using Stata, version 14.2 (StataCorp LLC, College Station, Texas).

RESULTS

Table 1 shows the characteristics of the participants. After the earthquakes, 44.5% of participants reported that their housing had been certified as having minor or worse damage, while 18.8% reported that they had moved to another place because of the disaster. The proportion of participants with MDE symptoms was 7.6%, and 16.7% had PTSD symptoms.

In Figure 3, panel A depicts changes in the community-level score for social cohesion, while panel B depicts changes in the community-level score for informal socializing and social participation. In school areas such as C, I, and J, social capital decreased after the disaster. These areas are mountainous and were also damaged from landslides during the rainy season after the earthquakes (24). On the other hand, in school areas such as A, B, and E, social capital increased after the disaster. These areas are flat, with a younger population and higher population density than the mountainous areas (24).

In model 1 (Table 2), we adjusted for predisaster social capital and other covariates and found that the model considering predisaster social capital only could not predict the onset of MDE well. After adjustment for changes in social capital in model 2, a 1-standard-deviation change in predisaster social cohesion (a cognitive dimension of social capital) at the community level was associated with a 41% reduction in the risk of MDE (relative risk (RR) = 0.59, 95% confidence interval (CI): 0.37, 0.95), while its change (i.e., a 1-standard-deviation decrease in the score) was associated with an 88% increase (RR = 1.88, 95% CI: 1.17, 3.03). Estimation of the risk of PTSD showed the same directions as MDE, but it had broader confidence intervals in the adjusted model. In contrast to social cohesion, there were no associations between the structural dimension of social capital and MDE and PTSD. For sensitivity analysis, we excluded participants who reported depressive symptoms (those with a Geriatric Depression Scale score of 10 points or higher at baseline) from the analysis (Web Table 3).

In addition, we separately analyzed the data for men and women, considering a potential sex difference in the relationship between social capital and mental health (25) (Table 3). For men, social cohesion at the individual level was moderately associated with the risk of MDE (for individual-level predisaster social cohesion, RR = 0.65 (95% CI: 0.41, 1.03), $P = 0.07$; for its decline, RR = 1.40 (95% CI: 0.98, 1.99), $P = 0.06$). On the other hand, for women, social cohesion at the community level was strongly associated with the risk of MDE (for predisaster community-level social cohesion, RR = 0.44 (95% CI: 0.24, 0.78); for its decline, RR = 2.44 (95% CI: 1.33, 4.47)). In contrast to social cohesion, predisaster informal socializing and social participation at the community level increased the risk of MDE among women (RR = 2.36, 95% CI: 1.43, 3.91), while its decline reduced the risk (RR = 0.35, 95% CI: 0.16, 0.79).

Table 1. Characteristics of Participants in a Study of Social Capital Before and After the 2016 Kumamoto Earthquakes (n = 828), Mifune, Japan, 2013–2016[a]

Characteristic	Baseline (2013)			Follow-up (2016)		
	No.	%	Mean (SD)	No.	%	Mean (SD)
Male sex	361	43.6				
Age group, years						
65–69	230	27.8				
70–74	259	31.3				
75–79	173	20.9				
80–84	112	13.5				
≥85	54	6.5				
Educational level[b]						
Low (≤9 years)	347	41.9				
Middle (10–12 years)	341	41.2				
High (≥13 years)	139	16.8				
Low household income[c]	527	63.7				
Living alone	97	11.7				
No illness	119	14.3				
Depressive symptoms (GDS score)						
Not depressed (≤4 points)	667	80.5				
Moderately depressed (5–9 points)	134	16.2				
Depressed (≥10 points)	27	3.3				
Social cohesion scale score			11.84 (1.98)			11.90 (2.09)
Trust			3.89 (0.76)			3.93 (0.77)
Mutual help			3.73 (0.82)			3.79 (0.85)
Community attachment			4.21 (0.81)			4.17 (0.86)
Informal socializing and social participation scale score			13.79 (5.10)			13.80 (4.92)
Frequency of meeting with friends			4.17 (1.59)			4.03 (1.57)
No. of friends			3.88 (1.25)			3.78 (1.24)
Sports groups			2.90 (2.07)			3.08 (2.15)
Hobby groups			2.84 (1.99)			2.91 (2.02)
Housing damage from earthquakes				368	44.5	
Moved because of earthquakes				156	18.8	
Mental health outcomes[d]						
MDE				63	7.6	
PTSD				138	16.7	

Abbreviations: GDS, Geriatric Depression Scale; MDE, major depressive episode; PTSD, posttraumatic stress disorder; SD, standard deviation.

[a] Imputed data were used.

[b] Since the estimation sample varied across imputations, the numbers of participants in the subgroups do not sum to 828.

[c] Annual equivalized household income less than 2.0 million Japanese yen.

[d] Symptoms of PTSD and MDE were assessed using the Screening Questionnaire for Disaster Mental Health (12).

DISCUSSION

To our knowledge, this is the first study to have shown how predisaster levels of social capital and their changes postdisaster affect the risk of mental disorders among community-dwelling older adults. The town of Mifune had made efforts to build community social capital and had the highest rate of participation in social activities among the 38 municipalities included in JAGES in 2016. In the present study, we observed changes in levels of social capital before and after the earthquakes. Some communities in mountainous areas had high levels of social capital, which was damaged

Table 2. Associations of Social Capital With the Risks of Mental Disorders After the 2016 Kumamoto Earthquakes, Mifune, Japan, 2013–2016

Variable	Major Depressive Episode						Posttraumatic Stress Disorder					
	Model 1[a]			Model 2[b]			Model 1[c]			Model 2[d]		
	RR (SE)	95% CI	*P* Value	RR (SE)	95% CI	*P* Value	RR (SE)	95% CI	*P* Value	RR (SE)	95% CI	*P* Value
Social cohesion *z* score												
Individual-level score[e]	0.86 (0.11)	0.68, 1.09	0.21	0.79 (0.11)	0.60, 1.04	0.09	1.02 (0.08)	0.86, 1.20	0.86	0.99 (0.09)	0.83, 1.19	0.95
Individual-level change[f]				1.22 (0.15)	0.96, 1.55	0.10				1.06 (0.09)	0.89, 1.25	0.52
Community-level score[e]	0.92 (0.18)	0.63, 1.35	0.68	0.59 (0.14)	0.37, 0.95	0.03	0.98 (0.10)	0.79, 1.21	0.84	0.85 (0.12)	0.64, 1.13	0.26
Community-level change[f]				1.88 (0.46)	1.17, 3.03	0.01				1.22 (0.1)	0.93, 1.61	0.16
Informal socializing and social participation *z* score												
Individual-level score[e]	0.87 (0.11)	0.69, 1.11	0.26	0.80 (0.12)	0.60, 1.06	0.12	0.89 (0.07)	0.77, 1.04	0.15	0.89 (0.09)	0.74, 1.08	0.26
Individual-level change[f]				1.14 (0.17)	0.85, 1.52	0.38				1.00 (0.10)	0.82, 1.21	0.96
Community-level score[e]	1.11 (0.22)	0.75, 1.64	0.59	1.58 (0.41)	0.94, 2.63	0.08	1.06 (0.13)	0.83, 1.35	0.64	1.14 (0.19)	0.82, 1.60	0.43
Community-level change[f]				0.55 (0.21)	0.26, 1.17	0.12				0.88 (0.22)	0.54, 1.42	0.60
Male sex	0.78 (0.19)	0.47, 1.27	0.31	0.80 (0.20)	0.49, 1.32	0.39	0.65 (0.11)	0.47, 0.90	0.009	0.65 (0.11)	0.47, 0.90	0.01
Age group, years[g]												
70–74	3.67 (1.36)	1.78, 7.60	<0.001	3.85 (1.40)	1.88, 7.86	<0.001	1.04 (0.22)	0.69, 1.57	0.85	1.04 (0.22)	0.69, 1.57	0.85
75–79	4.02 (1.45)	1.98, 8.17	<0.001	4.63 (1.69)	2.27, 9.46	<0.001	1.30 (0.29)	0.84, 2.00	0.23	1.34 (0.30)	0.87, 2.07	0.18
80–84	2.52 (1.16)	1.02, 6.23	0.046	2.92 (1.30)	1.22, 6.99	0.02	1.13 (0.30)	0.68, 1.89	0.64	1.17 (0.31)	0.69, 1.96	0.56
≥85	2.43 (1.57)	0.68, 8.65	0.17	2.67 (1.77)	0.73, 9.79	0.14	0.81 (0.31)	0.38, 1.72	0.59	0.83 (0.32)	0.39, 1.79	0.64
Educational level[g]												
Low (≤9 years)	0.90 (0.34)	0.43, 1.88	0.78	1.04 (0.39)	0.49, 2.19	0.92	1.11 (0.29)	0.67, 1.84	0.68	1.16 (0.30)	0.70, 1.93	0.56
Middle (10–12 years)	0.71 (0.28)	0.33, 1.54	0.38	0.80 (0.32)	0.36, 1.76	0.57	0.92 (0.24)	0.55, 1.53	0.75	0.93 (0.25)	0.56, 1.56	0.79
Low household income[h]	1.79 (0.66)	0.87, 3.68	0.11	1.75 (0.63)	0.86, 3.54	0.12	1.79 (0.41)	1.14, 2.80	0.01	1.81 (0.41)	1.16, 2.83	0.01
Living alone	1.47 (0.49)	0.77, 2.82	0.25	1.72 (0.59)	0.88, 3.36	0.11	1.16 (0.26)	0.74, 1.82	0.52	1.19 (0.28)	0.76, 1.87	0.45
No illness	0.66 (0.36)	0.23, 1.90	0.44	0.66 (0.35)	0.23, 1.85	0.43	0.43 (0.16)	0.21, 0.88	0.02	0.43 (0.15)	0.21, 0.87	0.02
Depressive symptoms[g]												
Moderately depressed	2.44 (0.81)	1.27, 4.67	0.007	2.31 (0.79)	1.18, 4.51	0.01	1.71 (0.36)	1.13, 2.57	0.01	1.69 (0.36)	1.12, 2.57	0.01
Depressed	7.24 (2.69)	3.50, 15.00	<0.001	6.68 (2.69)	3.04, 14.70	<0.001	2.88 (0.75)	1.72, 4.80	<0.001	2.81 (0.75)	1.66, 4.75	<0.001

Table continues

Table 2. Continued

Variable	Major Depressive Episode						Posttraumatic Stress Disorder					
	Model 1[a]			Model 2[b]			Model 1[c]			Model 2[d]		
	RR (SE)	95% CI	*P* Value	RR (SE)	95% CI	*P* Value	RR (SE)	95% CI	*P* Value	RR (SE)	95% CI	*P* Value
Housing damage from earthquakes	2.17 (0.60)	1.26, 3.73	0.005	2.06 (0.62)	1.14, 3.73	0.02	1.50 (0.27)	1.06, 2.12	0.02	1.46 (0.26)	1.02, 2.07	0.04
Moved because of earthquakes	2.01 (0.56)	1.17, 3.46	0.01	1.95 (0.58)	1.09, 3.51	0.03	1.38 (0.28)	0.93, 2.05	0.11	1.38 (0.29)	0.91, 2.07	0.13
Population density	1.00 (0.00)	1.00, 1.00	0.36	1.00 (0.00)	1.00, 1.00	0.78	1.00 (0.00)	1.00, 1.00	0.72	1.00 (0.00)	1.00, 1.00	0.93
Constant	0.00 (0.00)	0.00, 0.02	<0.001	0.01 (0.01)	0.00, 0.17	0.002	0.07 (0.04)	0.02, 0.20	<0.001	0.08 (0.07)	0.02, 0.39	0.002

Abbreviations: AIC, Akaike information criterion; CI, confidence interval; RR, relative risk; SE, standard error; VIF, variance inflation factor.

[a] VIF = 1.20, AIC = 418.2.

[b] VIF = 1.24, AIC = 414.9.

[c] VIF = 1.08, AIC = 756.8.

[d] VIF = 1.09, AIC = 762.2.

[e] Baseline score for social capital measured in 2013.

[f] Difference between the social capital scores measured in 2013 and 2016 (2013 score minus 2016 score).

[g] Reference categories were "65–69 years" for age, "high" for educational level, and "not depressed" for depressive symptoms.

[h] Annual equivalized household income less than 2.0 million Japanese yen.

by the disaster, possibly due to residents' prolonged refuge caused by subsequent landslides. On the other hand, communities in flat areas showed increased community-level social capital in the aftermath of the earthquakes. An increase in local cooperative actions had been observed in the wake of previous earthquakes in Japan; for example, during the 1995 Great Hanshin-Awaji Earthquake, residents drew water from the river and fought fires together (26). After the Great Kanto Earthquake in 1923, neighborhood associations spread and engaged in relief work and patrolling (27).

Social capital is often conceptualized in terms of cognitive aspects (i.e., "social cohesion," including the concepts of trust in others, mutual support, and attachment to the community) and structural aspects (i.e., "informal socializing and social participation," referring to the extent and intensity of social relationships and participation in civic activities) (28). Two systematic reviews showed that cognitive social capital is consistently associated with lower risks of common mental disorders, whereas evidence for structural social capital has been mixed (29, 30). Three studies have suggested a positive association between structural social capital and an increased risk of mental health (31–33). In line with these previous studies, we found that cognitive social capital benefits female victims of disaster, while structural social capital can harm their mental health. In a community with a high level of structural social capital, a person may feel pressure to provide support to others, and members of outgroups may feel isolated because of in-group solidarity (34).

Furthermore, social capital is measured as both an individual-level and a community-level variable (35). While community-level variations in the prevalence of mental disorders cannot be fully explained by individual-level variations in the availability of social capital in the aftermath of disasters, community-level social capital does, in fact, influence individual mental health outcomes (16, 36, 37), through several plausible pathways. For example, communities where neighbors support each other may make residents feel more secure and may suppress the occurrence of psychosocial stressors such as looting, waste-dumping, and fights (35). In addition, communities with high levels of social capital (also referred to as "collective efficacy") can transmit health-related information rapidly and can organize necessary medical support effectively (2). Community-level social capital can thus benefit even those who have limited access to social capital at the individual level. Our findings suggest that social cohesion at the individual level may be important for men to maintain their mental health, while women are more likely to be protectively affected by social cohesion at the community level. Given that women tend to have larger and more diverse social networks than men (38), women may be more sensitive to community social capital.

The major strength of this study was its design, which was a natural experiment. A recent review (3) showed that most previous studies failed to assess predisaster levels of social capital and mental health and thus could not infer causality. One exception is a study by Hikichi et al. (16) that used pre- and postdisaster data on the city of Iwanuma (in the Tohoku region of Japan), which was affected by the 2011 Great East Japan Earthquake and Tsunami. The authors showed that predisaster community social cohesion

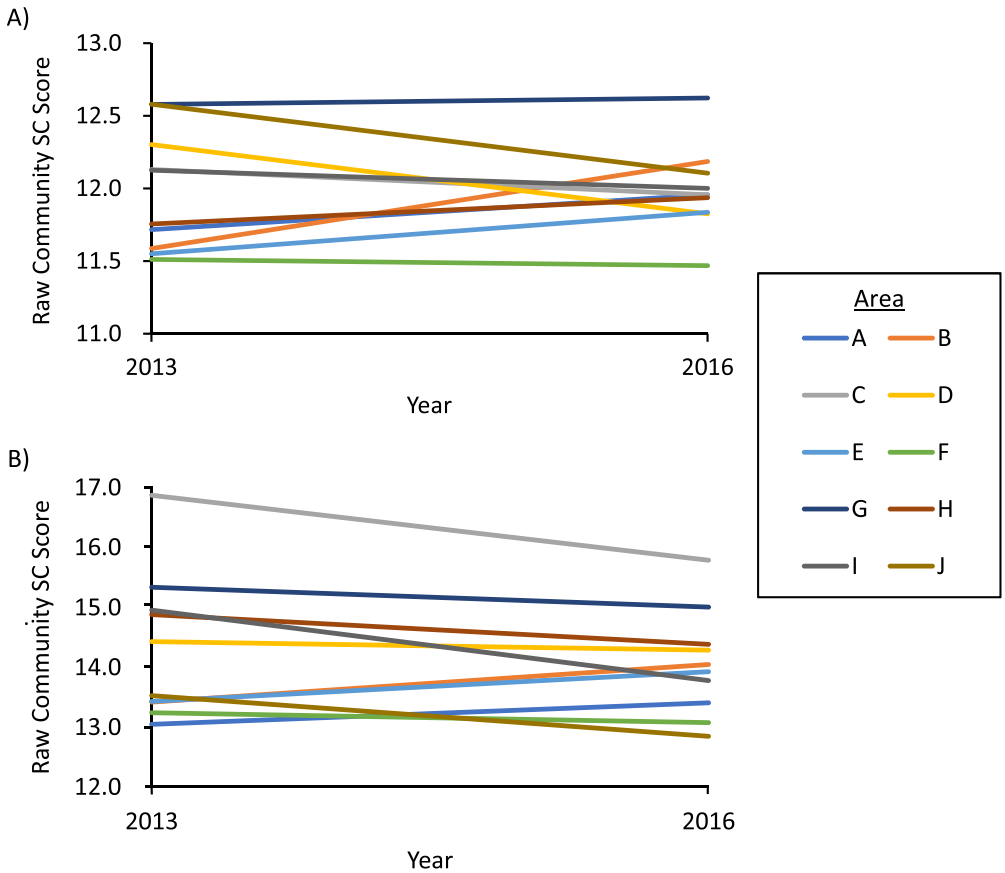

Figure 3. Changes in community social capital (SC) scores after the 2016 Kumamoto earthquakes, Mifune, Japan, 2013–2016. A) Changes in community-level scores for social cohesion; B) changes in scores for informal socializing and social participation. Numbers of participants in each area were as follows: area A, *n* = 229; area B, *n* = 70; area C, *n* = 23; area D, *n* = 119; area E, *n* = 91; area F, *n* = 143; area G, *n* = 45; area H, *n* = 49; area I, *n* = 40; area J, *n* = 19.

would contribute to the resilience of communities and that its preassessment would provide planners with valuable information about the prediction of mental health needs in the aftermath of a disaster. However, that study did not take into account postdisaster changes in social capital. Natural disasters alter not only physical landscapes but also the shape of communities. For example, relocation to prefabricated temporary public housing (resembling Federal Emergency Management Agency-style trailer housing in the United States) affects postdisaster social capital. Following the Great East Japan Earthquake and Tsunami, people who had been assigned temporary housing through a random lottery and found themselves surrounded by strangers experienced a loss of social cohesion and opportunities for social participation (17). Such changes in community social capital should therefore be considered to address mental health problems in disaster-affected areas. Furthermore, Hikichi et al. (16) conducted a follow-up survey approximately 2.5 years after the disaster, and they may have failed to capture persons who had experienced PTSD just after the disaster but recovered before the follow-up study, given that other investigators have reported that the prevalence of PTSD decreases by approximately half during the first 2 years after an earthquake (39, 40). In contrast, we conducted a follow-up survey 7 months after the earthquakes, which enabled us to capture mental disorders occurring immediately after the earthquakes.

Despite these strengths, the present study had several limitations. First, our study showed potential for selection bias, because participants were enrolled through a postal survey. We found that participants were more likely to be young (people aged 65–69 years comprised 38.5% of our analytical sample but 27.9% of those in the Mifune census), married, and living with someone in comparison with the entire older population (ages ≥65 years) captured by the census in Mifune (Web Table 1). In addition, persons lost to follow-up were more likely to be male, old (people aged ≥85 years comprised 6.5% of our analytical sample but 16.1% of nonrespondents at follow-up), less educated, depressed at baseline, and not married and to have lower scores for social capital as compared with those who completed the 2 waves of the survey (Web Table 1). However, the response rate of 71.6% in the baseline survey and the follow-up rate of 63.6% were comparable to or even higher than those in

Table 3. Associations of Social Capital with the Risks of Mental Disorders After the 2016 Kumamoto Earthquakes, by Sex, Mifune, Japan, 2013–2016

Variable	Men (*n* = 361)			Women (*n* = 467)		
	RR (SE)	95% CI	*P* Value	RR (SE)	95% CI	*P* Value
Major Depressive Episode						
Social cohesion *z* score						
Individual-level score[a]	0.65 (0.15)	0.41, 1.03	0.07	0.86 (0.17)	0.59, 1.26	0.44
Individual-level change[b]	1.40 (0.25)	0.98, 1.99	0.06	1.22 (0.23)	0.84, 1.77	0.30
Community-level score[a]	0.84 (0.32)	0.39, 1.79	0.65	0.44 (0.13)	0.24, 0.78	0.006
Community-level change[b]	1.63 (0.59)	0.80, 3.31	0.18	2.44 (0.76)	1.33, 4.47	0.004
Informal socializing and social participation *z* score						
Individual-level score[a]	0.98 (0.23)	0.63, 1.55	0.94	0.76 (0.14)	0.53, 1.09	0.14
Individual-level change[b]	0.88 (0.20)	0.57, 1.37	0.58	1.35 (0.26)	0.93, 1.97	0.12
Community-level score[a]	0.75 (0.35)	0.30, 1.87	0.54	2.36 (0.61)	1.43, 3.91	0.001
Community-level change[b]	1.06 (0.54)	0.39, 2.88	0.91	0.35 (0.14)	0.16, 0.79	0.01
Age group, years[c]						
70–74	6.71 (4.48)	1.81, 24.85	0.004	3.37 (1.43)	1.47, 7.74	0.004
75–79	18.18 (10.52)	5.85, 56.53	<0.001	2.19 (1.16)	0.77, 6.21	0.14
80–84	5.48 (4.88)	0.96, 31.36	0.06	2.39 (1.30)	0.82, 6.95	0.11
≥85	21.87 (20.10)	3.61, 132.51	0.001	1.34 (1.27)	0.21, 8.57	0.76
Educational level[c]						
Low (≤9 years)	1.26 (0.69)	0.43, 3.69	0.67	1.45 (0.97)	0.39, 5.37	0.58
Middle (10–12 years)	0.79 (0.61)	0.17, 3.56	0.75	1.21 (0.85)	0.31, 4.80	0.79
Low household income[d]	1.45 (0.78)	0.51, 4.16	0.49	2.53 (1.21)	0.99, 6.46	0.05
Living alone	3.60 (2.35)	1.00, 12.93	0.049	1.73 (0.80)	0.70, 4.27	0.23
No illness	1.56 (1.35)	0.28, 8.57	0.61	0.47 (0.34)	0.11, 1.93	0.29
Depressive symptoms[c]						
Moderately depressed	3.88 (2.17)	1.30, 11.59	0.02	1.89 (0.81)	0.81, 4.40	0.14
Depressed	12.74 (8.97)	3.20, 50.68	<0.001	5.71 (2.99)	2.05, 15.92	0.001
Housing damage from earthquakes	2.12 (0.87)	0.95, 4.72	0.07	2.32 (1.05)	0.96, 5.63	0.06
Moved because of earthquakes	1.61 (0.88)	0.56, 4.68	0.38	2.03 (0.78)	0.96, 4.30	0.06
Population density	1.00 (0.00)	1.00, 1.00	0.98	1.00 (0.00)	1.00, 1.00	0.45
Constant	0.00 (0.00)	0.00, 0.06	0.001	0.01 (0.02)	0.00, 0.47	0.02
Posttraumatic Stress Disorder						
Social cohesion *z* score						
Individual-level score[a]	0.89 (0.13)	0.66, 1.20	0.44	1.03 (0.13)	0.81, 1.31	0.78
Individual-level change[b]	1.11 (0.16)	0.84, 1.47	0.44	1.06 (0.12)	0.85, 1.33	0.59
Community-level score[a]	0.68 (0.18)	0.40, 1.14	0.14	0.93 (0.16)	0.67, 1.31	0.69
Community-level change[b]	1.57 (0.37)	0.98, 2.51	0.06	1.07 (0.18)	0.76, 1.50	0.70
Informal socializing and social participation *z* score						
Individual-level score[a]	1.02 (0.15)	0.77, 1.35	0.90	0.88 (0.12)	0.68, 1.14	0.34
Individual-level change[b]	0.92 (0.14)	0.68, 1.25	0.60	1.00 (0.13)	0.78, 1.29	0.98
Community-level score[a]	1.05 (0.36)	0.53, 2.06	0.89	1.16 (0.23)	0.79, 1.71	0.44
Community-level change[b]	1.07 (0.49)	0.44, 2.64	0.88	0.87 (0.24)	0.51, 1.51	0.63

Table continues

Table 3. Continued

Variable	Men (*n* = 361)			Women (*n* = 467)		
	RR (SE)	95% CI	*P* Value	RR (SE)	95% CI	*P* Value
Age group, years[c]						
70–74	1.16 (0.50)	0.50, 2.68	0.74	0.99 (0.24)	0.61, 1.60	0.96
75–79	2.41 (0.94)	1.12, 5.19	0.03	0.96 (0.28)	0.54, 1.71	0.89
80–84	1.72 (0.84)	0.67, 4.46	0.26	0.96 (0.31)	0.51, 1.82	0.90
≥85	1.40 (1.16)	0.28, 7.07	0.68	0.70 (0.31)	0.29, 1.68	0.43
Educational level[c]						
Low (≤9 years)	1.05 (0.36)	0.54, 2.04	0.90	1.47 (0.60)	0.66, 3.26	0.35
Middle (10–12 years)	0.83 (0.33)	0.38, 1.82	0.65	1.17 (0.47)	0.53, 2.57	0.70
Low household income[d]	2.63 (1.17)	1.09, 6.32	0.03	1.54 (0.43)	0.89, 2.66	0.12
Living alone	1.43 (0.76)	0.51, 4.04	0.50	1.23 (0.35)	0.71, 2.13	0.46
No illness	0.41 (0.29)	0.10, 1.62	0.20	0.44 (0.19)	0.19, 1.01	0.05
Depressive symptoms[c]						
Moderately depressed	2.20 (0.74)	1.13, 4.28	0.02	1.49 (0.42)	0.86, 2.59	0.16
Depressed	3.69 (1.69)	1.51, 9.05	0.004	2.63 (0.89)	1.36, 5.11	0.004
Housing damage from earthquakes	1.50 (0.40)	0.90, 2.52	0.12	1.46 (0.35)	0.91, 2.35	0.11
Moved because of earthquakes	1.27 (0.44)	0.65, 2.50	0.49	1.39 (0.36)	0.83, 2.32	0.21
Population density	1.00 (0.00)	1.00, 1.00	0.60	1.00 (0.00)	1.00, 1.00	0.81
Constant	0.01 (0.02)	0.00, 0.24	0.004	0.10 (0.10)	0.02, 0.67	0.02

Abbreviations: CI, confidence interval; RR, relative risk; SE, standard error.
[a] Baseline score for social capital measured in 2013.
[b] Difference between the social capital scores measured in 2013 and 2016 (2013 score minus 2016 score).
[c] Reference categories were "65–69 years" for age, "high" for educational level, and "not depressed" for depressive symptoms.
[d] Annual equivalized household income less than 2.0 million Japanese yen.

similar studies involving community-dwelling older adults (41). Second, simultaneity bias (i.e., changes in social capital being influenced by the onset of mental disorders) might have occurred, given that persons who were affected by the disaster and were depressed might have perceived themselves as having inadequate social capital. Nevertheless, the community-level variables were less subject to simultaneity bias than the individual-level variables, because individual responses were aggregated to school districts. Third, our mental health outcomes were self-reported and could have caused measurement errors. Even so, we used a psychometrically validated questionnaire that was well-designed for use in the Japanese older population (12). Fourth, we studied a specific earthquake in Japan, and thus the generalizability of the findings to other types of disasters and other regions might be limited.

In conclusion, for women, we found that predisaster social cohesion at the community level was negatively associated with the risk of MDE, while its postdisaster decline elevated the risk. In contrast to social cohesion, higher levels of social participation at the community level were positively associated with the risk of MDE among women. Hence, policymakers may encourage victims of disasters to participate in social activities, but they should carefully consider whether some residents have been left behind. Men were less likely to be affected by community-level social capital. Policymakers should pay attention to sex differences and types of social capital when they leverage social capital for disaster recovery.

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