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Social capital and cognitive decline in the aftermath of a natural disaster: a natural experiment from the 2011 Great East Japan Earthquake and Tsunami

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Abstract

Background—We examined prospectively whether social capital mitigates the adverse effects of natural disaster on cognitive decline.

Methods—The baseline for our study was established seven months before the 2011 Great East Japan Earthquake and Tsunami in a survey of older community-dwelling adults who lived 80 kilometers west of the epicenter (59.0% response rate). Approximately two and a half years after the disaster, the follow-up survey gathered information about personal experiences of disaster as well as incidence of cognitive disability (82.1% follow-up rate). Our primary outcome was cognitive disability (measured on an 8-level scale) assessed by in-home assessment.

Findings—The experience of housing damage was associated with risk of cognitive impairment (coefficient = 0.04, 95% confidence interval: 0.02 to 0.06). Factor analysis of our analytic sample

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(n = 3,566) established two sub-scales of social capital: a cognitive dimension (perceptions of community social cohesion) and a structural dimension (informal socializing and social participation). Fixed effects regression showed that informal socializing and social participation buffered the risk of cognitive decline resulting from housing damage.

Interpretation—Informal socializing and social participation may prevent cognitive impairment following natural disaster.

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In the aftermath of the 2011 Great East Japan Earthquake and Tsunami, 89% of the post-disaster related deaths were older residents who were 65 years old or over¹. A particular concern for older survivors is the potential risk of cognitive decline. We have previously reported that experience of disaster – particularly housing damage – is associated with an increased risk of cognitive decline among older survivors².

In turn, a wealth of epidemiological evidence suggests that the preservation of cognitive and function in older individuals is dependent on their ability to maintain social connections in the community³. For improving disaster resilience and protecting the health of older adults, it is increasingly recognized that preserving social connections in the community – also referred to as “social capital” – serves as a critical ingredient^{4,5}. According to Aldrich (2012)⁶, communities endowed with higher stocks of social capital – i.e. stronger bonds of trust between community members, as well as norms of mutual assistance – are better equipped to cope with the devastating consequences of disaster. However, no previous study has demonstrated whether social capital mitigates the impact of disaster experiences on cognitive decline.

Social capital is often separated into cognitive and structural components. The former refers to how people *perceive* social relations in their community (e.g. trust of others, mutual help, and community attachment), while the latter component captures what people actually *do* (e.g., informal socializing with their neighbors and participation in social activities)⁷.

In the present study, we took advantage of a unique “quasi experiment” in which information about social capital and cognitive function was gathered seven months prior to the disaster. The Japan Gerontological Evaluation Study (JAGES) was established in 2010 as a nationwide sample of community-dwelling residents aged 65 years or older. Our study area, Iwanuma city – located approximately 80 kilometers west of the earthquake epicenter – was one of the field sites of the JAGES cohort. Approximately 2.5 years after the disaster, we re-contacted the 3,594 survivors and linked their responses to incident cognitive disability ascertained by in-home assessment and medical examination under Japan’s national Long-Term Care Insurance (LTCI) registry. This unique design afforded us the opportunity to prospectively examine the association between changes in individual social capital and cognitive function, spanning the experience of disaster.

Methods

Study participants

One of the field sites of the JAGES cohort is based in the city of Iwanuma (total population 44,187 in 2010) in Miyagi Prefecture. We mailed questionnaires to every resident aged 65 years or older in August 2010 (n=8,576), using the official residential register. The survey inquired about personal characteristics as well as their health status. The response rate was 59.0% (n = 5,058), which is comparable to other surveys of community-dwelling residents.

The earthquake and tsunami occurred on March 11, 2011, seven months after the baseline survey was completed. Iwanuma city is a coastal municipality located approximately 80 kilometers west of the earthquake epicenter, so that it was in the direct line of the tsunami that killed 180 residents, damaged 5,542 houses and inundated 48% of the land area (Figure 1)⁸.

Approximately 2.5 years after the disaster (starting on October 2013), we conducted a follow-up survey of all survivors. The survey gathered information about personal experiences of disaster as well as updating their health status. Informed consent was obtained at the time of survey collection. The respondents were then linked to the national LTCI registry, which includes information about cognitive impairment based on in-home assessment by trained investigators (e.g., public health nurse).

The detailed flow-chart of the analytic sample is presented in Figure 2. Of the 4,380 eligible participants from the baseline survey, we managed to re-contact 3,594 individuals (follow-up rate: 82.1%). Our analytic sample is 3,566 due to incompletely signed informed consent forms and lack of linkage to the national LTCI database.

The survey protocol was reviewed and approved by the human subjects committee of the Harvard T.H. Chan School of Public Health, as well as the human subjects committees of Tohoku University, Nihon Fukushi University, and Chiba University.

Outcome variable

Our primary outcome is levels of cognitive decline assessed by a standardized in-home assessment under a national LTCI scheme established in 2000⁹. An applicant is assessed for eligibility to receive long-term care (e.g., meals on wheels) by a trained investigator dispatched from the certification committee in each municipality.

During the home visit, each individual is assessed with regard to their activities of daily living and instrumental activities of daily living status, cognitive function (e.g., short-term memory, orientation and communication) as well as presence of mental and behavioral disorders (e.g., delusions of persecution, confabulation, and soliloquy) using a standardized protocol. Following the assessment, the applicants are classified into one of 8 levels (1= independent, 8=requires specialized medical treatment in a long-term care facility) according to the severity of their cognitive disability (eTable 1)². This index of cognitive impairment is strongly correlated with the Mini Mental State Examination (Spearman's rank correlation $\rho = -0.73$, $p < .001$)¹⁰ and level I of the 8-point scale has been demonstrated to

correspond with a 0.5 point rating on the Clinical Dementia Rating scale (specificity and sensitivity, 0.88)¹¹.

The initial certification is valid for 6 months, after which periodic re-assessments are conducted every 12 months. Individuals and their caregivers can request a re-assessment before the expiration date, if their health status changes markedly⁹.

The committee also asks a panel of physicians to independently assess the cognitive disability level of applicants to determine the care requirements of the applicants¹². The medical assessment is conducted independently of the in-home assessment, but we confirmed a high correlation between these two methods of assessment (Pearson's correlation $\gamma=0.80$, $p < .001$). In our primary analyses, we used the in-home assessment as our outcome, but in sensitivity analyses we also used the medical examination data.

We linked JAGES cohort participants to the LTCI register in Iwanuma city for the follow-up period from April 1, 2010 to January 24, 2014.

Explanatory variables

Our primary exposure variables are the cognitive and structural dimensions of social capital. The cognitive dimension was assessed based on answers to questionnaire items about residents' perceptions of trust of others in the community, levels of mutual help, and community attachment. These were evaluated using the questions "Do you think that people living in your community can be trusted in general?" (Trust); "Do you think people living in your community try to help others in most situations?" (Mutual help); and "How attached are you to the community in which you live?" (Community attachment). Responses were ordered along a 5-point Likert scale, with 1 indicating "not at all" and 5 indicating "very much".

The structural dimension of social capital was measured by the frequency of meeting with friends, the number of friends whom the respondent met during the past month, and the frequency of participating in sports and hobby clubs per a week. Respondents were asked "How often do you see your friends?" (1 = rarely, 6 = almost every day); "How many friends/acquaintances have you seen over the past month?" (1 = none, 5 = 10 or more); "How often do you attend sports or hobby group activities?" (1 = not at all, 6 = almost every day).

We also inquired about personal experiences of damage in the earthquake and tsunami, i.e., damage or loss of housing as well as loss of relatives or friends. Two or more technical officers surveyed property damage and the local government certificated the result (eTable 2).

Covariates and risk factors

We selected as time-varying confounding variables: age, equivalized income, medical diagnosis of stroke and diabetes¹³, depression symptoms (measured by the Geriatric Depression Scale-15, GDS-15)¹⁴, smoking, drinking¹⁵, daily walking time¹⁶. Other time invariant characteristics, such as sex and educational attainment, were omitted from our

fixed effects regressions¹⁷. We also controlled for length of time (in years) between the pre- and post-disaster assessments for each subject (mean 3.69, SD 0.38)².

Household income was equalized by dividing the gross income by the square root of the number of household members and categorized into “Under 2.0 million JPY” versus “2.0 million JPY and over”. Depressive symptoms were categorized into lower risk (four points and under) versus higher risk (five points and over)¹⁸.

Statistical analysis

In the present study, we used a fixed effects (or first difference) model in which we regressed within-individual changes in the dependent variable (Y: change in level of cognitive impairment) on changes in the independent variable (X: change in level of social capital), which differences out the confounding influences of all observed and unobserved time-invariant factors.

We conducted an exploratory factor analysis with principal factor method followed by promax rotation to confirm the factor structure of our seven items measuring social capital and examined the effect of each sub-scale of social capital on cognitive decline.

We hypothesized that improvements in social capital (before vs. after the disaster) will buffer the impact of disaster experiences on cognitive decline, while a decline in social capital will have the opposite effect. To understand these interactions, we stratified the baseline sample into two groups – “high” social capital before the disaster versus “low” social capital, based on a median split. This resulted in two sets of groups for comparison: (i) people who reported low social capital both before and after the disaster (reference group) vs. people who experienced improvements in social capital after the disaster (“2010 low and 2013 high”); and (ii) people who reported high social capital both before & after the disaster (reference) vs. people who experienced declining social capital after the disaster (“2010 high and 2013 low”).

To address potential bias due to missing data, we used multiple imputation by Markov Chain Monte Carlo method assuming missingness at random for explanatory variables and covariates. We created five imputed data sets and combined each result of analysis using the Stata command “mi estimate”.

All analyses were performed using STATA version 14.0 (STATA Corp LP., College Station, Texas, USA).

Role of the funding source

The funders had no role in the design or conduct of the study; nor collection, management, analysis, and interpretation of the data; nor preparation, review, or approval of the manuscript; nor the decision to submit the manuscript for publication. The corresponding author had full access to all the data in the study and assumes final responsibility for the decision to submit for publication.

Results

Table 1 presents the characteristics of respondents at baseline (prior to the disaster) and at follow-up 2.5 years after the disaster. From the comparison with results of the local Census at baseline (eTable 3), females made up 56.5% of respondents, and this proportion is very close to the actual Census of older residents in Iwanuma city in October, 2010 (male 42.8%, female 57.2%)¹⁹. The age distribution of our sample is also close to the local Census data except for the group aged 85 years and over (respondents 6.2%, Census data 13.2%)¹⁹. A somewhat higher proportion of our respondents were married (71.4%) compared to the Census data (64.7%)²⁰. The proportion of employed individuals in our data (17.8%) was also quite close to the Census data (17.2%)²¹. These comparisons support the representativeness of our data relative to Iwanuma city as a whole.

In addition, we also compared the characteristics of our analytic sample to non-respondents at the follow-up survey (n = 786). The sex distribution was similar, although our analytic sample was somewhat older than the non-respondents (see eTable 3). The proportion of married persons in our analytic sample (71.4 %) was higher than among non-respondents (64.9 %). More respondents were likely to be employed at the time of the follow-up survey (17.8 %) compared to the non-respondents (14.0 %). The non-respondents were also less likely to be classified as functionally independent (84.1%) compared to the analytic sample (95.9%). This may have resulted in some attrition bias, but the differences were not large. (eTable 3).

Among the respondents, 37.3 % reported losing relatives or friends in the disaster, while 57.3 % reported personal damage to their property (Table 1). The prevalence of respondents whose cognitive function was classified as non-independent at the follow-up survey (11.5%) was three times higher than at baseline (4.2%). The prevalence of stroke (2.2%) had also increased to 5.5% at the follow-up survey. In addition, all components of social cohesion and informal socializing/social participation decreased during the followup.

The results of the factor analysis supported our approach to create two sub-scales for social capital – one representing the cognitive dimension (“social cohesion”) and the other representing the structural dimension (“informal socializing and social participation”) (eTable 4). Each eigenvalue of the sub-scales exceeded 1.0 (1.80, 1.14, respectively) thereby fulfilling the Kaiser-Guttman criterion²², and they explained 73% and 46% of the total variance, respectively (eTable 5). The sub-scales had good internal consistency reliability, with Cronbach’s $\alpha = 0.77$ and 0.71, respectively (eTable 4).

We calculated sex-and age-adjusted averaged cognitive disability scores at both surveys according to the four patterns of transition in social capital before/after the disaster (eTable 5). Respondents who reported declining levels of social capital (2010 high – 2013 low) showed an increase in the level of cognitive impairment at the follow-up survey (1.11 to 1.38, for social cohesion; 1.06 to 1.28, for informal socializing and social participation).

As shown in Table 2, the fixed effects model for the overall samples indicated that housing damage was associated with higher risk of cognitive impairment (coefficient = 0.04, 95% CI: 0.02 to 0.06), while the main effects for social cohesion and informal socializing/social

participation were protectively associated with cognitive impairment (coefficient = -0.04 , 95% CI: -0.07 to -0.01 ; and coefficient = -0.06 , 95% CI: -0.09 to -0.03 , respectively). In addition, the interaction term for housing damage \times informal socializing/social participation was also statistically significant ($p < .001$, see also Figure 3). Sensitivity analyses using the results of medical examination also showed similar results (eTable 6).

In the subgroup analysis comparing “2010 low and 2013 low” versus “2010 low and 2013 high”, the interaction term for housing damage \times informal socializing/social participation was also statistically significant ($p < .001$) (model 2 in Table 3). In the comparison of “2010 high and 2013 high” vs. “2010 high and 2013 low”, the interaction term of housing damage \times informal socializing/social participation was also statistically significant ($p = .01$) (model 2 in Table 4). That is, informal socializing and social participation appeared to buffer the impact of housing damage on cognitive impairment.

Although the interaction terms for housing damage \times social cohesion was not significant in any of the models, the point estimates were in the expected direction (Table 2 to 4 and eTable 6 to 8).

Discussion

This study demonstrates that experiences of disaster (particularly, housing damage) are associated with the increased risk of cognitive impairment, while social capital appeared to buffer that association. Subgroup analyses suggested that increased informal socializing and social participation mitigates the impact of housing damage on deterioration of cognitive function, while decreases in informal socializing/social participation potentiated the impact of property damage on incident cognitive disability.

The association between changes in social capital and cognitive decline is both statistically and clinically important. For example, the magnitude of the association between decreased social cohesion and cognitive decline (beta coefficient = 0.13 , 95% CI: 0.07 to 0.19) is larger than the effect of incident depressive symptoms on cognitive decline (beta coefficient = 0.08 , 95% CI: -0.01 to 0.15) (model 1 in Table 4).

Previous studies have demonstrated that disaster experiences are linked with heightened risk of cognitive decline among affected older individuals in the aftermath of the 2011 Great East Japan Earthquake² as well as Hurricanes Katrina and Rita²³. Studies have also suggested that social capital is protectively associated with depression and posttraumatic stress disorder following disasters⁴. Our study extends the evidence by showing that social capital can buffer the impact of disaster experiences on cognitive decline.

According to Aldrich (2012)⁶, the three broad mechanisms by which social capital assists in disaster resilience include: (a) norms of reciprocity serve as a kind of “informal insurance”, enabling residents to draw on each other for instrumental and emotional assistance; (b) stronger community bonds enable residents to more effectively “voice” their needs and demands during disaster recovery; and (c) social solidarity raises the cost of “exit” from the community in the aftermath of disaster, thereby enabling the speedier reconstruction of stricken communities. To these we may add yet a fourth mechanism to explain our findings,

i.e., stronger connections to the community helped older victims from becoming socially isolated after they experienced housing damage and were relocated to temporary trailer housing. After the disaster, the residents who moved together with their neighbors into the temporary shelters continued to organize a variety of communal activities within the trailer home villages²⁴. We hypothesize that these communal activities preserved the social connections between displaced residents, and that mutual support (as well as apparently mundane daily activities such as visiting with neighbors) helped to maintain cognitive functioning among vulnerable seniors.

A major strength of this study is the availability of information pre-dating the disaster about levels of cognitive disability as well as other health conditions. Our design was therefore able to effectively address the problem of recall bias in most studies conducted in post-disaster settings. A second strength is the record linkage to medically-verified cognitive disability obtained during home visits.

An important limitation of our study is that our first differences analyses cannot rule out simultaneity, e.g. changes in informal socializing/social participation occurred *because of* (or at the same time as) changes in cognitive impairment. In the more severe cases of cognitive decline, there is also the possibility of information bias – i.e. people did not accurately recall their most recent patterns of socializing with others. On the other hand, the baseline reports of social cohesion/social participation were obtained previous to the disaster, thereby eliminating the possibility of recall bias due to the traumatic events of the disaster itself. Lastly, selection bias might have arisen due to the somewhat higher proportion of non-respondents in the follow-up survey who were cognitively impaired at baseline. However, our response rate is quite comparable to similar surveys involving community-dwelling residents²⁵. In addition, we confirmed that the demographic profile of our participants is quite similar to the Census of Iwanuma residents aged 65 years or older (eTable 3). Furthermore, the response rate of our follow-up survey among survivors was quite high (82.1%). Owing to the compulsory residential registration system in Japan, only seventeen residents from the baseline sample could not be tracked (Figure 2).

In conclusion, our findings suggest that social capital mitigates the impact of housing damage on cognitive decline in the aftermath of a natural disaster. A previous mixed methods study questioned 281 survivors of the 2011 Earthquake and Tsunami who had been resettled into trailer homes in the aftermath of the disaster²⁶. Compared to those who moved together with other members of their community, survivors who were resettled by lottery (individual relocation) were less likely to report that they received social support from their new neighbors, and also less likely to report that they provided social support to others. Hence the method of relocating disaster victims is likely to have an important impact on their ability to maintain community ties. In addition, interventions that promote social cohesion and civic participation may be effective in promoting cognitive resilience in the aftermath of disaster. The World Bank recently reported on such a campaign in Ofunato, a city in Iwate prefecture that was devastated by the 2011 disaster, called the “Ibasho Café” initiative (“*ibasho*” in Japanese means “a place to gather”). The project objective was to help strengthen the social capital needed to recover from the disaster, giving community members of all ages a place where they can develop more and deeper connections with each other²⁷.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Research in context

Evidence before this study

We searched PubMed for manuscripts published in any language from database inception to January 24, 2017, using the following search terms: [(“disaster”[Title/Abstract] OR “earthquake”[Title/Abstract]) AND (“social capital”[Title/Abstract]) AND (“Cognitive Disorders”[MeSH Major Topic]) OR “dementia”[Title/Abstract]]. We specified “MeSH Major Topic” for “cognitive disorders” and searched in title or abstract for rest of words. As a result of the search using these inclusion criteria, we could not identify any articles. That is, no previous studies have examined whether social capital can buffer the impact of natural disaster experiences on cognitive function.

Added value of this study

Previous studies have demonstrated that disaster experiences are linked to heightened risk of cognitive decline among affected older individuals in the aftermath of the 2011 Great East Japan Earthquake as well as Hurricanes Katrina and Rita. Previous studies also suggested that social capital is protectively associated with depression and posttraumatic stress disorder following disasters. Our study extends the evidence that social capital buffers the impact of disaster experiences on cognitive decline. This study demonstrates that informal socializing and social participation can buffer the adverse impact of housing damage on cognitive function among older survivors of natural disaster.

Implications of all the available evidence

Interventions to promote civic participation may be useful in promoting cognitive resilience in the aftermath of disaster.

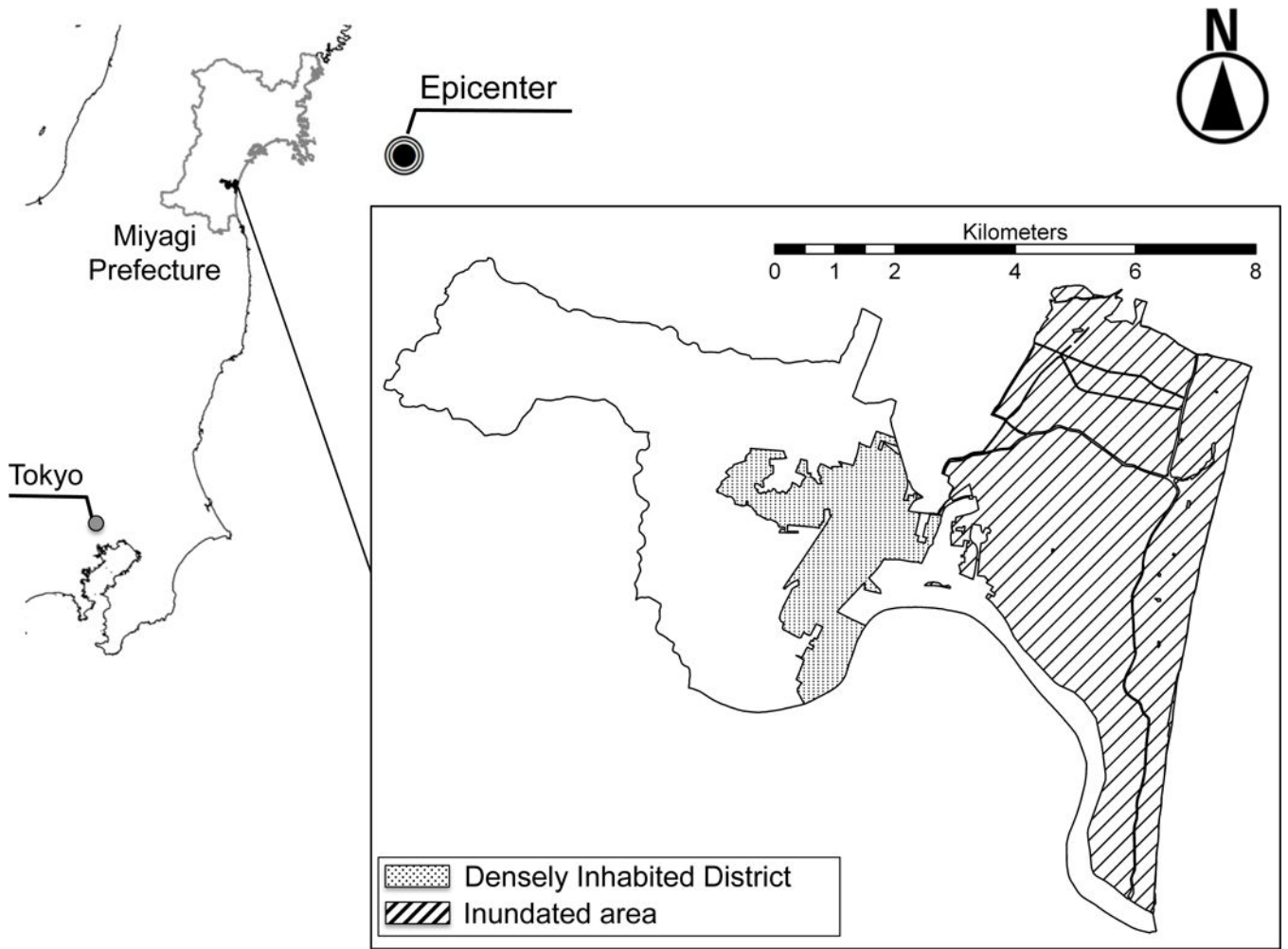


Figure 1.
Map of Inundated Area in Iwanuma City, Japan

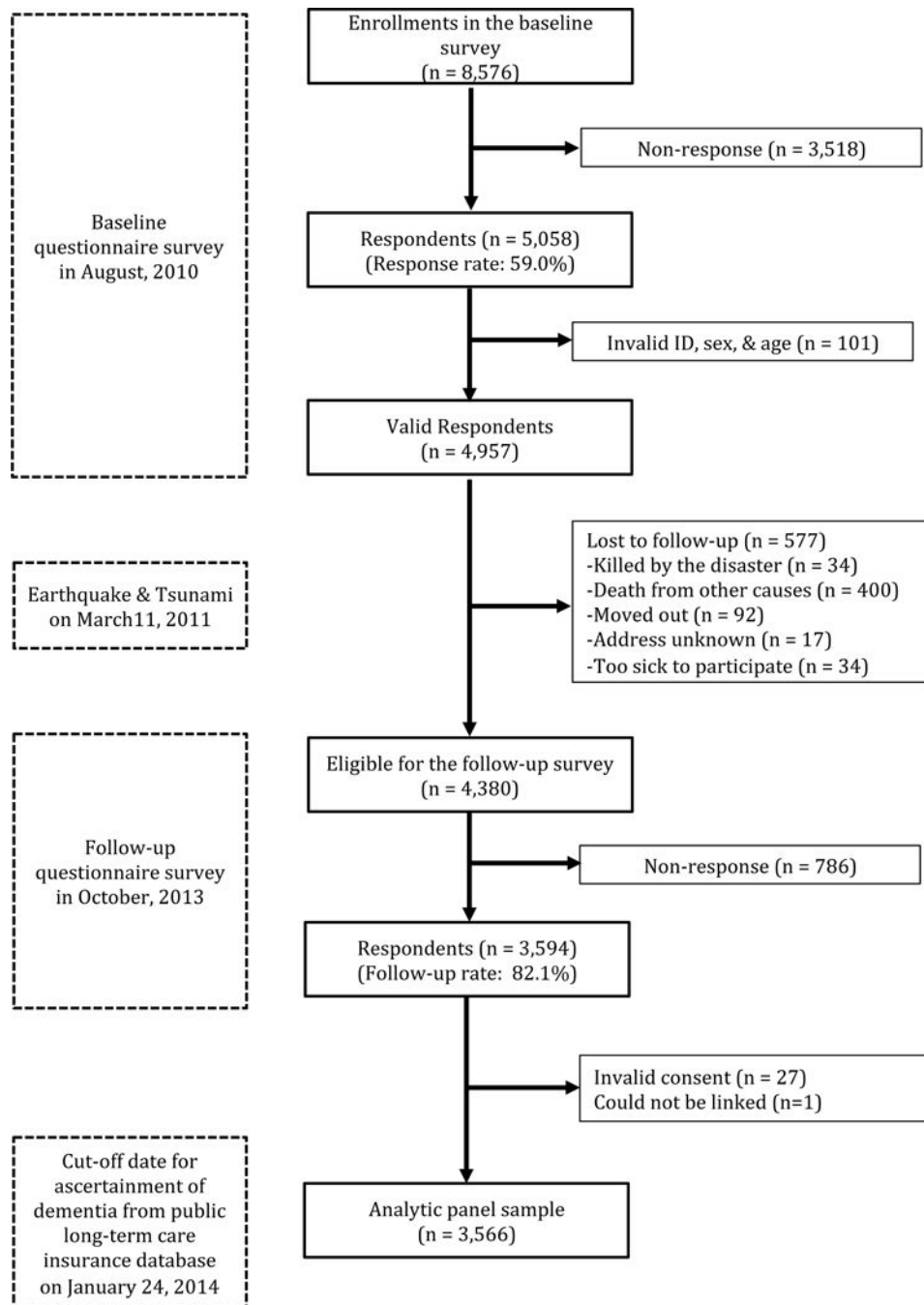


Figure 2. Flow Chart for the Analytic Panel Sample (n = 3,566) Aged 65 Years and Older, Iwanuma, Japan, 2010–2013

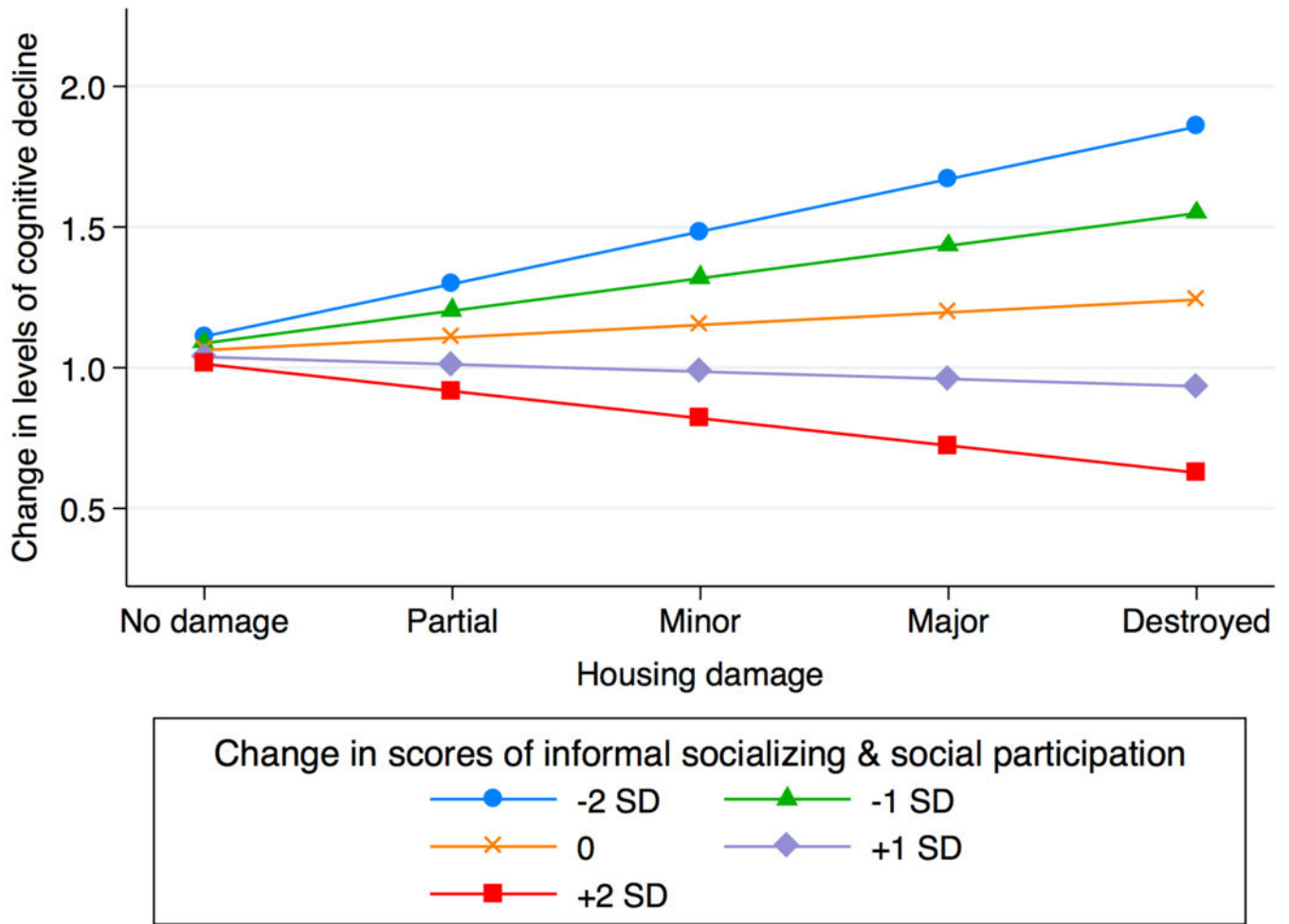


Figure 3. Marginal Effect of the Interaction of Housing Damage × Informal Socializing/Social participation in the Overall Analytic Sample (n = 3,566) Aged 65 Years and Older, Iwanuma, Japan, 2010–2013

Characteristics of Overall Analytic Sample at Baseline and Follow-up Survey (n = 3,566) Aged 65 Years and Older, Iwanuma, Japan, 2010–2013

Table 1

	Baseline survey in August, 2010				Follow-up survey in October, 2013			
	n	%	Mean	SD	n	%	Mean	SD
Cognitive impairment level								
Independent	3,421	95.8			3,156	88.5		
I	77	2.2			181	5.1		
IIa	6	0.2			51	1.4		
IIb	52	1.5			116	3.3		
IIIa	8	0.2			43	1.2		
IIIb	2	0.1			15	0.4		
IV	0	0.0			4	0.1		
M	0	0.0			0	0.0		
Missing	0	0.0			0	0.0		
Housing damage ^a								
No damage					1,423	39.9		
Affected					1,496	42.0		
Minor					257	7.2		
Major					131	3.7		
Destroyed					158	4.4		
Missing					101	2.8		
Loss of relatives and/or friends ^b								
No					2,166	60.7		
Yes					1,329	37.3		
Missing					71	2.0		
Age								
(Continuous)	3,566	100.0	73.64	6.28	3,566	100.0	76.84	6.29
Missing	0	0.0			0	0.0		
Equivalentized income								

	Baseline survey in August, 2010				Follow-up survey in October, 2013			
	n	%	Mean	SD	n	%	Mean	SD
Under 2.0 million JPY	1,422	39.8			1,586	44.4		
2.0 million JPY and over	1,489	41.8			1,400	39.3		
Missing	655	18.4			580	16.3		
Stroke								
No	2,664	74.7			2,845	79.8		
Yes	77	2.2			196	5.5		
Missing	825	23.1			525	14.7		
Diabetes								
No	2,285	64.1			2,551	71.6		
Yes	456	12.8			490	13.7		
Missing	825	23.1			525	14.7		
Depressive symptoms (GDS scale)								
4 points and under	2,090	58.6			2,072	58.1		
5 points and over	984	27.6			1,026	28.8		
Missing	492	13.8			468	13.1		
Current drinking								
No	2,208	61.9			2,421	67.9		
Yes	1,277	35.8			1,121	31.4		
Missing	81	2.3			24	0.7		
Current smoking								
No	2,903	81.4			3,265	91.6		
Yes	366	10.3			278	7.8		
Missing	297	8.3			23	0.6		
Walking time per day								
Under 30 minutes	1,284	36.0			1,281	35.9		
30 to 59 minutes	1,183	33.2			1,227	34.4		
60 to 89 minutes	493	13.8			534	15.0		
90 minutes and over	435	12.2			470	13.2		

	Baseline survey in August, 2010				Follow-up survey in October, 2013			
	n	%	Mean	SD	n	%	Mean	SD
Missing	171	4.8			54	1.5		
Perceived mutual help between neighbors								
1: Not at all-5: Very much	3,456	96.9	3.54	0.83	3,483	97.7	3.53	0.80
Missing	110	3.1			83	2.3		
Trust of neighbors								
1: Not at all-5: Very much	3,487	97.8	3.75	0.77	3,511	98.5	3.74	0.72
Missing	79	2.2			55	1.5		
Community attachment								
1: Not at all-5: Very much	3,484	97.7	4.00	0.83	3,517	98.6	3.95	0.82
Missing	82	2.3			49	1.4		
Frequency meeting with friends								
1: Rarely-6: Almost everyday	3,414	95.7	3.73	1.48	3,517	98.6	3.63	1.57
Missing	152	4.3			49	1.4		
Number of friends who met for the past month								
1: None-5: 10 or more	3,387	95.0	3.58	1.27	3,507	98.3	3.42	1.35
Missing	179	5.0			59	1.7		
Frequency participating to sports club								
1: None-6: Almost everyday	2,991	83.9	1.86	1.43	3,421	95.9	1.78	1.42
Missing	575	16.1			145	4.1		
Frequency participating to hobby club								
1: None-6: Almost everyday	3,048	85.5	2.25	1.46	3,428	96.1	1.90	1.38
Missing	518	14.5			138	3.9		
Sex (time-invariant variable) ^c								
Male	1,552	43.5						
Female	2,014	56.5						
Missing	0	0.0						
Educational attainment (time-invariant variable) ^d								
9 years and under	1,229	34.5						

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	Baseline survey in August, 2010			Follow-up survey in October, 2013		
	n	%	Mean	n	%	Mean
10 years and over	2,199	61.7				
Missing 1	138	3.8				

Abbreviations: JPY, Japanese Yen.

a, b Empty cells at baseline due to before the disaster.

c, d Empty cells at follow-up due to time-invariant variables.

Table 2

Effects of Disaster Experiences and Social Capital on Changes in Cognitive Impairment Level in Overall Analytic Sample (n = 3,566) Aged 65 Years and Older, Iwanuma, Japan, 2010–2013

	Coefficient (95% CI)	P
Housing damage		
1: None - 5: Destroy (Continuous)	0.04 (0.02 to 0.06)	< .001
Loss of relatives/friends		
Yes = 1, No = 0	-0.02 (-0.07 to 0.02)	.31
Age		
(Continuous)	0.30 (0.26 to 0.35)	< .001
Equivalent income		
2 million JPY = 1, < 2 million JPY = 0	-0.01 (-0.05 to 0.04)	.92
Stroke		
Yes = 1, No = 0	0.20 (0.10 to 0.31)	< .001
Diabetes		
Yes = 1, No = 0	-0.01 (-0.11 to 0.09)	.87
Depressive symptoms		
5 p = 1, 4 = 0	0.09 (0.04 to 0.15)	.001
Current drinking		
Yes = 1, No = 0	0.04 (-0.04 to 0.12)	.30
Current smoking		
Yes = 1, No = 0	-0.06 (-0.18 to 0.05)	.27
Increased walking time		
1: < 30 minute-4: 90 minute (Continuous)	-0.04 (0.06 to -0.01)	.002
The length of time between pre- and post-disaster assessment		
(Continuous)	-0.24 (-0.27 to -0.20)	< .001
Social cohesion		
(Continuous)	-0.04 (-0.07 to -0.01)	.04
Informal socializing and social participation		
(Continuous)	-0.06 (-0.09 to -0.03)	< .001
Housing damage * social cohesion		
(Continuous)	-0.01 (-0.03 to 0.02)	.79
Housing damage * informal socializing and social participation		
(Continuous)	-0.07 (-0.08 to -0.05)	< .001

Abbreviations: CI, confidence interval; JPY, Japanese Yen.

Table 3

Effects of Disaster Damage and Social Capital on Changes in Cognitive Impairment Level, in Comparing Low-Low vs Low-High of Social Capital for Stratified Sample, Aged 65 Years and Older, Iwanuma, Japan, 2010–2013

	Model 1: Social cohesion (n = 1,487)		Model 2: Informal socializing and social participation (n = 1,818)	
	Coefficient (95% CI)	P	Coefficient (95% CI)	P
Housing damage				
1: None - 5: Destroy (Continuous)	0.04 (0.01 to 0.07)	.03	0.07 (0.03 to 0.10)	< .001
Loss of relatives/friends				
Yes = 1, No = 0	-0.04 (-0.12 to 0.03)	.21	-0.04 (-0.12 to 0.05)	.37
Age				
(Continuous)	0.33 (0.27 to 0.39)	< .001	0.36 (0.28 to 0.43)	< .001
Equivalent income				
2 million JPY = 1, < 2 million JPY = 0	0.01 (-0.08 to 0.08)	.97	0.01 (-0.07 to 0.09)	.87
Stroke				
Yes = 1, No = 0	0.29 (0.12 to 0.45)	.001	0.24 (0.04 to 0.44)	.02
Diabetes				
Yes = 1, No = 0	-0.03 (-0.17 to 0.12)	.71	0.08 (-0.12 to 0.28)	.41
Depressive symptoms				
5 p = 1, 4 = 0	0.15 (0.07 to 0.22)	< .001	0.09 (-0.03 to 0.21)	.14
Current drinking				
Yes = 1, No = 0	0.03 (-0.08 to 0.14)	.55	0.03 (-0.11 to 0.18)	.64
Current smoking				
Yes = 1, No = 0	-0.07 (-0.24 to 0.10)	.41	-0.11 (-0.31 to 0.09)	.30
Increased walking time				
1: < 30 minute-4: 90 minute (Continuous)	-0.02 (-0.05 to 0.02)	.30	-0.05 (-0.09 to -0.01)	.02
The length of time between predisaster and postdisaster assessment				
(Continuous)	-0.25 (-0.31 to -0.20)	< .001	-0.27 (-0.34 to -0.21)	< .001
Social cohesion				
(Continuous)	0.03 (-0.03 to 0.08)	.32		
Interaction term: Housing damage * social cohesion				
(Continuous)	-0.02 (-0.06 to 0.02)	.43		
Informal socializing and social participation				
(Continuous)			-0.04 (-0.10 to 0.02)	.23
Interaction term: Housing damage * informal socializing and social participation				
(Continuous)			-0.10 (-0.14 to -0.05)	< .001

Abbreviations: CI, confidence interval; JPY, Japanese Yen.

Table 4

Effects of Disaster Damage and Social Capital on Changes in Cognitive Impairment Level, Comparing High-High vs High-Low of Social Capital in Stratified Sample Aged 65 Years and Older, Iwanuma, Japan, 2010–2013

	Model 1: Social cohesion (n = 1,404)		Model 2: Informal socializing and social participation (n = 1,233)	
	Coefficient (95% CI)	P	Coefficient (95% CI)	P
Housing damage				
1: None - 5: Destroy (Continuous)	0.05 (0.02 to 0.08)	.002	0.04 (0.01 to 0.06)	.009
Loss of relatives/friends				
Yes = 1, No = 0	-0.02 (-0.08 to 0.04)	.48	-0.01 (-0.06 to 0.05)	.76
Age				
(Continuous)	0.30 (0.24 to 0.36)	< .001	0.24 (0.18 to 0.29)	< .001
Equivalent income				
2 million JPY = 1, < 2 million JPY = 0	-0.02 (-0.08 to 0.04)	.56	-0.01 (-0.05 to 0.04)	.80
Stroke				
Yes = 1, No = 0	0.18 (0.02 to 0.33)	.03	0.16 (-0.02 to 0.35)	.08
Diabetes				
Yes = 1, No = 0	0.02 (-0.12 to 0.15)	.81	-0.09 (-0.21 to 0.04)	.16
Depressive symptoms				
5 p = 1, 4 = 0	0.08 (-0.01 to 0.15)	.05	0.10 (0.02 to 0.19)	.02
Current drinking				
Yes = 1, No = 0	0.07 (-0.04 to 0.18)	.24	0.05 (-0.04 to 0.13)	.31
Current smoking				
Yes = 1, No = 0	-0.08 (-0.23 to 0.07)	.32	-0.02 (-0.15 to 0.11)	.76
Increased walking time				
1: < 30 minute-4: 90 minute (Continuous)	-0.06 (-0.09 to -0.03)	< .001	-0.03 (-0.06 to -0.01)	.03
The length of time between predisaster and postdisaster assessment				
(Continuous)	-0.24 (-0.30 to -0.19)	< .001	-0.19 (-0.24 to -0.15)	< .001
Social cohesion				
(Continuous)	0.13 (0.07 to 0.19)	< .001		
Interaction term: Housing damage * social cohesion				
(Continuous)	0.03 (-0.01 to 0.08)	.17		
Informal socializing and social participation				
(Continuous)			0.10 (0.06 to 0.14)	< .001
Interaction term: Housing damage * informal socializing and social participation				
(Continuous)			0.04 (0.01 to 0.07)	.01

Abbreviations: CI, confidence interval; JPY, Japanese Yen.