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Social capital as a shield against anxiety among displaced residents from Fukushima

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3 Social capital as a shield against anxiety among displaced 4 residents from Fukushima

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Abstract The March 2011 meltdowns at the Fukushima nuclear power plants in Japan resulted in an increased risk of psychological distress among affected residents. We conducted original surveys of Futaba residents, a town in Fukushima where all of the residents were forced to evacuate from their homes due to radioactive contamination, obtaining 585 responses (a response rate of about 20%). Using this original data set, we investigate the role of social capital in maintaining mental health among the residents. First, we found the level of stress captured by the Kessler index (K6) to be unusually high compared both with people across Japan and with those who were displaced because of the earthquake and/or tsunami (but not the nuclear catastrophe). However, having high levels of social capital—captured by the number of neighbors from Futaba after displacement, participation in volunteer work after displacement, and participation in tea parties after displacement—plays an important role in reducing anxiety and distress among Futaba residents. Finally, we provide concrete recommendations for policy makers and NGOs to increase resilience among affected residents by strengthening social ties.

Keywords Social capital · Mental health · Fukushima · Nuclear disasters · Great East Japan Earthquake

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25 1 Introduction

26 **AQ2** More than 6 years have passed since the 11 March 2011 Great East Japan Earthquake and
27 the resulting tsunami and nuclear reactor meltdowns. The compound disaster claimed some
28 18,500 lives and destroyed thousands of homes and businesses along the coast of the
29 Tohoku region causing more than \$250 billion in losses (National Police Agency of Japan
30 2015; Cabinet office of the Government of Japan 2011). Some 120,000 people remain
31 displaced from their homes in Fukushima prefecture because of radioactive fallout from
32 the Fukushima Daiichi nuclear plant; thousands of others remain in temporary shelters in
33 non-irradiated areas awaiting permanent shelter (*Mainichi Shinbun* 8 March 2015).
34 Evacuees from the disaster face various challenges such as uncertainty about their
35 livelihoods and health, a loss of normalcy, and the evacuation of their homes and towns.

36 Comparative epidemiological research has shown that disasters negatively affect the
37 mental health of survivors (Deeg et al. 2005; Reiningger et al. 2013; Fergusson et al. 2014).
38 Previous studies reported that the risk prevalence of post-traumatic stress disorder (PTSD)
39 is higher after manmade or technological disasters than natural disasters (Neria et al. 2008).
40 A study of Chernobyl-affected residents suggested that perceived exposure to high levels
41 of radiation seriously impacted the mental health of residents (Bromet 2012). Initial sur-
42 veys of the evacuees from Fukushima prefecture after the 2011 Tohoku disaster found
43 increased stress and higher levels of psychological distress (Yasumura et al. 2012; Yabe
44 et al. 2014; Niwa 2014; Oe et al. 2016).

45 On the other hand, research has illuminated how social capital serves as a key factor for
46 improving disaster preparedness and building resilience to crisis (Aldrich 2012). Studies of
47 disasters have shown that deeper reservoirs of social ties improve disaster survival,
48 physical and mental health (Aida et al. 2013; Greene 2015; Aldrich and Sawada 2015;
49 Gaston et al. 2016). However, few empirical studies examined the role of social capital in
50 maintaining mental health during and after disasters, especially among residents affected
51 by nuclear catastrophe. One study in Miyagi prefecture showed that high levels of social
52 cohesion before the disaster were associated with a lower risk of post-traumatic disorder
53 after the disaster (Hikichi et al. 2016). That study focused on the role of social cohesion
54 before the disaster but did not explore the role of social capital after it. To our knowledge,
55 there have been no studies focusing on the role of social capital after the disaster in
56 maintaining mental health among evacuees from Fukushima.

57 To bridge these gaps in the literature, we measure and analyze the levels of social
58 capital and mental health of 585 displaced residents from the town of Futaba in Fukushima
59 Prefecture through original survey research. We uncover two important findings. First, the
60 average level of mental stress among displaced Futaba residents is unusually high com-
61 pared with all Japanese citizens. Their psychological distress scores are high compared
62 even to individuals displaced in areas of Tohoku because of the earthquake and tsunami but
63 not by the nuclear catastrophe. Second, high levels of social capital captured by the number
64 of neighbors from Futaba after displacement, participation in volunteer work after dis-
65 placement, and participation in tea parties after displacement act as a shield against
66 unusually poor mental health.

67 This paper makes several contributions to the literature. First, it is the first paper to
68 quantitatively investigate the nexus between mental health and social capital among the
69 displaced population from Fukushima and demonstrate a positive association with social
70 ties. Next, we demonstrate that the influence of a nuclear power plant accident on mental
71 health can be more serious than that of other natural disasters under Great East Japan



72 Earthquake. The results bring important policy implications for disaster managers, vul-
73 nerable communities, and decision makers as different toolkits are necessary to improve
74 mental health in a nuclear crisis. With social capital as a shield against psychological
75 distress, we also suggest that decision makers implement evacuation plans which ensure—
76 as much as possible—continuity among social networks through techniques such as
77 keeping evacuees from the same original community together in temporary shelters.
78 Disaster managers should support local community activities such as volunteer work
79 opportunities and social activities. Finally, we find that income consistently correlates
80 positively with mental health, and suggest that disaster managers focus on providing jobs,
81 not just compensation, to evacuees.

82 2 Methods

83 2.1 Data collection and measurement of mental health and social capital

84 Futaba town, which (pre-disaster) had some 7000 residents split among some 2900
85 households, remains one of the towns most affected by the nuclear power plant accident
86 after the Great East Japan Earthquake on March 11, 2011, as it sits some 4 km (2.5 miles)
87 from the Fukushima Daiichi reactor. After the meltdowns at Tokyo Electric Power
88 Company (TEPCO) reactors, the central government set up an exclusion zone around the
89 area to prohibit entry to the region. All Futaba residents were forced to evacuate from the
90 town to locations across Japan and, as of summer of 2017, continue to live as displaced
91 residents. A date for their return has not been released by the government or TEPCO, the
92 power utility responsible for the Fukushima nuclear power plants.

93 With support of the Futaba's City Hall, we distributed a survey to all households of the
94 town with the monthly Futaba town newsletter by mail on July 3, 2013. We received 585
95 answers by August 22, 2013, for a response rate of about 20% of all the household heads.
96 While a response rate of 20% is not necessarily low compared to other general Japan
97 surveys which do not provide incentives, the rate is not as high as other post-disaster
98 surveys. As such, we employed 2010 census data to explore the determinants of survey
99 participation. According to the estimation results of our survey participation regression
100 model based on the combined 2010 census data and our data, older residents, male resi-
101 dents, and residents of certain settlements were more likely to complete our questionnaire
102 (results available upon request). To handle potential sample selection bias arising from
103 endogenous survey participation, we combine our data with 2010 census data for validation
104 and adopted Heckman's correction method (Heckman 1979).

105 The questionnaire asks about general demographic characteristics such as age, sex,
106 family composition before and after the disaster, living place before and after the disaster,
107 income before and after the disaster, and educational achievement. Also, we included
108 various measures of social capital before and after the disaster along with the K6 questions
109 (Kessler et al. 2002) to measure their state of mental health (the distributed questionnaire is
110 available upon request). For each question in the K6 battery, respondents selected an
111 answer on a scale from 0 to 4. The total score for the six questions is summarized as the K6
112 score of the respondent; higher scores indicate more propensity for mental health problems.
113 In the Japanese context, experts developed a Japanese language version of K6 and
114 demonstrated screening performances equivalent to the original (Furukawa et al. 2008).

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115 To capture levels of social capital, we included various measures based on past research
 116 for network, trust, and civic participation frameworks as shown in Tables 1 and 2 (Cabinet
 117 **AQ3** Office of the Government of Japan 2003). Table 1 presents questions we used to capture
 118 social capital levels. In addition to participation measures, such as participation in vol-
 119 unteer activities and tea parties, we ask about the number of Futaba neighbors after
 120 displacement to measures levels of social ties continuing from their pre-disaster commu-
 121 nity. We ask about the number of Futaba neighbors after displacement who knew each
 122 other before the disaster and the number of Futaba neighbor after displacement who did not
 123 know each other. Table 2 presents social capital-related measures we use to derive a factor
 124 variable “trust perception” that we will explain detail in the analysis section. To capture
 125 trust perception, we go beyond standard *attitudinal* measures of trust and social capital—
 126 such as those from the General Social Survey (GSS)—to include *behavioral* measures such
 127 as “Do you leave the door unlocked when you go out? (Anderson et al. 2004).” Descriptive
 128 **AQ4** statistics of all the variables used in our analysis are shown in Table 6 in “Appendix 1.”

129 We analyze the impact of bonding social capital—the connections between people who
 130 are quite similar—after displacement in individual level on mental health (Aldrich 2012).
 131 Capturing bonding social capital is more appropriate than capturing bridging or linking
 132 social capital—which involve cross-group or vertical ties—in our setting. Our survey
 133 participants all come from one small town in Fukushima, which makes it difficult to
 134 observe variations in bridging and linking social capital in the pre-disaster community.
 135 Also, we can investigate the role of bonding social capital by exploiting a serendipitous
 136 situation arising from exogenous displacement. As past research has demonstrated, crises
 137 regularly activate bonding ties more than other forms of social connection (Beggs et al.
 138 1996).

139 2.2 Analysis

140 We begin by looking at psychological distress captured by K6 scores. We compare the
 141 distribution of K6 scores among Futaba residents with those from across Japan, residents in

Table 1 Social capital proxies

Variable	Question in the questionnaire	Answer
Number of Futaba unknown neighbors	Number of Futaba neighbors after displacement who did not know each other before the disaster	Category 1. Over 20 2. 10 to 19 3. 6 to 9 4. 3 to 5
Number of Futaba known neighbors	Number of Futaba neighbors after the disaster who knew each other before the disaster	5. 1 to 2 6. None (For analysis, interval regression is used for constructing continuous variable. Explanation of interval regression is available in “Appendix 2”)
Participation in volunteer activities	# Hours participating in volunteer work per week	Numerical: hour/week (For analysis, a dummy variable for 0< is employed)
Participation in tea party	# Hours joining tea party or other activities per week	Numerical: hour/week (For analysis, a dummy variable for 0< is employed)

Table 2 Social capital proxies for deriving a factor (trust to neighbors and general people)

Variable	Question in the questionnaire	Answer
General trust	Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people?	Category (ordered) 4: People can be trusted 3: People can be trusted more often than not 2: You cannot be too careful more often than not 1: You cannot be too careful
Mutual help	Talking of neighborly ties, how often does household head give something to neighbors or help neighbors, or get something from neighbors or get help from neighbors?	Category (ordered) 4: So often 3: Moderately 2: Not so often 1: None
Fairness	Do you think most people try to be fair?	Category 1: Yes 2: No 3: Don't know
Self-trustworthiness	Do you think you are trustworthy?	Category 1: Yes 2: No 3: Don't know
Trust in neighbors	Neighbors will help me when I am in trouble	Category (ordered) 5: Strongly agree 4: Agree 3: Can't tell 2: Don't agree 1: Don't agree at all
Leaves door open	Do you leave the door open when you go out?	Category 1: Yes 2: No 3: Don't know
Borrows from neighbors	Do you often lend or borrow money or things to or from your friends?	Category 1: Yes 2: No 3: Don't know

142 other disaster-affected areas, and evacuees in other disaster-affected areas, using age and
143 gender distribution to validate the findings.

144 Second, we investigate the relationship between social capital and mental health using a
145 two-step empirical procedure. First, we conduct a factor analysis to derive a factor from
146 variables shown in Table 2, which are general trust, mutual help, fairness, self-trustwor-
147 thiness, trust in neighbors, leaves doors open, and borrows from neighbors. General trust
148 follows the General Social Survey (GSS) measure asking "Generally speaking, would you
149 say that most people can be trusted or that you can't be too careful in dealing with
150 people?" Respondents selected an answer from four choices: (4) people can be trusted, (3)
151 people can be trusted more often than not, (2) you cannot be too careful more often than
152 not, and (1) you cannot be too careful. Mutual help indicates the frequency of mutual help
153 with neighbors.

154 Our survey measures fairness through a dummy variable for those who think that people
 155 generally try to be fair. We capture self-trustworthiness with a dummy variable for those
 156 who agree that others think that they are trustworthy. Trust in neighbors indicates the
 157 agreement level (from 1 to 5) with the sentence “Neighbors will help me when I am in
 158 trouble.” We also included a dummy variable for those who leave the door open when they
 159 go out and for those who sometimes borrow or lend money or goods from or to others. The
 160 proxies used for deriving a factor measure trust and trusting behavior within the com-
 161 munity and trust in general after displacement. Therefore, we name this factor as “trust
 162 perception.”

163 Second, using the derived factor “trust perception,” we test an intervening model as
 164 shown in Fig. 1. Following Mackinnon et al. (2002) and Shrout and Bolger (2002), we use
 165 the following estimation models.

$$I = \beta_{I0} + S\beta_{IS} + \varepsilon_I \quad (1)$$

$$P = \beta_{P0} + S\beta_{PS} + \alpha_{PI}I + \varepsilon_P \quad (2)$$

169 where P represents K6 score. I represents the intervening variable “trust perception.” S is a
 170 set of social capital proxies: the number of Futaba neighbors after displacement who knew
 171 each other before the disaster, the number of Futaba neighbors after displacement who they
 172 did not know each other, a dummy variable for those who participate in volunteer activities
 173 after displacement, and a dummy variable for those who participate in tea parties after
 174 displacement. We first test the significance of β_{IS} using the specification (1) and the
 175 significance of α_{PI} using the specification (2). We also check the insignificance of β_{PS} using
 176 specification (2) to make sure that there is no direct impact of social capital on K6 score
 177 and then we test the significance of $\beta_{IS} \times \alpha_{PI}$ using Sobel (1982), Aroian et al. (1995) and
 178 Goodman (1960) tests. In addition, we estimate the reduced-form version of the model (2)
 179 to quantify determinants of mental health other than social capital proxies and use control
 180 variables to manage potential confounding factors.

181 2.3 Limitation

182 As we have cross-sectional study with a response rate of about 20%, we recognize the
 183 potential for two biases in our estimation: sample selection bias arising from endogenous
 184 participation in our survey and endogeneity bias arising from endogenous social capital
 185 due to each evacuee’s relocation choice. To mitigate the former, we adopted a Heckman
 186 correction model using observed characteristics in the 2010 Census such as sex and age
 187 categories of each respondent and non-respondent. Though we adjust demographic char-
 188 acteristics using the Heckman correction model, we recognize that demographic charac-
 189 teristics are not the only driving factor in the decision of responding. Those worse off and

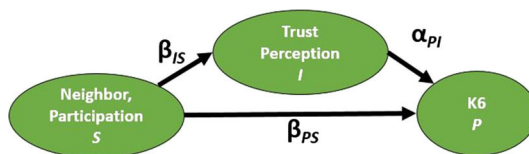


Fig. 1 Intervening model. S represents social capital variables, I is the intervening variable trust perception, and P indicates K6, the mental health proxy



190 less connected can be less likely to respond, which could result in underestimating the
191 effect.

192 As to the latter bias, we estimated the model with administrative unit fixed effects to
193 eliminate endogeneity bias due to time-invariant unobserved heterogeneity across local
194 government levels. Furthermore, we also note that the possibility of common method bias
195 as a limitation to our study as both explanatory variables and outcome variable are based
196 on self-reported answers (Podsakoff et al. 2003).

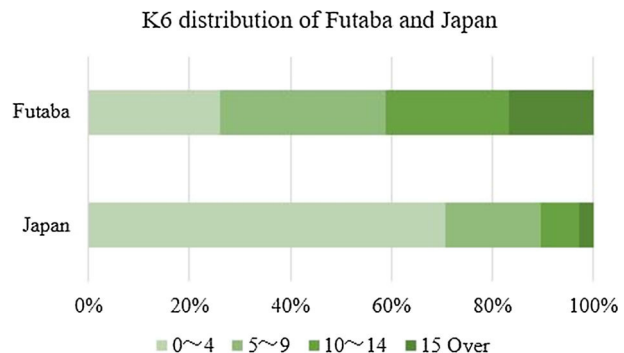
197 3 Results

198 The average level of psychological distress among Futaba residents is unusually high
199 compared with those from across Japan as shown in Fig. 2. The age- and gender-stratified
200 comparison of K6 score also validates our finding (age- and gender-stratified comparisons
201 are not presented here but are available upon request). The Japanese data used for compar-
202 ison come from the Comprehensive Survey of Living Conditions conducted by Japa-
203 nese ministry of Health, Labor and Welfare in 2013 which we use because it is one of the
204 most large-scale, random surveys covering all the population of Japan.

205 **AQ6** Furthermore, the average level of psychological distress among Futaba residents is high
206 even when compared with other disaster-affected areas such as the Wakabayashi district of
207 Sendai, Ogatsu and Oshika districts of Ishinomaki, Yamada, Ouchi, and Rikuzentakata
208 that were seriously damaged by the earthquake and tsunami (but not the nuclear plant
209 **AQ7** meltdowns) as shown in Fig. 3. The data on disaster-affected areas come from *Higashi*
210 *Nihon Daishinsai hisaisya no kenkōjō taitō ni kansuru chōsa* [Exploration of health status
211 of disaster-affected residents by the Great East Japan Earthquake] conducted in 2011 by
212 Hayashi et al. These data were chosen for comparison since it is one of the largest scale
213 survey data targeting residents in seriously damaged areas and the city-, town-, or district-
214 level distribution of K6 score was available.

215 However, we recognize the limitation of the comparison shown in Fig. 3; namely, our
216 survey respondents consist of only evacuees while the supplemental data do not reflect
217 evacuees' mental health. This is because the data reflect the answers of those who did not
218 need to evacuate though the areas were seriously damaged. Therefore, we conducted a
219 further comparison of the K6 distribution of Futaba residents using data which reflect the
220 **AQ8** mental health of evacuees in another disaster-affected area as shown in Fig. 4. The data
221 used for comparison here are from *Ōkyū kasetsu jūtaku Nyūkyōsha kenkō chōsa* (Health

Fig. 2 K6 distribution of Futaba and Japan. *Notes* Futaba data are from author surveys and Japan data are from *Kokumin seikatsu kiso chōsa 2013* [Comprehensive Survey of Living Conditions 2013]



K6 score comparison among disaster affected areas

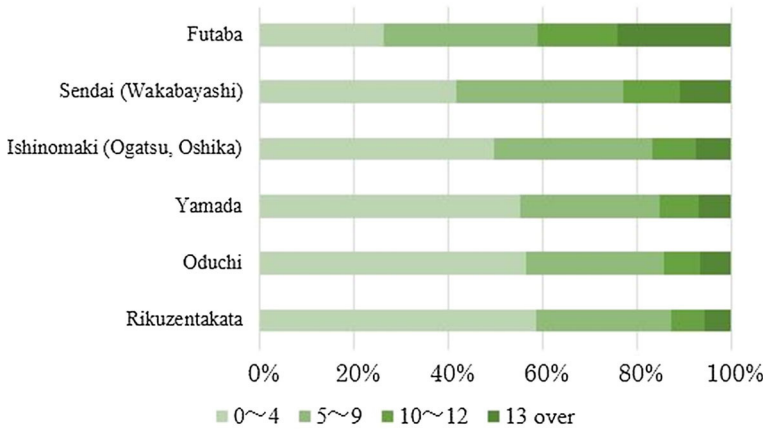


Fig. 3 K6 score comparison among disaster-affected areas. *Notes* Futaba data are from author surveys and data from Sendai and Ishinomaki are from *Higashinihon daishinsai hisaisha no kenkōjōtai nikansuru chōsa kenkyū, 2011* [The study about health of Great East Japan disaster-affected people, 2011] by Hayashi et al. (2012)

K6 score comparison among evacuees in disaster affected areas

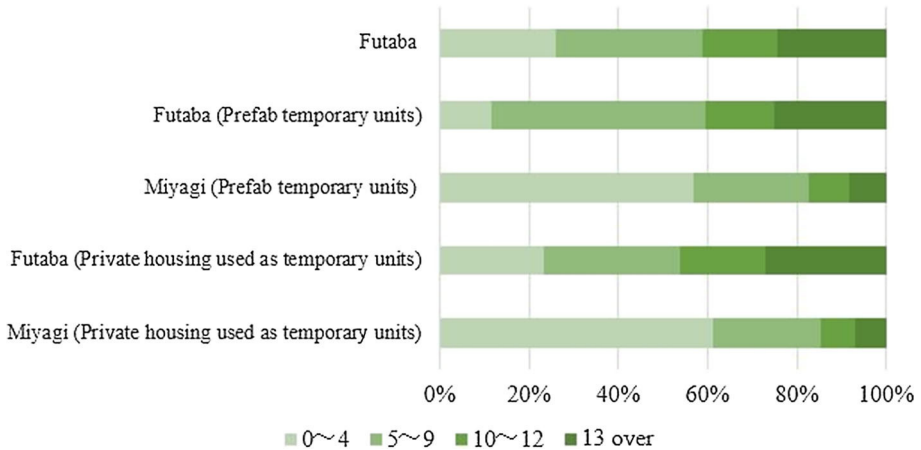


Fig. 4 K6 score distribution among evacuees in disaster-affected areas. *Notes* Futaba data are from author survey. Miyagi data (prefab temporary units) are from *Ōkyū kasetsujūtaku (Prefab) Nyūkyōsha kenkō chōsa* [Health survey of prefab temporary units' residents] in 2013 by Miyagi prefectural government. Miyagi (private housing used as temporary units) is from *Minkan chintai kariage jutaku tō nyūkyōsha kenkō chōsa* [Health survey of residents in private housing used as temporary units] in 2013 by Miyagi prefectural government

222 survey of prefabricated temporary shelter residents) and *Minkan chintai kariage jutaku tō*
 223 *nyūkyōsha kenkō chōsa* (Health survey of residents in private housing used as temporary
 224 units) conducted in Miyagi prefecture in 2013 by the prefectural government. We used



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225 these data as they reflect the status of those who live in temporary units in Miyagi, that is,
 226 the mental health status of disaster evacuees.

227 Figure 4 shows that Futaba residents have high K6 scores even when compared with
 228 evacuees in other disaster-affected areas. Gender- and age-stratified comparison of per-
 229 centage of K6 score over 13 among evacuees (not presented but available upon request)
 230 shows that K6 scores are especially high among elderly Futaba evacuees (over 60s)
 231 compared to evacuees in other disaster-affected areas. This comparison shows that dis-
 232 placement caused by the nuclear accident led to more serious mental health problems than
 233 displacement caused by other natural disasters.

234 Next, we find that levels of social capital as captured by post-disaster number of
 235 Futaba known and unknown neighbors, participation in volunteer activities, and partici-
 236 pation in tea parties can improve mental health through a factor we deem *trust per-*
 237 *ception*. We demonstrate this through a two-step empirical analysis. First, we derived the
 238 intervening variable trust perception by conducting a factor analysis of general trust, trust
 239 in neighbors, frequency of mutual help with neighbors, self-evaluation of trustworthiness,
 240 and evaluation of fairness of society. As the first factor with the largest eigenvalue highly
 241 correlates with these five variables as we can see in Table 3, we label this factor *trust*
 242 *perception*. Then, we used this factor in an intervening variable model as shown in
 243 Fig. 1.

244 The estimated results of model (1) of β_{IS} and (2) of β_{PS} and α_{PI} of Fig. 1 with Heckman
 245 correction and administrative unit fixed effects are displayed in Table 4 which shows that
 246 the four social capital variables (number of Futaba known and unknown neighbors after
 247 displacement, participation in volunteer activities, and participation in tea parties) signifi-
 248 cantly and positively correlate with the factor trust perception, thereby demonstrating the
 249 significance of β_{IS} in model (1). Also, the estimation results of model (2) show that trust
 250 perception is significantly negatively correlated with K6 scores (α_{PI}) while the four social
 251 capital proxies captured by estimated β_{PS} are largely insignificant, which is consistent with
 252 the intervening model. The Sobel, Aroian, and Goodman tests show the significance of
 253 $\beta_{IS} \times \alpha_{PI}$ in Table 5 and validate our intervening variable model. It should be noted that
 254 the inverse mills ratio of all the estimation results is insignificant which means that sample
 255 selection bias is not a serious obstacle.

Table 3 Factor loadings result to derive the intervening variable, “trust perception”

Variable	Factor 1 (trust perception)	Uniqueness
General trust	0.3376	0.886
Mutual help	0.5957	0.6452
Trust in neighbors	0.6918	0.5214
Leaves door open (yes)	#	0.9808
Borrows from neighbors (yes)	#	0.9845
People are fair (yes)	0.4562	0.7919
Self-trustworthiness (yes)	0.5033	0.7467
KMO measure = 0.63		

Shows that factor loadings are smaller than 0.3 in absolute value. We retained only the first factor because the eigenvalues associated with the remaining factors are smaller than 1 following Kaiser’s criterion (Kaiser 1960). KMO measure represents Kaiser–Meyer–Olkin measure of sampling adequacy (Kaiser 1974) which shows that the derived factor is meaningful at acceptable level

Table 4 Regression results of Heckman selection model (1) and (2) with administrative unit fixed effects

	[1] Dependent variable: trust perception			[2] Dependent variable: K6		
	(a)	(b)	(c)	(d)	(e)	(f)
Factor <i>I</i> (trust perception)				-0.903***	-0.799**	-0.830**
				(0.333)	(0.320)	(0.331)
No. of Futaba unknown neighbor	0.0203***	0.0186***	0.0152**	0.103**	0.0795	0.0727
	(0.00645)	(0.00692)	(0.00651)	(0.0508)	(0.0518)	(0.0501)
No. of Futaba known neighbor	0.0256***	0.0261***	0.0292***	0.0277	0.0193	0.0378
	(0.00718)	(0.00735)	(0.00701)	(0.0563)	(0.0550)	(0.0543)
Volunteer participation dummy	0.211**	0.237**	0.201*	-0.178	-0.730	-1.400*
	(0.104)	(0.105)	(0.107)	(0.812)	(0.776)	(0.813)
Tea party participation dummy	0.304***	0.284***	0.440***	-0.936	-0.748	-0.0395
	(0.0879)	(0.0893)	(0.0935)	(0.688)	(0.670)	(0.740)
Constant	-0.375**	-0.788*	-1.180**	10.16***	3.818	4.111
	(0.171)	(0.444)	(0.460)	(1.345)	(3.093)	(3.352)
Inverse mills ratio for the Heckman correction	0.0164	0.191	0.210	-0.389	0.292	0.516
	(0.0847)	(0.152)	(0.144)	(0.653)	(1.006)	(0.973)
Control variables	FE	FE + short set	FE + long set	FE	FE + short set	FE + long set
<i>N</i>	5691	5684	5678	5671	5665	5660
Wald test statistics of a null hypothesis that all coefficients except the constant term are zero	142.35	189.24	307.83	100.88	212.53	275.94
<i>p</i> value for the null hypothesis	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000

Standard error in parentheses. Interval regression is used for constructing continuous variable for number of Futaba neighbors (known and unknown). We also report a Wald test statistics of a null hypothesis that all coefficients in the regression model except the constant term are zero. Our results reject the null hypothesis strongly. Explanation of interval regression is available in “Appendix 2.” Omitted control variables from all the columns are prefecture fixed effects (except for Fukushima prefecture) and city fixed effects in Fukushima prefecture. We adopted a Heckman correction model using observed characteristics in the 2010 Census such as sex and age categories of each respondent and non-respondent. In addition, omitted control variables on (b) and (e) are house type, education, gender, income level and income level before the disaster dummies, and age. In addition to those, on (c) and (f), general trust before the disaster, mutual help before the disaster, trust in neighbors before the disaster, leaves door open before the disaster, borrows from neighbors dummies before the disaster, people are fair dummies before the disaster, self-trustworthiness dummies before the disaster, volunteer participation dummies before the disaster, and tea party participation dummies before the disaster are included. Those coefficients are not reported in the table but are available from the corresponding author upon request

* Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level



Table 5 Joint significance test for regression results of Heckman selection model with administrative unit fixed effects

	β_{IS}	α_{PI}	$\beta_{IS} \alpha_{PI}$	Sobel test		Aroian test		Goodman test	
				Score	p value	Score	p value	Score	p value
No. of Futaba unknown neighbor									
Test of (a) and (d) of Table 4	0.0203***	-0.903***	-0.0183	-2.054	0.0399	-1.997	0.0458	-2.117	0.0343
Test of (b) and (e) of Table 4	0.0186***	-0.799**	-0.0149	-1.829	0.0673	-1.765	0.0776	-1.901	0.0573
Test of (c) and (f) of Table 4	0.0152**	-0.830***	-0.0126	-1.709	0.0875	-1.640	0.1009	-1.787	0.0740
No. of Futaba known neighbor									
Test of (a) and (d) of Table 4	0.0256***	-0.903***	-0.0231	-2.158	0.0309	-2.107	0.0352	-2.214	0.0268
Test of (b) and (e) of Table 4	0.0261***	-0.799**	-0.0209	-2.042	0.0411	-1.990	0.0466	-2.099	0.0358
Test of (c) and (f) of Table 4	0.0292***	-0.830***	-0.0242	-2.148	0.0317	-2.104	0.0354	-2.195	0.0281
Volunteer participation dummy									
Test of (a) and (d) of Table 4	0.211**	-0.903***	-0.1905	-1.624	0.1042	-1.558	0.1192	-1.700	0.0891
Test of (b) and (e) of Table 4	0.237**	-0.799**	-0.1894	-1.674	0.0941	-1.605	0.1085	-1.754	0.0795
Test of (c) and (f) of Table 4	0.201*	-0.830***	-0.1668	-1.503	0.1327	-1.432	0.1521	-1.586	0.1126
Tea party participation dummy									
Test of (a) and (d) of Table 4	0.304***	-0.903***	0.2745	-2.134	0.0328	-2.081	0.0375	-2.191	0.0284
Test of (b) and (e) of Table 4	0.284***	-0.799**	0.2565	-2.589	0.0096	-2.574	0.0100	-2.604	0.0092
Test of (c) and (f) of Table 4	0.440***	-0.830***	0.3652	-2.213	0.0269	-2.175	0.0296	-2.253	0.0243

* Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level

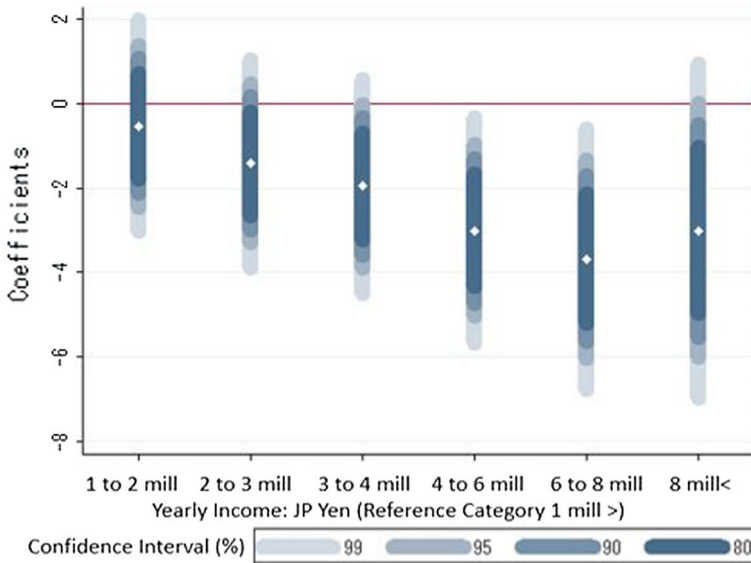


Fig. 5 K6 regression on wealth

256 In addition to social capital measures, the income of the residents is strongly associated
 257 with mental health. To quantify the overall effects of income on mental health, Fig. 5
 258 displays the estimation results of a reduced-form version of the model. Futaba residents
 259 have received various types of monetary compensation from TEPCO, but these subsidies
 260 are not included in our analysis.

261 4 Discussion

262 Several takeaways come from these empirical results. First, the K6 scores of ex-Futaba
 263 residents indicate the high possibility of severe mental distress caused by the nuclear
 264 disaster; residents may be experiencing PTSD, anxiety, and depression because of direct
 265 and indirect costs.¹ Causes of distress include rapid evacuation, uncertainty about the
 266 future, and potential radiation impact on their health and livelihoods. There are a sub-
 267 stantial number of residents who described these concerns in open-ended sections of our
 268 survey. Also, many evacuees feel betrayed by the government and the Tokyo Electric
 269 Power Company because of the collapse of the safety myth about nuclear power. As a
 270 result, specialized mental health care should be provided for those who were affected by
 271 nuclear disaster; decision makers and NGOs may need different toolkits for handling these
 272 kinds of natural–technological (*natech*) disasters (Arata et al. 2000).

1FL01 ¹ As larger amounts of damage correlate with higher distress among Futaba residents (Iwasaki and Sawada
 1FL02 2016), we can strengthen and externally validate the claim that disasters damage mental health of affected
 1FL03 residents. However, as our results only examine the case of Futaba residents, it is only suggestive that
 1FL04 nuclear catastrophe led to more serious damages to mental health than other natural disasters. For external
 1FL05 validation, further comparisons with studies under other nuclear disaster settings are necessary. As to
 1FL06 internal validity, those worse off are less likely to respond, which could result in underestimating the serious
 1FL07 mental health situation of the Futaba residents.



Author Proof

273 Second, our results show that social capital positively correlates with mental health
274 through the intervening factor trust perception.² This association between social capital and
275 mental health corresponds with a theory by Cohen et al. (2000) in which social networks
276 can improve mental health through positive affective states. Furthermore, local govern-
277 ments across Tohoku have created various policies and activities to maintain social net-
278 works among disaster-affected residents to create better mental health. For example, in
279 Saitama prefecture, to where many evacuated residents from Fukushima have moved, local
280 communities provide various opportunities for disaster-affected residents to gather and
281 have tea parties through programs such as the *Saigai-Tsunagari Café* (post-disaster social
282 connection café), *F-café-juju*, and the *Oshaberi-salon* (NPO hands-on Saitama 2013). Our
283 study provides the first quantitative evidence of the potential efficacy of these social capital
284 strengthening activities after the disaster. These activities should be expanded, and NGOs
285 and other organizations should work to attract shut-in, introverted residents who avoid
286 joining activities.

287 Our results also show that disaster-affected residents who participate in volunteer work
288 improve their psychological well-being. From the anthropological perspective, some dis-
289 aster-affected residents faced an emotional debt because of the support they received. One
290 scholar theorized that residents can restore their dignity by presenting “counter-gifts” to
291 others (Uchio 2013).

292 The *Ibasho-café*, a program setup in the tsunami-affected city of Ofunato to provide a
293 place for disaster-affected residents to gather and allow elderly residents to take leadership
294 roles, similarly builds on the role of engagement and civic participation (Kiyota et al. 2015;
295 Aldrich and Kiyota 2017). Our analysis suggests that volunteer work and bottom up social
296 activities should be supported and expanded in disaster-affected areas. Governments tend
297 to focus on infrastructure reconstruction; the Japanese government budgeted 26.3 trillion
298 yen (\$310 billion) for reconstruction rehabilitation for 5 years after the Great East Japan
299 Earthquake with the largest portion (about 38%) for infrastructure reconstruction (Re-
300 construction Agency 2015a, b). Our results suggest that focusing on strengthening social
301 capital and social ties is important in revitalizing disaster-affected areas.

302 Further, we show that having more neighbors from Futaba town can improve mental
303 health. This result supports various policies by Japanese local governments which dis-
304 tribute temporary and permanent shelter spaces according to residents’ original neigh-
305 borhoods (Aldrich and Meyer 2015). Our study provides empirical support for the
306 effectiveness of these group-relocation activities (Aldrich 2012), and we suggest that
307 decision makers work to evacuate residents in ways which keep social networks intact.

308 Finally, income and livelihood conditions influence mental health. This is consistent
309 with various empirical studies of mental health which argue for the importance of eco-
310 nomic resources in maintaining mental health (Keleher and Armstrong 2006). Authorities
311 should promote public policies which provide jobs and income—and not just compensa-
312 tion—for evacuees and internally displaced people following disaster.

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315 bright Foundation.

2FL01 ² As our results only examine Futaba residents, our claim that social capital can be a shield against
2FL02 deterioration of mental health cannot have external validity. For external validation, further comparisons
2FL03 with other nuclear disaster settings will be necessary. As to internal validity, those worse off and less
2FL04 connected are less likely to respond, which could result in underestimating the effect of the social capital on
2FL05 mental health among Futaba residents.



316 **Appendix 1: Descriptive statistics**

317 See Table 6.

Table 6 Descriptive statistics

Variable	Obs	Mean	SD	Min	Max
Age (in years)	575	62.967	14.388	24	94
Gender dummies					
Male	585	0.774	0.418	0	1
Female	585	0.210	0.408	0	1
No answer	585	0.015	0.123	0	1
House type dummies					
<i>Kasetsu</i> (temporary prefab) units	585	0.103	0.304	0	1
Relative's house	585	0.053	0.224	0	1
<i>Kariage</i> (private housing used as temporary) units	585	0.603	0.490	0	1
House bought	585	0.106	0.308	0	1
Rental housing	585	0.055	0.228	0	1
Nursing home	585	0.015	0.123	0	1
<i>Kisai</i> high school	585	0.017	0.130	0	1
Employer's provision	585	0.032	0.177	0	1
No answer	585	0.016	0.123	0	1
Income dummies (in yen)					
Less than 1 million	585	0.159	0.366	0	1
1 million to 2 million	585	0.174	0.380	0	1
2 million to 3 million	585	0.171	0.377	0	1
3 million to 4 million	585	0.144	0.351	0	1
4 million to 6 million	585	0.126	0.333	0	1
6 million to 8 million	585	0.091	0.287	0	1
More than 8 million	585	0.046	0.210	0	1
No answer	585	0.089	0.285	0	1
Health condition dummies					
Much better	585	0.007	0.082	0	1
Better	585	0.032	0.177	0	1
No change	585	0.268	0.443	0	1
Worse	585	0.480	0.500	0	1
Much worse	585	0.109	0.312	0	1
No answer	585	0.103	0.304	0	1
K6 measure	524	8.656	6.014	0	24
No. of Futaba unknown neighbor	583	3.702	6.043	0	22
No. of Futaba known neighbor	583	3.513	5.452	0	28
Tea party dummies					
0 h/week	585	0.421	0.494	0	1
More than 0 h/week	585	0.195	0.396	0	1
No answer	585	0.385	0.487	0	1



Table 6 continued

Variable	Obs	Mean	SD	Min	Max
Volunteer dummies					
0 h/week	585	0.451	0.498	0	1
More than 0 h/week	585	0.123	0.329	0	1
No answer	585	0.426	0.495	0	1
General trust (after disaster)	571	2.317	0.852	1	4
Mutual help (after disaster)	574	1.911	0.853	1	4
Trust in neighbors (after disaster)	564	2.465	1.197	1	5
Leaves door open dummies					
Yes	585	0.050	0.217	0	1
No	585	0.909	0.287	0	1
Don't know	585	0.014	0.116	0	1
No answer	585	0.027	0.163	0	1
Borrows from neighbors dummies					
Yes	585	0.027	0.163	0	1
No	585	0.909	0.287	0	1
Don't know	585	0.024	0.153	0	1
No answer	585	0.039	0.195	0	1
People are fair dummies					
Yes	585	0.306	0.461	0	1
No	585	0.159	0.366	0	1
Don't know	585	0.472	0.500	0	1
No answer	585	0.063	0.244	0	1
Self-trustworthiness dummies					
Yes	585	0.243	0.429	0	1
No	585	0.080	0.272	0	1
Don't know	585	0.638	0.481	0	1
No answer	585	0.039	0.195	0	1

Kasetsu housing refers to temporary shelters provided by government, while *kariage* housing refers to cash compensation for housing rentals. Income variables do not include any compensation. Health condition: We ask, "How is the household head's health compared to his or her health before the disaster?"

318 **Appendix 2: Interval regression of number of unknown and known**
 319 **Futaba neighbors**

320 These variables are treated as continuous variables, but they were originally structured as
 321 ordered categories. However, to better understand the estimation results, we constructed a
 322 continuous variable using interval regression. For the estimation, in addition to the cate-
 323 gory number of unknown and known Futaba neighbors, gender dummies, age, house type
 324 dummies, current prefecture dummies, and residential block in Futaba dummies were
 325 employed. After the estimation, the numbers were rounded. Furthermore, upper and lower
 326 bounds were adjusted according to the original categories. Estimation results of interval
 327 regression are not reported here but are available upon request.
 328
 329

Author Proof

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