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Mental Health of Miyagi Prefecture Residents Seven Years after the Great East Japan Earthquake

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Abstract

Seven years have passed since the Great East Japan Earthquake left many injured and dead in the Tohoku area of Japan in 2011. To understand the long-term effects of the Great East Japan Earthquake on the health status of residents in the disaster area, we conducted an original survey in 2018. This paper examines the long-term effects of the earthquake on the mental health status of residents of Miyagi prefecture, which was severely devastated by the earthquake and tsunami. Using original survey data, we identify the mechanisms by which different types of damage have impacted residents' mental health. Our analyses confirm that injury to or loss of a family member had a significant long-term effect on respondents' mental health, as measured by indices of mental health status, cognitive condition, and motivation for work and daily life. Also, the results of a robustness check using physical health status as the outcome variable further identify the mechanisms underlying the effects of different types of damage on residents' health. Understanding the pathway by which the earthquake has influenced residents' mental health will help policymakers to design effective ways to support them. For example, according to our findings, providing ongoing mental health support to those residents facing injury to or loss of family members would effectively relieve the stress associated with the earthquake and promote the recovery of their mental health and motivation for work and daily life. However, this paper has some limitations. For example, as the measurements of the types of damage are relatively crude, measurement errors could have contaminated our statistical results. In addition, we did not use the random sampling method for data collection, which could have led to biased results.

Keywords: earthquake, mental health, bereavement, the long-term effect

1. Introduction

In 2011, the Great East Japan Earthquake hit the Tohoku area of Japan. The most powerful on record, this earthquake and subsequent tsunamis brought about a significant loss of life and property. According to the Extreme Disaster Management Headquarters in Japan, the number of dead and missing persons had risen to 22,199 by March 1, 2018, and

the estimated cost of the damage was approximately 16.9 trillion yen as of June 24, 2011, including damage to buildings, lifeline facilities, social infrastructure, and other facilities [1]. Although the succession of natural disasters and associated events, such as earthquakes, tsunamis, and nuclear power plant accidents, made a recovery more complex and challenging in the affected area, officials at all levels of government have made their best efforts to accelerate improvement in the disaster area and have earned some achievements [2]. Therefore, we believe that the impact of a loss of property on residents' health status is gradually becoming smaller with the recovery of the economy in the Tohoku area. Many people purchase private insurance to cover the risk of natural disasters, including earthquake, because of the multiple types of natural disasters that frequently occur in Japan [3], which would have further reduced the impact of the loss of property. However, neither economic recovery nor private insurance is helpful to relieve the pain of losing beloved relatives or friends. Therefore, negative emotions such as sorrow and depression can persist and influence people's health. To understand the overall effects of the Great East Japan Earthquake, we should focus not only on the damage to tangible objects, such as roads, houses, and public capital but also on the damage to disaster area residents' health and daily lives. In particular, the impact of the earthquake on people's mental health is invisible and easy to neglect, owing to the remarkable recovery and reconstruction. In this paper, we attempt to examine the long-term impact of different types of damage on the mental health status of residents in Miyagi prefecture.

Our paper makes a twofold contribution to the existing literature. First, our study uses individual-level data to examine the long-term impact of the disaster. Several previous studies are considering the effect of earthquakes on suicide rate or mortality using municipality-level data [4, 5]. However, the number of suicides or other deaths represents only a minority of people seriously influenced by an earthquake. The use of limited indicators such as suicide rate or mortality is inadequate to evaluate the earthquake's effect on the majority of residents in the disaster area.

Consequently, it is necessary to use individual-level outcomes to assess the mental health status of respondents. Second, our study examines the impact of the earthquake with a focus on different types of damage. Few studies are discussing this issue, as a result of a shortage of data. Our original survey collected abundant information on loss, including the different types of damage suffered by individuals, which provided us with an opportunity to examine the impact of different kinds of damage on respondents' mental health status.

The remainder of this paper proceeds as follows. Section 2 provides a brief overview of the literature. Section 3 introduces the data used in this paper. The hypothesis and empirical results are reported in Section 4, and conclusions are discussed in Section 5.

2. Previous Studies

Based on the duration for which they persist, we can classify the effects of the earthquake on people's mental health into two categories. The first category covers short-term effects, which are broadly identified as the prevalence of Post-Traumatic Stress Disorder[1] and associated negative emotions. Some previous studies have documented the short-term impacts of natural disasters on people's health status covering the analysis of both individual-level data [3, 6, 7] and municipality-level data [4, 5]. For example, [3] uses the Great East Japan Earthquake as a natural experiment to examine the effect of the earthquake on different outcomes. The results identified significantly positive coefficient estimates for its impact on indices of the respondents' mental health, measured by items such as "Restless sleep" and "Felt sad," which indicates the earthquake-induced deterioration in the respondents' mental health.

The second category covers long-term effects. Because of the lack of individual-level data, few previous studies have been able to conduct a detailed analysis of the mechanisms underlying long-term effects. For example, [8] examines the long-term effects of the Great East Japan Earthquake on residents' mental health using survey data. However, this paper points out several limitations of its findings. The health gap observed between the Tohoku area and the Tokyo area consists of both an initial difference formed before the earthquake and the subsequent difference caused by the earthquake. To model the impact of the earthquake, the author must make the strong assumption that the portion of the health gap attributable to causes other than the earthquake has not varied over time.

This paper does not provide enough evidence to explain the mechanisms or potential pathways by which the earthquake could have caused a health deficit in the affected area. Therefore, based on previous studies, the present study attempts to examine in detail the impact of the earthquake on Miyagi prefecture residents' mental health by discussing the pathways by which different types of damage impact mental health using individual-level data. As the most heavily influenced area, the number of dead and missing persons in Miyagi prefecture was estimated to be 11,789 by March 1, 2018, accounting for about 53.1% of the total amount. It is reasonable to hypothesize that damage suffered by individuals continues to have a long-term impact on the residents of Miyagi prefecture.

3. Data

3.1 Background on the Dataset

Data on infrastructure recovery in disaster areas are usually available from the websites of the Japanese Government or local governments. However, detailed data on individuals in a disaster area is relatively difficult to obtain. After the earthquake, some organizations conducted surveys to understand the direct and short-term effect on the lives, health status, and life satisfaction of the residents in the disaster area; these included the Great East Japan Earthquake Special

[1] This is a disorder that develops in some people who have experienced a shocking, dangerous event or natural disaster.

Survey conducted by the Panel Data Research Center at Keio University [9]. With the arrival of economic recovery, the public focus on the disaster area is decreasing. However, the earthquake's effects on people's mental health may persist regardless of the degree of economic recovery.

To understand the long-term effects of the Great East Japan Earthquake on the health status of residents in the disaster area, we surveyed the lives and health status of residents seven years after the disaster [10] through a premier online survey company in Japan. The authors' Institutional Research Ethics Committee approved this original survey. The respondents were disproportionately recruited from the disaster area and the Tokyo metropolitan area. We took two days (February 27 and 28, 2018) to conduct this survey and obtained detailed data from 1,045 respondents (520 individuals from the disaster area, i.e., Iwate, Miyagi, and Fukushima prefectures, and 525 individuals from the Tokyo metropolitan area). Because the sampling method of this survey is different from that of other surveys based on random sampling method, we cannot deny the possibility that our data lacks representativeness, which would contaminate our statistical results. The survey consisted of six parts, covering the damage experienced and aid situation, living environment, health status, the status of children, recovery situation, and individual characteristics. The results, presented in frequency tables and contingency tables, are beneficial in comprehensively understanding the present status of residents in the disaster area [10], and the data collected from Miyagi prefecture residents are used for further analyses in the present study.

3.2 Dependent Variables

In the present study, we use self-rated health status to evaluate the present health status of respondents, including their physical health condition (Q6.2), cognitive condition (Q6.3), mental health condition (Q6.4), and motivation for work and daily life (Q6.5). Respondents reported their health status on a five-point scale (1 = very good, 2 = good, 3 = fair, 4 = poor, 5 = very poor). To facilitate interpretation of the results, we adjusted the responses in reverse order (1 = very poor, 2 = poor, 3 = fair, 4 = good, 5 = very good). Table 1 shows descriptive statistics for the data used in this paper, illustrating that the mean mental health condition score was lower than other health indicators. Table 2 shows the results of a test for health outcomes, which shows that the mean mental health condition score is significantly lower than those of the physical health and cognitive conditions.

TABLE 1 DESCRIPTIVE STATISTICS

Item	Possible responses and encodings	Mean	SD	Min	Max
1. Physical Health Condition	1 (very poor) to 5 (very good)	3.223	0.927	1.000	5.000
2. Cognitive Condition	1 (very poor) to 5 (very good)	3.277	0.813	1.000	5.000
3. Mental Health Condition	1 (very poor) to 5 (very good)	3.080	0.895	1.000	5.000
4. Motivation for Work and Daily Life	1 (very poor) to 5 (very good)	3.117	0.838	1.000	5.000
Damage to Personal House	Yes = 1, other = 0	0.282	0.451	0.000	1.000
Damage to Work Status	Yes = 1, other = 0	0.154	0.362	0.000	1.000

Injury to or Loss of a Family Member	Yes = 1, other = 0	0.106	0.309	0.000	1.000
Age	Years	45.255	14.143	20.000	69.000
Gender	Male = 1, female =0	0.463	0.500	0.000	1.000
Marital Status	Married = 1, other = 0	0.601	0.491	0.000	1.000
Self-employed	Yes = 1, other = 0	0.069	0.254	0.000	1.000
Homemaker	Yes = 1, other = 0	0.128	0.335	0.000	1.000
Part-time Job	Yes = 1, other = 0	0.149	0.357	0.000	1.000
Moving Related to the Earthquake	Yes = 1, other = 0	0.101	0.302	0.000	1.000
Moving Unrelated to the Earthquake	Yes = 1, other = 0	0.223	0.418	0.000	1.000
Access to Health Resources	Very good/good = 1, other = 0	0.415	0.494	0.000	1.000
Communication with Other Residents	Very good/good = 1, other = 0	0.234	0.425	0.000	1.000
Financial Status	Very good/good = 1, other = 0	0.154	0.362	0.000	1.000
Seismic Intensity	Observed Japan Meteorological Agency Seismic Intensity Scale on 3.11, 2011 of each municipality.	6.090	0.254	5.000	6.600

Note 1) These results are based on the individual data from [10]

3.3 Independent Variables

To investigate the determinants of the respondents' mental health status, we mainly focused on the types of damage experienced by them. Three types of damage were recorded using binary variables. Based on the information provided by responses to Q3.1, a dummy variable representing damage to the respondent's home was assigned a value of 1 when the respondent reported that their house had been damaged by the earthquake or tsunami. Otherwise, this binary variable was assigned a value of 0.

In the same way, we also allocated values to dummy variables representing damage to the respondent's work status (based on Q3.2) and injury to or loss of family members. Simplifying the analysis, we define the family members only including grandparents, parents, spouse, siblings, children, and grandchildren. As illustrated in Table 1, we observed that there was a large amount of variation in frequency among the three types of damage. In total, 28.2% of the respondents faced the issue of having lost their houses, while 10.6% of the respondents faced injury to or loss of a family member. To precisely understand the situation of the types of damage, we have shown the results of a test in Table 2. Although we found a significant difference between damage to home and injury to or loss of a family member, the impact of the latter will not be quickly eliminated due to economic recovery.

TABLE 2 RESULTS OF THE T-TEST

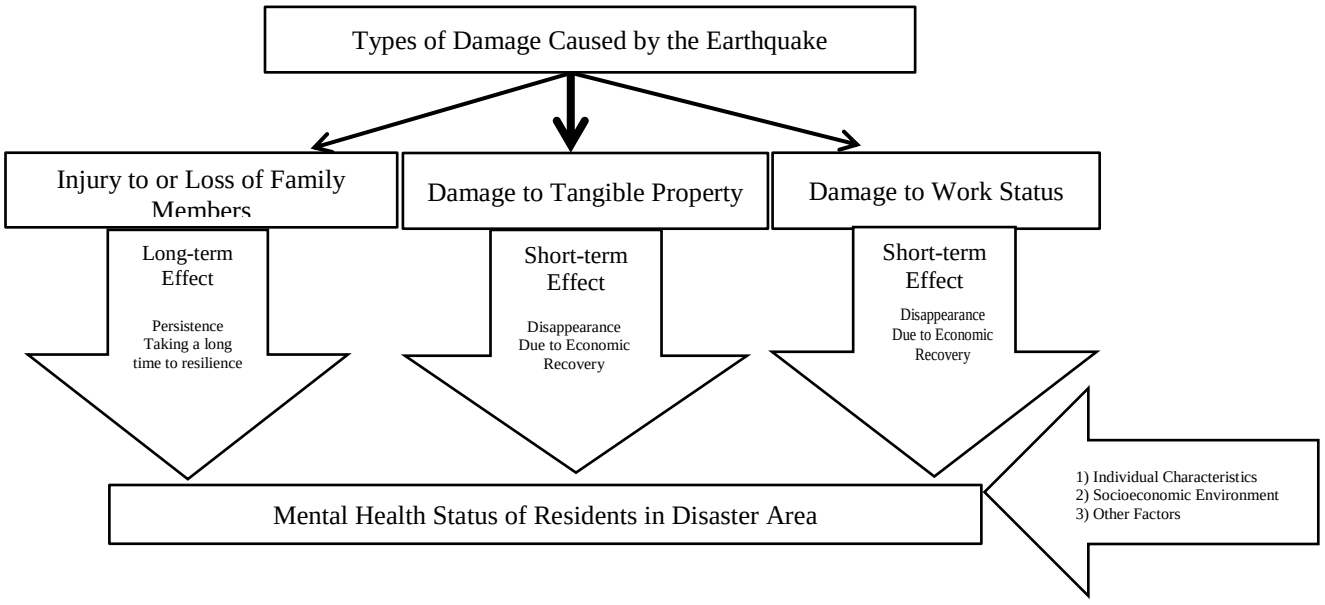
Variable A	Variable B	Diff(B-A)	Observations
Mental Health Condition (Mean)	Physical Health Condition (Mean)		
3.080	3.223	–0.144**	188
Mental Health Condition (Mean)	Cognitive Condition (Mean)		
3.080	3.277	–0.197***	188
Mental Health Condition (Mean)	The Motivation for Work and Daily Life (Mean)		
3.080	3.117	–0.037	188
Injury to or Loss of a Family Member (Mean)	Damage to Home (Mean)	–0.176***	188

	0.106		0.282	
Injury to or Loss of a Family Member (Mean)		Damage to Work Status (Mean)		
	0.106		0.154	–0.048	188

Note: 1) These results are based on a two-tailed test and calculated by the authors. 2) *, **, *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

In addition to the demographic characteristics of respondents, we also controlled in our analysis for some variables associated with respondents' socioeconomic environments, including the use of dummy variables representing access to health resources, communication with other residents, and financial status. Based on responses to Q5.3, a dummy variable representing access to health resources was assigned a value of 1 if the respondent's access to health resources such as hospitals was excellent or good ; otherwise, it was assigned a value of 0. As shown in Table 1, 41.5% of the respondents reported that their access to health resources was relatively good at present. Similarly, we also defined dummy variables representing communication with other residents (based on Q5.5) and financial status (based on Q5.7). On average, 23.4% of the residents were able to communicate with other residents very easily, while only 15.4% reported that their present financial status was good. In addition, this survey also collected information on place of residence until the earthquake. Using a combination of individual-level data and municipality-level seismic intensity data enabled us to construct more exact and informative models [11]. As indicated in Table 1, the mean level of seismic intensity across all municipalities was about 6.1, representative of the fact that Miyagi prefecture was severely devastated by the earthquake. Table 1 also presents the descriptive statistics and definitions of the other independent variables.

Fig. 1 Mechanisms underlying the impact of the earthquake on residents' mental health



Note: This figure is produced by the authors.

4. Regression Analysis

4.1 Hypothesis

As seen in Table 1, although we found that the proportion of respondents facing damage to their home was relatively high, the impact of such damage may be expected to diminish with the arrival of economic recovery. However, the impact of an injury to or loss of family members on respondents' mental health may persist for a long time as a result of the shortage of effective interventions. Fig. 1 indicates an outline of the mechanism discussed in this paper. There are three types of damage, including damage to tangible property (such as houses), damage to work status, and injury to or loss of family members. By the distinct characteristics of these different kinds of damage, their effects on residents' mental health may differ regarding duration. As the first two types of damage are relatively easy to recover from, they may influence residents for only a short period. In contrast, injury to or loss of a family member may have long-term effects on mental health, as the recovery of resilience after such an event may take a long time. As the mean score for mental health condition was much lower than the mean score for physical health condition seven years after the earthquake, we hypothesized that only injury to or loss of a family member would be found to influence the mental health status of residents persistently. In addition, other important factors such as individual characteristics and socioeconomic environment would be expected to determine the mental health status of residents.

4.2 Coefficients Estimated using Ordered Probit Models

In this study, we used several indices to measure the mental health condition of respondents, including indicators of a mental health condition, cognitive condition, and motivation for work and daily life. Because all of these indices were measured as ordinal variables, an ordered probit model was used to analyze the results. The independent variables include damage to the home, damage to work status, loss of a family member, age, gender, marital status, employment status (self-employed, homemaker, or employed part-time), whether the respondent had moved for reasons related to the earthquake or for reasons unrelated to the earthquake, access to health resources, communication with other residents, financial status, and seismic intensity in their location.

Model 1, presented in Table 3, provides coefficient estimates for the relationships of each of these variables with respondents' mental health. With respect to the three different types of damage as predictors, only the coefficient for injury to or loss of a family member was statistically significant; this coefficient was negative, indicating that injury to or loss of any family member as a result of the earthquake negatively influenced the present mental health condition of respondents, all else being equal. Because each type of damage originates strictly exogenously, we can infer that this relationship is causal. These results are consistent with our hypothesis that the only type of damage exerting a long-term

effect on the residents would be an injury to or loss of a family member. Next, in Model 2 (Table 3), we used a binary variable representing cognitive condition as an index of health status. Concerning the coefficient estimates for each type of damage, we obtained similar results: damage to one's home or work status had no significant effects, while injury to or loss of a family member had a significantly adverse influence, consistent with [12].

Moreover, we also examined the effects on residents' motivation for work and daily life in Model 3 (Table 3). Again, we obtained similar results. The results above empirically confirm the fact that injury to or loss of a family member as a result of the earthquake had a persistent causal effect on multiple dimensions of health among respondents in Miyagi prefecture.

Regarding the estimated coefficients of several other critical independent variables, we also obtained some impressive results. First, improved access to health resources increased the probability of reporting good health.This may reflect that improving access to health resources can reduce the cost of using these resources and promote their use. However, we cannot deny the fact that improving access to health resources can cause a moral hazard to arise, with its attendant behaviors. Because such behaviors could partially cancel out the positive effect of improved access to health resources on residents' health, our estimated coefficients may exhibit a downward bias. Next, concerning the estimated coefficients for communication with other residents, strengthening communication between residents can be helpful to facilitate the accumulation of human and social capital and the soonest possible recovery from injury to or loss of close family members. Among the three models, the coefficient relating to this variable was significantly positive only in Model 3, indicating that strengthening communication can be an effective means of improving the probability of residents' reporting motivation for work. However, residents' motivation for work might simultaneously influence their degree of communication with other residents. Because contact with other residents is endogenous, the result mentioned above may reflect correlation. In addition, we observed that financial status positively correlated with health status.

We hypothesized that an injury to or loss of a family member would be found to have a persistent impact on mental health status. However, this would not be the case for physical health. Therefore,we employed in a robustness check on our findings. In Model 4, shown in Table 3, we estimated the coefficients for physical health corresponding to each type of damage, which were utterly consistent with our argument.

TABLE 3 ESTIMATED COEFFICIENTS FOR FOUR ORDERED PROBIT MODELS WITH DIFFERENT DEPENDENT VARIABLES

	Model 1	Model 2	Model 3	Model 4
	Mental Health Condition	Cognitive Condition	Motivation on Working and Daily Life	Physical Health Condition
Damage to Home	–0.003	–0.048	0.213	–0.030
	(–0.02)	(–0.32)	(1.12)	(–0.13)
Damage to Work Status	–0.061	–0.290	–0.176	–0.293
	(–0.25)	(–1.07)	(–1.11)	(–1.19)
Injury to or Loss of a Family Member	–0.451*	–0.274**	–0.492***	–0.280
	(–1.68)	(–2.44)	(–2.92)	(–0.95)
Age	0.012**	0.005	–0.004	0.006
	(2.13)	(1.04)	(–0.76)	(1.36)
Gender	0.265	0.190	0.287	–0.095
	(1.55)	(0.90)	(1.49)	(–0.51)
Marital Status	0.242	–0.232*	0.152	–0.101
	(1.55)	(–1.89)	(1.04)	(–0.86)
Self-employed	0.133	0.392*	0.208	0.231
	(0.44)	(1.72)	(0.70)	(0.93)
Homemaker	0.268	0.485*	0.383	–0.001
	(0.90)	(1.91)	(1.54)	(–0.01)
Part-time Job	0.144	0.149	0.227	–0.007
	(0.90)	(1.00)	(0.97)	(–0.04)
Moving Related to the Earthquake	–0.240	–0.401	–0.229	–0.616***
	(–1.06)	(–1.12)	(–0.83)	(–3.33)
Moving Unrelated to the Earthquake	0.139	0.073	–0.116	0.021
	(0.65)	(0.49)	(–0.61)	(0.07)
Access to Health Resources	0.351*	0.276**	0.476*	0.513***
	(1.84)	(2.19)	(1.78)	(3.10)
Communication with Other Residents	0.028	0.077	0.423***	0.090
	(0.19)	(0.41)	(2.79)	(0.73)
Financial Status	0.842***	0.538***	0.406	0.270
	(2.60)	(3.09)	(1.42)	(1.05)
Seismic Intensity	–0.145	0.279	–0.515*	–0.177
	(–0.47)	(0.88)	(–1.87)	(–0.81)
Pseudo R^2	0.081	0.062	0.081	0.056
N	180	180	180	180

Note 1) Estimates based on analysis carried out by the authors. 2) *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. 3) All models include robust cluster standard errors (clustering at the municipality level). 4) As the dependent variables are ordinal variables, ordered probit models were used to estimate the effects of the earthquake. 5) T-statistic are in parentheses.

5. Discussion and Conclusion

Using individual data from our original survey, we not only identified the frequency with which residents suffered the types of damage caused by the earthquake but also investigated the possibility that different types of damage could have different impacts on the mental health status of the residents of Miyagi prefecture. The main findings were as follows.

First, by this original survey data, we found that the proportion of residents suffering damage to tangible property was almost as three times that of residents suffering an injury to or loss of family members; these figures are difficult to obtain from official government statistics. Second, we confirmed that injury to or loss of a family member had a significant long-term effect on respondents' mental health, as measured by indicators of mental health status, cognitive condition, and motivation for work and daily life, while none of the coefficients relating to damage to the home or

damage to work status were statistically significant. These results provide evidence to support our hypothesis that only injury to or loss of a family member has a long-term effect on residents' mental health status. Although the measurements of types of damage are crude, which would contaminate our statistical results, understanding the mechanism by which the earthquake influenced residents' mental health will help policymakers to design effective ways to support residents. For example, according to our findings, providing ongoing mental health support for residents facing injury to or loss of family members would effectively relieve the stress associated with the earthquake and promote recovery of mental health and motivation for work and daily life. In addition, the results of the robustness check using physical health status as the relevant outcome further identified the mechanisms underlying the impact of different types of damage on residents' health.

We also obtained some impressive results about critical independent variables. Improving access to health resources can increase the probability of residents' reporting that their health condition is good. Therefore, it seems that an efficient way to improve the mental health status of the residents of Miyagi prefecture is to improve the accessibility of health resources. We also found that communication with other residents could increase the probability of residents' reporting high motivation for work and daily life. However, this finding cannot necessarily be explained by a causal relationship, owing to the problem of simultaneity. Although we expect that strengthening communication with others could improve residents' mental health, high motivation for work and daily life may simultaneously promote communication with other residents. It is impossible to identify the direction of causation specifically on the sole basis of our results. Therefore, future studies should adopt methodologies allowing these simultaneity issues to be resolved. Furthermore, we should not neglect the limitation of the data used in this study. As data collection was not based on the random sampling method, its lack of representativeness could bias our estimates, and it is necessary to address this issue.

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