Brief Empirical Report

# Trajectories of distress following the Great East Japan Earthquake: a multi-wave prospective study

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## Abstract

The March 2011 Great East Japan Earthquake, tsunami and nuclear leak were complex traumas. We examine psychological distress in the years following the earthquake, using growth mixture modelling to clasify responses from 2,599 linked respondents (2012 to 2016). We identify four classes of trajectories following the disaster; resilient (76% respondents), delayed distress (8%), recovery (8%) and chronic (7%). Compared to the resilient trajectory other class members were less likely to be female and had less social support. Survivors in the recovery group were more likely to live in prefabricated housing. While distress has decreased over time, specific populations continue to require targeted intervention.



Keywords: Psychological distress; natural disasters; distress trajectories; Japan

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## Introduction

The Great East Japan Earthquake (GEJE), off the coast of Miyagi Prefecture, on 11th March, 2011, was accompanied by a 'Level 7' nuclear accident. With more than 18,000 fatalities the disaster led to the migration of one third of a million people (National Police Agency, 2014). These events occurred in a deprived region already affected by high suicide rates, and with limited health resources. A number studies have illustrated the negative impact of seismic events on psychological well-being (Fergusson, Horwood, Boden, and Mulder, 2014). However, sustained, large scale longitudinal research on the impact of such events is still rare.

A five-year study of 224 participants following an earthquake in Niigata Prefecture, Japan reported a significant decrease in psychological distress in each of the first four years after the disaster (Nakamura, Kitamura, and Someya, 2014). In Fukushima following the GEJE both post-traumatic stress disorder (PTSD) and general psychological distress declined in each of the three years post disaster (Oe, Takahashi, and Maeda, 2017). Responses to trauma, however, are likely to be heterogenous across affected populations, and several studies have identified different trajectories of distress following major disasters. Of these, the most common groupings are resilience (stable and healthy adjustment), delayed dysfunction (where distress worsens over time), recovery (elevated symptoms returning to normal functioning) and chronically elevated symptoms (persistence of impairment) (Bonanno, Westphal, and Mancini, 2011; Galatzer-Levy, Huang, and Bonanno, 2018;

Johannesson, Arinell, and Amberg, 2015). Demographic factors, pre-existing susceptibilities and post-disaster experiences are all associated with these trajectories (Bonanno et al. 2011). Women typically report greater psychological distress following natural disasters (Nakamura et al. 2014). An individual's history of psychological disorder is associated with increased risk of psychological distress post-disaster (Suzuki et al. 2015). Place of residence impacts on likely exposure to disaster as well as the availability of community resources. Poorer, temporary housing conditions also increase risk of depression or anxiety (Johannesson et al, 2015), although it is uncertain whether this persists over time (Sasaki et al, 2017). Emotional support from families, friends and relatives is positively associated with resilience (Johannesson et al. 2015). Finally, age has shown mixed associations with psychological distress amongst earthquake survivors. Here some studies find the elderly more vulnerable (Oe et al. 2017), others that previous exposure to disaster makes this population more resistant (Cherniack, 2008).

In this paper we map predictors and trajectories of distress from residents of the three most affected Prefectures of the GEJE (Miyagi, Iwate and Fukushima). We consider data from 2,599 respondents linked across surveys yearly from 2012 to 2016. We use this to address there questions: 1) how do levels of psychological distress change in the six years following the GEJE? 2) what are the major trajectories of distress over this period? 3) to what extent are the above covariates associated with these distress trajectories over these five years?

*Method*

We report a prospective cohort study examining psychological distress across multiple waves. Data was collected by Miyagi Prefecture, which recorded the largest

number of deaths from the disasters. Survivors whose housings was damaged by the earthquake / tsunami were provided temporary housing largely financed by the Prefecture. This was randomly allocated and grouped into two types of temporary housing - privately rented homes (in 35 of the municipalities) or prefabricated housing (in 10 municipalities).

Data was collected by the Miyagi Prefecture using methodology standard throughout Japan for survey collection. The Prefecture annually distributed self-report questionnaires to those living in both private residences those in prefabricated housing from September 2012. Respondents returned their questionnaires through mail or directly to administrative officers with no obligation to participate. Participants were not rewarded for their responses. Family-based response rate ranged from 50% to 70% over the six waves. Supplementary Table S1 in the Supplemental Material (online) shows number of families contacted, response rates, and final number of surveys in each wave. Supplementary Figures S1 & S2 (online) indicate data retention. We were unfortunately unable to follow up those who moved from their registered temporary housings. The study profile for waves 1 and 2 has been described elsewhere (Goodwin, Takahashi, Sun, and Ben-Ezra, 2015; Kusama et al. 2018; Matsuyama et al. 2016)

The Prefecture allocated data linkage codes to respondents by name, date of birth, gender and address at the time of disaster, allowing individuals to be identified across waves. Following linkage, the Prefecture deleted personal information to form an anonymised data set, providing the research team with a sub-set of linked respondents for further analysis. In this paper we focus on trajectories of distress over time. To do this we analysed respondents from those five years for which full annual data was available (2012-2016; *N* = 2599).

All procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. Ethical approval was obtained from the Prefecture and from the relevant Ethics Committees of Tohoku and Warwick Universities (ref: 70/17-18).

*Measures*

Measures were selected on the basis of previous work on psychological distress and were analogous to those employed by Japanese prefectures following earthquakes in Kobe and Niigata Provinces (e.g. Nakamura et al, 2014).

*Demographic variables and support*

All participants provided their sex, age (susequently recorded into quintiles), Prefecture of residence at the time of the earthquake and housing type (private or prefabricated). Respondents also indicated past history of psychiatric illness and whether they had someone to listen to their concerns (all yes / no).

*Outcomes*

All participants completed a Japanese version of the six item Kessler Psychological Distress Scale (K6: Kessler et al, 2002), intended to detect non-specific psychological distress. Scores range from 0 to 24 (maximum distress) (α=.91 in current cohort data). Scores from 8-12 indicate probable mild-moderate mental illness (MMI), 13-24 severe mental illness (SMI).

*Statistics*

We report findings for all respondents aged ≥ 18 years who completed all five waves. To examine trajectories over time in our linked data we use latent growth mixture modelling (LGMM) (MPlus v. 6: Muthén and Muthén, 2010). We adopt a step-by-step approach, employing a single-group model as the baseline before comparing to more sophisticated models, using model fit statistics (AIC, BIC, ABIC, LRT, Lo-Mendell-Rubin and Bootstrapped likelihood ratio tests and entropy criteria). This allowed us to to judge number of subgroups/classes without imposing a-priori limitations on number or definition of trajectories or a linear/nonlinear trajectory shape (Bonanno et al, 2011). We test for cubic trajectories in both our unconditional and conditional models, taking into account missing data by using the full information maximum likelihood estimation. Multinomial regression, t-tests and ANOVA (SPSS v.23) were then used to examine predictors of class membership, using the resilient class as reference group. Here, we use the covariates listed above with the exception of original Prefecture (only small numbers of respondents in our linked data lived outside Miyagi at the time of the earthquake).

## Results

*Baseline characteristics and attrition*

Supplementary Table S2 (available online) reports baseline characteristics for respondents. 53.9% respondents were female, 97.5% originally resided in Miyagi prefecture, 73.3% had a supporter and 97.8% had no psychiatric disease history. Respondents ranged from 18-97 at the start of our data collection, with a mean age of 54.63 (SD 15.92). Supplementary Figure 3 provides psychological distress over time. We report prevalence of MMI and SMI (Supplementary Table S3, online) and

compare those who completed all waves of the survey versus those who participated in a specific wave (Supplementary Table S4, available online). There were no significant differences between linked respondents who completed all waves versus responses for those completing only that wave.

*Growth Mixture Modeling*

Compared to a 3-class solution, the Likelihood Ratio Test (LRT) for a 4-class solution was statistically significant ($p < .0001$). Compared to a 4-class solution, the LRT for a 5-class solution were not significant ($p=.10$), suggesting no substantial improvement in fit. Other fit indices (e.g. BLRT) favoured a 4-class solution, with sample means closely approximating estimated means. Entropy was .85, estimated posterior probabilities for the groups ranged from .82 to .95 (Supplementary Tables S5 and S6, available online).

We modelled trajectories using two methods: a) using K6 data only (the simple model) and b) including covariate data to aid class alignment (conditional model). Both analyses led to the same number of classes (4) which were adequately explained by linear trajectories (see Supplementary Table 5, online; fit and class proportions are in Supplementary Table 6). As a result we only discuss findings for the conditional model. Further results for the simple model are available from the first author.

The four trajectory groups (classes) are illustrated in Figure 1. Resilient respondents (76.3% of total sample) demonstrated stable levels of low distress throughout the waves (with an intercept score of 3.2 decreasing slightly over time: slope = -.12). Only 0.2% of this group could be classified at risk of severe mental illness (SMI) in 2012, with rates not exceeding 1% in any wave. Class 2 (delayed

distress, 8.1% respondents overall) showed low distress at wave 1, but with a significant increase in distress over time (slope 1.41). For this group SMI risk rose from 3.3% (in 2012) to 34.5% (in 2016). Class 3 (chronic distress, 7.1% respondents) exhibited consistently high levels of distress (intercept = 14.44, with only a small decrease slope over time (-0.43)). Risk of SMI was high in both 2012 (62.5%) and 2016 (44.9%). Finally, after high initial distress (intercept 15.25) Group 4 (recovery, 8.4% respondents) showed consistent improvement (slope -2.13)), with risk of SMI dropping from 55.4% (2012) to 0.6% (2016). More detailed scores for potential moderate or severe mental illness by group over time are shown in Supplementary Table 7 (online).

We then profiled trajectories using multinomial logistic regressions (Supplementary Table S8). Compared to the reference group (resilient trajectory), other groups were more likely to include female respondents (there were 52% of females amongst resilient survivors, 57%, 61% and 64% females in classes 2-4, respectively) and less likely to report receiving support. Chronic and recovery groups were also both more likely to report a psychiatric history prior to the earthquake (9% of group members reported this, compared to just 1% of those in the resilient or delayed distress classes). Compared to the reference resilient sample those in the recovery group were more likely to live in prefabricated accommodation. Age effects were small across the groups.

## Discussion

Complex disasters, such as the major earthquake, tsunami and nuclear leak in Japan in 2011, can have a severe impact on psychological health (Cherniack, 2008). In this paper, we report a rare longitudinal prospective panel study of psychological distress

175 up to six years after these events. As in previous work, on both seismic events
176 (Nakamura et al. 2014) and related disasters (Wickrama and Ketring, 2012) we find a
177 decrease in psychological distress over time. Growth linear mixture modelling
178 suggested four trajectories of distress, affirming, across five waves, groups reported
179 over shorter periods (Galatzer-Levy et al., 2018). While more than three-quarters
180 (76%) of respondents showed resilience, approximately even groups of others
181 demonstrated delayed distress, recovery or chronic distress over time. These
182 trajectories were associated with both pre-existing vulnerabilities and post-trauma
183 housing conditions and support.

184 Average (mean) levels of psychological distress were generally low throughout
185 our data. Eighty-four percent of our respondents report positive trajectories
186 (resilience or recovery) with, as elsewhere, resilience the most common response
187 (Bonanno et al, 2011; Bryant et al. 2015; Galatzer-Levy et al, 2018; Johannesson et
188 al, 2015). This may reflect the high levels of resilience in the Japanese population in
189 general, often associated with the concept of *shouganai* ("it cannot be helped"). As
190 elsewhere, respondents who recovered usually did so within two years following the
191 stressful event (Bonanno et al, 2011) (the recovery group risk of several mental
192 illness more than halved between 2012 and 2013). One reason for this recovery may
193 lie in the higher proportion of prefabricated housing residents within this group. While
194 cross-sectional data showed that prefabricated housing, with its greater noise and
195 extreme temperatures, is a risk factor for psychological well-being (Sasaki et al,
196 2017), the close proximity of these prefabricated homes also means it was easier for
197 those in these dwellings to obtain municipal and voluntary support (Kusama et al.
198 2018; Murakami et al, 2017). This support can be a major bulwark against distress
199 (Johannesson et al, 2015). Additional logistic regressions (Supplementary Table S9,

online) demonstrated the association between the presence of a supporter at first time of survey completion and psychological well-being in the subsequent three years.

For all this, the minority of survivors who fail to recover there may be a sustained risk of trauma (Bui et al. 2010). The negative impact of prior psychiatric disorders on psychological well-being was demonstrated by the higher proportion of those with prior (pre-earthquake) diagnoses in the chronic and recovery trajectories. Previous psychiatric diagnosis was also related to increased exposure to risk following an earthquake in New Zealand (Fergusson et al, 2014). Sex effects were as anticipated, with greater distress amongst female respondents, and fewer women in the stable resilient trajectory.

Our study had several strengths. Previous studies on psychological distress following seismic events have been largely cross-sectional (risking conflating trajetories, Galatzer-Levy et al, 2018) and have been conducted primarily in Western settings. We use latent growth mixture models to consider trajectories of distress over a period of five years. We provide novel insights into the input of housing over a protracted time period. Survival analyses show we maintained participants with comparable levels of distress to those who did not complete all survey waves. At the same time, we recognise a number of limitations. We lacked several additional socioeconomic details, such as income and education level. We had more participants than families, running the risk of nonindependence of participants in our analyses. However, because very few members of the same family participated throughout the five waves (with only one or two family members linked in 78% of families) we were not able meaningfully conduct multi-level analysis clustering by family, and linked participants by their individual ID numbers rather than families.

Future studies could make particular efforts to include maintain participation by family in order to conduct analyses at this additional level. We were unable to determine additional measures of personal exposure or additional stressors, including the need to provide medicinal aid to others. More extensive information on a range of individual variations before an event would have been valuable (Galatzer-Levy et al,. 2018). Location at the time of an earthquake may also be significant but could not be formally assessed in our models as few respondents lived outside Miyagi. Victims of atomic events can suffer long-lasting anxieties that threaten their identity (Ben-Ezra et al, 2015). Fukushima refugees suffered serious disruption to their social networks, often involving the separation of spouses and children. High rates of distress in Fukushima have been reported elsewhere, reflecting public stigma towards those living in the Prefecture, as well as family dissention around the decision to evacuate (or return) (Hasegawa et al, 2015). Finally, data was self-reported. While widely used in Japan, the K6 measure of distress we used is not necessarily equivalent to clinical interviews, and may lead to conservative estimates (Goto and Wilson, 2003).

Despite the above, we believe our work has a number of important implications. This is one of the largest longitudinal studies of natural disasters using representative samples over a protracted period. Our longitudinal data underlines the significance of identifying vulnerable populations post-disaster, and the need to orientate health services accordingly. This is important in avoiding a simplistic 'one size fits all' for interventions (Bonanno et al, 2011). Those most at risk are likely to include survivors with previous psychological illnesses, women, and those who had to move home. This has implications for estimates of likely treatment effects as well as efficacy of these interventions (Galatzer-Levy et al, 2018). Expert communication is needed to gain trust of these individuals and better explain the risks following such an event. Finally, despite evidence of decline in psychological distress over time, social support retains importance for several years after the event. The random allocation of housing for survivors may make this problematic, with communities easily fractured during movement (Koyama et al, 2014). Sustained support may therefore be needed, even amongst those in apparently comfortable housing arrangements.

*Future research*

Our study suggests several avenues for future work. A large percentage of our respondents exhibit a 'resilient' trajectory. This response may result from the relative absence of further natural threats facing our populations (e.g. the emergence of new diseases). Multiple threats are associated with more negative post-disaster trajectories (Galatzer-Levy et al, 2018), with the emergence of cascading threats particularly challenging when resources are already stretched (e.g. locations with low levels of economic development). Further research could profitably explore

trajectories in these settings, particularly in those hazard-prone areas neglected in prior research (including many locations in Africa and Asia). Second, we must be wary of reifying the 'cats cradle' pattern of trajectories we observed in our study. Such trajectories may not be simply linear or stable over time (Sher et al, 2011), with different study designs likely to lead to different class memberships (e.g. prospective studies report higher resilience than longitudinal analyses: Galatzer-Levy et al, 2018). Finally, one interesting avenue for research may explore mental health implications when an individual's trajectory is significantly different from that of their societal group (e.g. when an individual's chronic trajectory is at odds with others in their ethnic group). Such work could complement other emerging research that emphasises a combination of individual and community-level relationships in the development of mental health post-disaster (Matsumaya et al, 2016).

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## Conflict of interest

The authors declare no conflicts of interest with respect to the authorship or publication of this article.

## Ethics

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

## Author Contributions

RG, KS and SS conducted the data analyses, MT, JU and SS reviewed and revised initial data waves and aided in interpretation. RG, JA and MT helped conceptualise the study and reviewed and revised the report. All authors approved the final manuscript submission.

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## Figure and Table Legends

Included in Main text (1 figure):

Figure 1- Growth mixture model for psychological distress (K6) with covariates, based on sample and estimated means

Other Supplementary materials (separate document)

SOM-R (Online, for review). (No SOM-U is now submitted)

Supplementary Table S1: Responses per wave and housing type (all responses and linked)

Supplementary Table S2: Base-line characteristics of respondents completing all waves

Supplementary Table S3. Prevalence of mild-moderate mental illness (MMI), severe mental illness (SMI) for each wave

Supplementary Table S4: Comparison of K6 scores between those who responded to all waves and not all waves

Supplementary Table S5: Parameter estimates and Model Fit Statistics.

Supplementary Table S6: Fit indices and class proportions for 1- to 5-class models.

Supplementary Table S7: Mental Illness Across Trajectories (K6 scores)

Supplementary Table S8: Multinomial Logistic Regressions for Univariate Predictors of Class Membership (vs. Reference group Resilient)

Supplementary Table S9: Association between first support and repeated K6 scores (2,599 participants)

Supplementary Figure S1: Flow charts of the data set for private housings

Supplementary Figure S2: Flow charts of the data set for prefabricated housings

Supplementary Figure S3: Psychological distress over time