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Persistent mental health impacts of disaster. Five-year follow-up after the 2011 great east Japan earthquake and tsunami: Iwanuma Study

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ABSTRACT

Few studies have tracked the long-term mental health outcomes following major disaster. We sought to document the trajectories of depressive symptoms and post-traumatic stress symptoms (PTSS) in the aftermath of the 2011 Great East Japan earthquake and tsunami. A cohort of community-dwelling older adults were followed for 5.5 years after the disaster at 3 waves (2010, 2013 and 2016). Depressive symptoms were measured by the Geriatric Depression Scale Short Form, while PTSS was assessed by the Screening Questionnaire for Disaster Mental Health. We examined the trajectories of mental illness symptoms based on the probabilities of persistence, recovery, and delayed onset. Among people without pre-disaster depressive symptoms, 13.6% had developed depressive symptoms 2.5 years after the disaster. Of these, half of those had recovered and half had persisted at the 5.5 year follow-up. 11.1% of survivors reported post-traumatic stress symptoms in 2013; of these, 58% recovered by 2016, while 4.8% experienced delayed onset. Job loss was associated with persistent PTSS (OR 2.03; 95%CI 1.01–4.12) while a drop in subjective economic status predicted delayed onset of PTSS (OR 2.13; 1.34–3.39). However, disaster-related experiences were unrelated to the trajectory of depressive symptoms at 5.5 years. The probabilities of remission (58%) and delayed onset (5%) of PTSS are consistent with prior disaster research. The experience of job loss and drop in subjective economic status appeared to exert a lingering influence on the persistence or delayed onset of PTSS. Depressive symptoms after the disaster had remitted in roughly half of the survivors after 5.5 years.

1. Introduction

In the weeks and months following a major disaster, survivors must cope with the effects of traumatic experiences, bereavement, resource loss, and dislocation. In this context, one of the earliest health impacts to emerge in affected populations is an increased incidence of psychopathology, in particular depression and PTSD (Neria et al., 2009). Long after the wreckage caused by the disaster has been cleaned up, and volunteers and aid officials have departed the scene, survivors must continue to cope with ongoing adversities, including property loss, financial hardship, and residential dislocation (Norris and Wind, 2009). For example, following the two largest earthquakes in Japan in recent history – the 1995 Hanshin-Awaji earthquake and the 2011 Great East Japan Earthquake & Tsunami – hundreds of thousands of victims lost their homes and ended up being relocated to temporary housing. The term "temporary" housing (*kasetsu jyutaku* in Japanese) turns out to be a misnomer since survivors were housed in these cramped, pre-fabricated dwellings for up to five years, before they could be finally moved to permanent accommodations.

Despite the continuing adversities experienced by disaster-affected populations, evidence documenting the long-term mental health burden remains sparse, with follow-up extending to about 2–4 years at most (Morina et al., 2014). Hence there is a gap in our understanding of the long-term (i.e., more than five years) persistence versus recovery from mental illness following disaster exposure.

Disaster researchers have noted the paradox that during the acute phase of disaster, portrayals by the media often exaggerate the sense of panic, anxiety, and helplessness in the community, followed

subsequently by a drop in interest ("falling off the front page"), resulting in an underestimation of long-term mental health burdens (McFarlane et al., 2009). Norris et al. (2002) concluded in their seminal review of studies that: (a) the peak of psychological symptoms occurs in the first year after the disaster, (b) symptoms tend to improve as time passes, and (c) delayed onset of the disorder is not commonly observed.

While several systematic reviews have been attempted to summarize the long-term mental health impacts of disaster (Morina et al., 2014; Steinert et al., 2015), estimates of long-term prognosis vary widely according to the nature and severity of the disaster, as well as characteristics of the affected populations. For example, the remission rates for PTSD range anywhere between 8 and 92% (Morina et al., 2014; Steinert et al., 2015). Furthermore, in those systematic reviews, few studies have captured the mental health status of survivors pre-dating their disaster experiences (Morina et al., 2014; Steinert et al., 2015). For example, one of the few existing studies following up to 12 years after Hurricane Katrina reported that around 40% and 30% of survivors had recovered from PTSS and depressive symptoms, respectively, while 3% and 9% experienced delayed onset of PTSS and depressive symptoms, and 14% and 28% had persistent PTSS and depressive symptoms even 12 years after the disaster (Raker et al., 2019). However, this study does not allow us to determine if the disaster caused worsening of mental health, or whether poor mental health already pre-dated disaster exposure in affected populations. Thus, absence of pre-disaster assessment of mental health could lead to inaccurate estimates of the incidence of mental illness (Galea et al., 2008a). Further, the information collected by asking survivors to retrospectively recall their mental health prior to disaster is obviously hampered by recall bias. Hence, providing better estimates of the long-term trajectories of mental illness, using pre- & post-disaster data, is an important first step in effective service planning after a disaster. Accordingly, we conducted this current study to fill the research gaps, that few studies had pre-dated disaster information of mental health or long-term study period. In this paper, we sought to describe the trajectories of depressive symptoms and PTSS following the 2011 Great East Japan earthquake and tsunami (Aim 1), and explore the risk factors which would exert a lingering influence of persistence or delayed onsets of these mental health problems after 5.5 years (Aim 2).

2. Methods

2.1. Study population

The Iwanuma Study is a longitudinal cohort of community-dwelling older adults who were directly affected by the 2011 Great East Japan Earthquake & Tsunami. The city of Iwanuma in Miyagi Prefecture (population 44,187 in 2010) was originally selected as one of the field sites of a nationwide cohort study of aging and health, called the Japan Gerontological Evaluation Study (JAGES) (https://www.jages.net/). The baseline survey of the Iwanuma Study was conducted in August 2010 (i.e., seven months before the 2011 disaster), when a census was undertaken of all the city's residents aged 65 years or older. At that time, we obtained information about participants' socio-demographic characteristics, mental and physical health status, and health habits from a postal questionnaire. The baseline questionnaire was distributed to 8576 residents, resulting in a 59% response (n = 5058). This response rate is typical of surveys of community-dwelling residents, and we confirmed that the respondents were broadly comparable to the city population-based on government Census data (Hikichi et al., 2016).

A flow chart summarizing our analytic sample is illustrated in Fig. 1. Among 4957 valid respondents to the baseline survey, 34 people lost their lives on the day of the disaster (0.68% mortality rate). In the fall of 2013 (2.5 years after the disaster), we conducted the first follow-up survey, yielding an 82.1% response rate (Fig. 1). The second follow-up survey was conducted in 2016, yielding a response rate of 84.6%.

For the analysis of trajectories of depressive symptoms and PTSS, we excluded individuals missing information on PTSS in 2013 and/or 2016

(n = 483) as well as missing information on depressive symptoms in 2010, 2013, and/or 2016 (n = 1024). Our analytic samples for the trajectories of PTSS and depressive symptoms were therefore 2298 and 1,757, respectively.

This research protocol was reviewed and approved by the human-subjects committee of the Harvard T.H. Chan School of Public Health, Tohoku University, Nihon Fukushi University, and Chiba University. Informed consent was assumed with the voluntary return of the questionnaire.

2.2. Outcomes

2.2.1. Posttraumatic stress symptoms (PTSS)

The Screening Questionnaire for Disaster Mental Health (SQD) was used to assess PTSS. The SQD was validated to screen for posttraumatic stress disorder (PTSD) among older survivors affected by the 1995 Hanshin-Awaji Earthquake in Japan (Fujii et al., 2007). This questionnaire includes 9 items: (1) Do you have trouble falling asleep or sleeping through the night? (2) Do you have nightmares about the event? (3) Do you feel irritable? (4) Do you feel that you are hypersensitive to small noises or tremors? (5) Do you avoid places, people, topics related to the event? (6) Do you think about the event when you do not want to? (7) Do you have trouble enjoying things you used to enjoy? (8) Do you get upset when something reminds you of the event? and (9) Do you notice that you are making an effort to try not to think about the event, or are trying to forget it? Responses were binary (yes/no), and summed to create an overall PTSS score (range 0–9). According to the guideline, a score of 6 or higher is considered severe, and indicative of possible PTSD. The reliability and validity of this measure were confirmed with ROC-AUC of 0.91 (95%CI: 0.83, 0.99) against the Clinician Administered PTSD Scale (CASP) as the gold standard, and we have previously used this scale in the Iwanuma cohort (Hikichi et al., 2016; Inoue et al., 2019).

2.2.2. Depressive symptoms

We used the Geriatric Depression Scale (GDS) Short Form to assess depressive symptoms. This scale was developed to assess depressive symptoms in older populations (Sheikh and Yesavage, 1986; Yesavage et al., 1982), and includes 15 items as follows. (1) Are you basically satisfied with your life? (*reverse coded*) (2) Have you dropped many of your activities and interests? (3) Do you feel that your life is empty? (4) Do you often get bored? (5) Are you in good spirits most of the time? (*reverse coded*) (6) Are you afraid that something bad is going to happen to you? (7) Do you feel happy most of the time? (*reverse coded*) (8) Do you often feel helpless? (9) Do you prefer to stay at home, rather than going out and doing new things? (10) Do you feel you have more problems with memory than most? (11) Do you think it is wonderful to be alive now? (*reverse coded*) (12) Do you feel pretty worthless the way you are now? (13) Do you feel full of energy? (*reverse coded*) (14) Do you feel that your situation is hopeless? (15) Do you think that most people are better off than you are? Responses are binary (yes/no), and the overall summed score ranges from 0 to 15, with higher scores indicating more severe depressive symptoms. A score of 5 or higher is used as the cut point for major depressive symptoms, which was validated with ROC-AUC of 0.94 (sensitivity of 92% and specificity of 87%) against the Structured Clinical Interview for the *Diagnostic and Statistical Manual of Mental Disorders, Third Edition, Revised*, as the gold standard (Lyness et al., 1997). We have previously used the GDS to study depressive symptoms in the Iwanuma cohort (Hikichi et al., 2019, 2016; Tsuboya et al., 2016).

2.2.3. Trajectories of PTSS and depressive symptoms

We categorized PTSS trajectories into the following 4 mutually exclusive groups; persistent (PTSS in both 2013 & 2016), recovered (PTSS in 2013, but not in 2016), delayed (no PTSS in 2013, but reported PTSS in 2016), and never (neither in 2013 nor 2016).

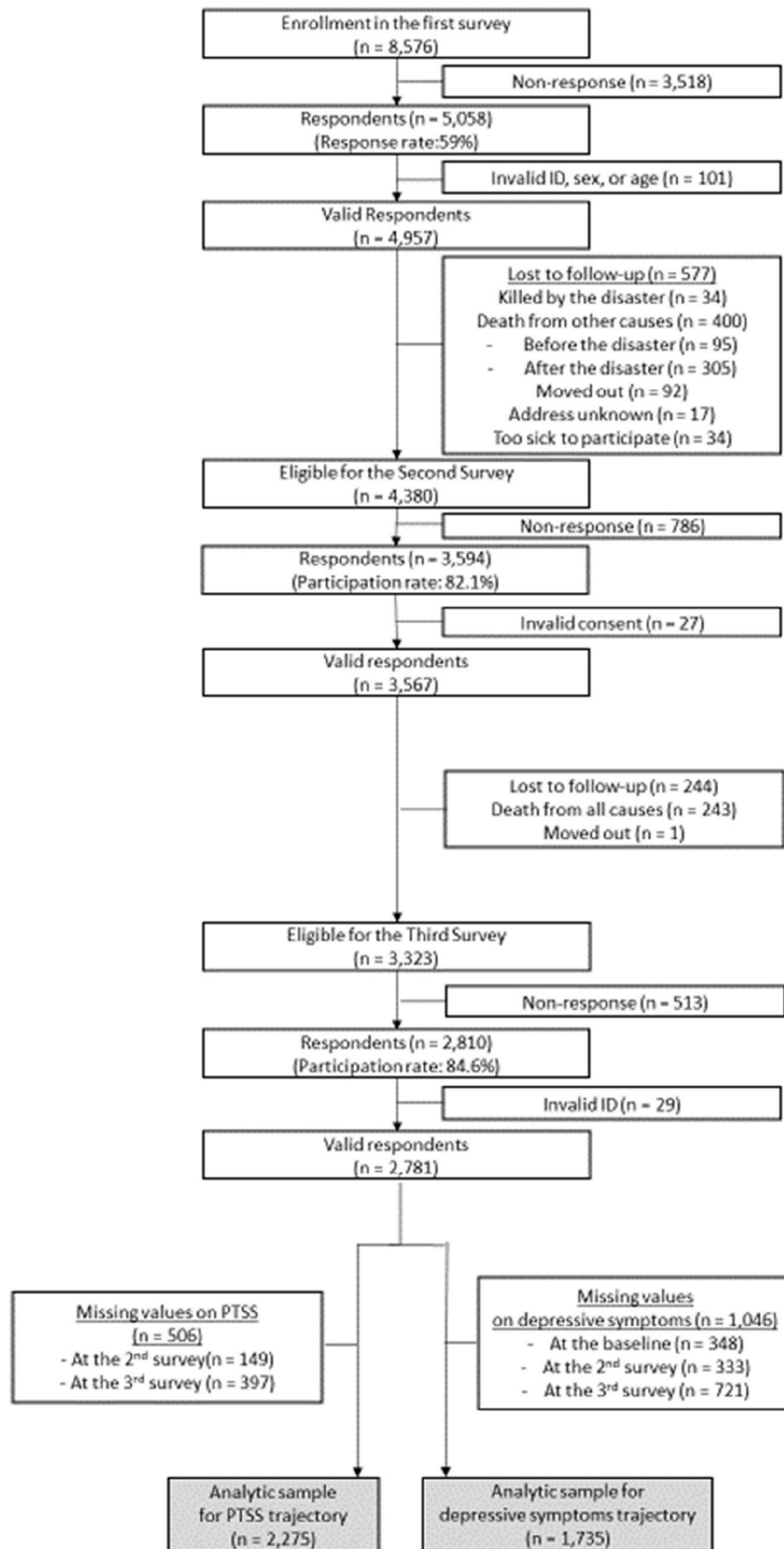As we have information about depressive symptoms across 3 waves

Fig. 1. Participants flow for analytic sample.

(including the pre-disaster wave), we split the sample into those with pre-existing symptoms before the disaster versus those without pre-disaster symptoms.

The group with pre-disaster symptoms were categorized into three trajectories: persistent (depressive symptoms in all three waves), recovered (by 2016), and fluctuating (no symptoms in 2013, but new symptoms in 2016). The group who did not have significant depressive symptoms before the disaster were categorized into four trajectory groups: persistent (depressive symptoms in both 2013 & 2016), recovered (symptoms in 2013 but recovered by 2016), delayed (no symptoms in 2013 but reported symptoms in 2016), and never (no depressive symptoms in any of three waves).

We summarized the trajectories in Fig. 2.

2.3. Explanatory variables

We used five items to assess traumatic experiences stemming from the disaster; (i) loss of relatives and/or close friends, (ii) housing damage, categorized into five levels based on the objective assessment by building inspectors: (a) no damage, (b) affected, (c) minor, (d) major, and (e) destroyed (Details are summarized in Supplemental Table 1), (iii) job loss due to the disaster, (iv) drop in subjective economic status after the disaster, and (v) interruption in medical care due to the disaster.

We controlled for the following variables; gender (male vs. female), age at baseline (65–74 vs. 75 or older), education attainment (9 years or shorter vs. longer than 9 years), equivalized household annual income at baseline (less than 200 million JPY vs. 200 million JPY or more), marital status at baseline (single vs. married), receiving emotional support at baseline (yes vs. no), and receiving care support at baseline (yes vs. no). Emotional support was measured by the question; "do you have anybody who listens to your worries or complaints?", while caregiver support was measured by the following question; "do you have anybody who can nurse or take care of you if you become sick and confined to bed for a few days?"

2.4. Statistical analysis

First, we summarized the trajectories for depression and PTSS in a figure. Second, we performed logistic regression analyses to examine the impact of disaster trauma (e.g., housing damage, losing relatives or friends, job loss, drop in subjective economic status, and interruption in medical care) on mental health trajectories. Separate models were constructed to understand the predictors of each type of trajectory. Hence the model for PTSS persistence examined the impact of disaster experiences on the persistence of PTSS as opposed to recovery. The model for delayed onset PTSS examined the impact of disaster-related trauma on delayed onset as opposed to never having PTSS.
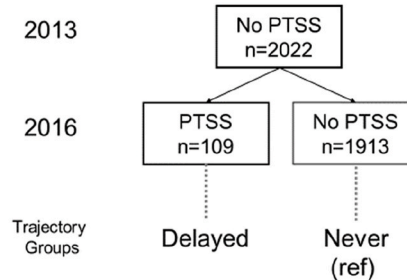
In order to describe the trajectories of depressive symptoms, we constructed four models. For those with pre-disaster symptoms, we constructed models for the risk of persistence (as opposed to recovery), and for fluctuating symptoms (as opposed to recovery by 2013). For
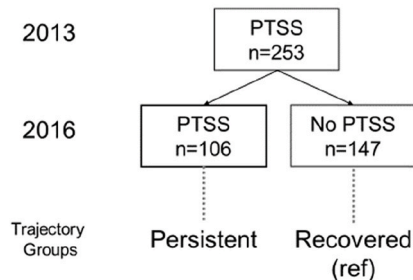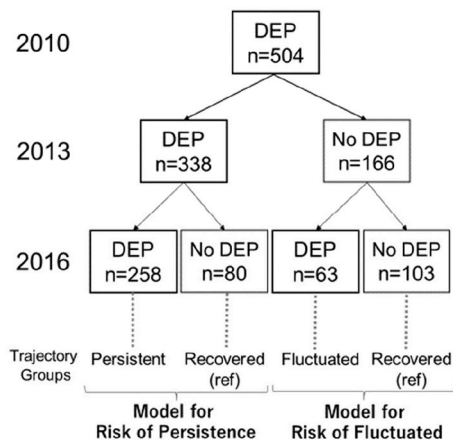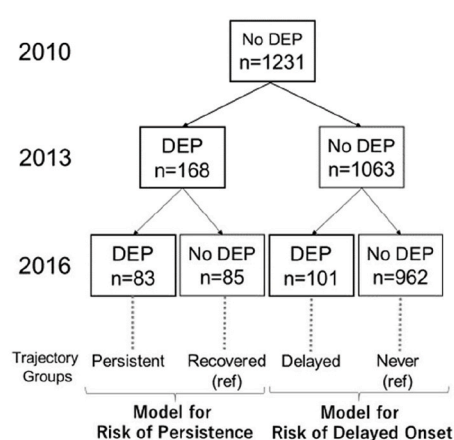

Fig. 2. Analytic Models for PTSS and DEP trajectories.

those without pre-disaster symptoms, separate models were constructed for the risk of persistence (as opposed to recovery) and the risk of delayed onset (as opposed to never having depressive symptoms). The trajectory of each group for these four models are found in Fig. 2.

Missing values of independent variables were imputed by the Markov chain Monte Carlo methods using "mi" command of STATA. We used the command of "mi estimate" to estimates model parameters from 20 imputed datasets. On the other hand, we did not impute the missing values for outcomes (i.e., depressive symptoms and PTSS) in order to preserve consistency with the raw data on trajectories of mental health. All the analyses were performed using STATA 15 SE (StataCorp, 2015).

3. Results

Demographic characteristics of the analytic samples are summarized in Table 1.

Fig. 2 shows the trajectories of PTSS and depressive symptoms, in order to address our first aim (c.f., to describe the trajectories of depressive symptoms and PTSS following the 2011 Great East Japan earthquake and tsunami). Two and half years after the disaster, 11.1% of survivors reported significant post-traumatic stress symptoms (PTSS), although we cannot exclude the possibility that some of these people might have suffered from PTSS before the disaster, e.g., due to unrelated traumatic experiences. By 5.5 years' follow-up, almost 60% had

recovered from PTSS, while 4.8% experienced delayed onset. Although we could not capture pre-disaster PTSS, we collected symtpoms at two time points (2.5 and 5.5 yearsafter the disaster), which enabled us to track the trajectory of PTSS.

In addition, 14% of survivors had developed new depressive symptoms at the 2.5 year follow-up wave after the disaster. However, this incidence rate should be assessed against the background of a 29% prevalence of significant depressive symptoms that already existed prior to the disaster. Among the 14% of survivors who reported significant depression symptoms at 2.5 year follow-up, half had persisted, but half had remitted by 5.5 years follow-up.

In order to address our second aim (c.f., explore the risk factors which would exert a lingering influence of persistence or delayed onsets of these mental health problems after 5.5 years), we exhibited the results of logistic regression analyses in Table 2 (PTSS) and Table 3 (depressive symptoms).

3.1. PTSS trajectories

Table 2 presents the results of models examining the predictors of PTSS trajectories.

(1) **Persistence of PTSS**: Job loss was marginally associated with a higher risk of persistent PTSS (as opposed to recovery) (OR 2.03, 95%CI 1.01–4.12). In addition, depressive symptoms pre-dating the disaster was a strong predictor of persistence (OR 1.90, 95% CI: 1.02–3.54).

Table 1
Demographic characteristics of analytic sample, iwanuma, Japan.

Characteristic	Analytic sample	
	for PTSS trajectory	for DS trajectory
	N = 2275	N = 1735
	%	%
Gender		
Male	44.5	49.2
Female	55.5	50.8
Age (baseline)		
65-74	67.4	70.5
≥75	32.6	29.5
Education, years		
≤9years	30.8	29.6
>9years	69.2	70.4
Equivalized Income (baseline)		
<200 million JPY	47.3	45.2
≥200 million JPY	52.7	54.8
Marital status (baseline)		
Single	23.8	22.3
Married	76.2	77.7
Receiving emotional support (baseline)		
No	5.1	5.5
Yes	94.9	94.5
Receiving care support (baseline)		
No	3.5	3.1
Yes	96.5	96.9
Loss of relatives or friends		
No	60.7	59.1
Yes	39.3	40.7
Housing damage		
No damage	40.3	39.7
Affected	44.7	45.7
Minor	7.6	7.7
Major	3.7	3.3
Destroyed	3.7	3.6
Job loss		
No loss	84.1	83.2
Lost job after the disaster	15.9	16.8
Drop in subjective economic status (ref: stable or better)		
Stable or better	76.1	75.9
Dropped	23.9	24.1
Interruption in internal medicine care		
No	95.7	95.8
Yes	4.3	4.2

Estimated using multiple imputation.

Table 2
Results of Models for PTSS trajectories.

	Model for PTSS Persistence		Model for Delayed Onset PTSS	
	with PTSS in 2013 (n = 253)		*without* PTSS in 2013 (n = 2022)	
	Persistent vs. Recovered in 2016		Delayed vs. Never in 2016	
	OR	95%CI	OR	95%CI
Female (ref: Male)	0.87	(0.47, 1.59)	1.07	(0.69, 1.65)
Age ≥75 (ref: 65–74)	1.08	(0.62, 1.88)	1.19	(0.79, 1.79)
Education >9years (ref: ≤9years)	0.84	(0.47, 1.50)	0.86	(0.56, 1.32)
Equivalized household Income ≥200 million JPY (baseline; ref: <200)	1.03	(0.56, 1.89)	0.96	(0.60, 1.53)
Married (baseline; ref: single)	1.06	(0.54, 2.07)	0.90	(0.55, 1.47)
Receiving emotional support (baseline; ref: no support)	0.69	(0.14, 3.36)	0.96	(0.39, 2.35)
Receiving care support (baseline; ref: no support)	2.99	(0.69, 12.92)	2.60	(0.59, 11.46)
Depressive symptoms (baseline; no symptoms)	**1.90**	(1.02, 3.54)	**2.56**	(1.67, 3.93)
Loss of family/friend (ref: no loss)	0.92	(0.53, 1.62)	1.08	(0.71, 1.64)
Housing damage: affected (ref: no damage)	1.19	(0.60, 2.38)	1.30	(0.82, 2.03)
Housing damage: Minor (ref: no damage)	1.64	(0.64, 4.20)	0.63	(0.23, 1.71)
Housing damage: Major (ref: no damage)	0.94	(0.29, 3.09)	1.88	(0.76, 4.69)
Housing damage: Destroyed (ref: no damage)	0.98	(0.34, 2.84)	2.41	(0.94, 6.16)
Drop in subjective economic status (ref: stable or better)	1.51	(0.85, 2.70)	**2.13**	(1.34, 3.39)
Job loss (ref: no loss)	**2.03**	(1.01, 4.12)	0.87	(0.50, 1.50)
Interruption in internal medicine care (ref: no)	1.87	(0.79, 4.44)	0.56	(0.17, 1.86)

Estimated using multiple imputation.

Table 3
Results of Models for the trajectories of depressive symptoms.

	Models for DEP Persistence (n = 504)				Models for DEP Onset (n = 1231)			
	Risk of Persistence (n = 338)		Risk of Fluctuated (n = 166)		Risk of Persistence (n = 168)		Risk of Delayed Onset (n = 1063)	
	Persistent vs. Recovered		Fluctuated vs. Recovered		Persistent vs. Recovered		Delayed vs. Never	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Female (ref: Male)	0.65	(0.36, 1.15)	0.73	(0.35, 1.51)	**0.47**	(0.23, 0.97)	1.21	(0.77, 1.90)
Age ≥75 (ref: 65–74)	1.65	(0.91, 2.98)	1.35	(0.61, 2.99)	1.09	(0.50, 2.41)	**2.06**	(1.32, 3.20)
Education >9years (ref: ≦9years)	1.30	(0.73, 2.34)	0.65	(0.30, 1.42)	1.49	(0.70, 3.18)	0.73	(0.46, 1.17)
Equivalized household Income ≥200 million JPY (baseline; ref: <200)	0.60	(0.34, 1.06)	0.86	(0.39, 1.89)	0.86	(0.41, 1.79)	0.70	(0.43, 1.13)
Married (baseline; ref: single)	0.80	(0.42, 1.52)	**0.25**	(0.09, 0.70)	0.48	(0.20, 1.17)	0.81	(0.48, 1.37)
Receiving emotional support (baseline; ref: no support)	0.78	(0.27, 2.25)	0.57	(0.16, 2.03)	0.20	(0.04, 1.11)	1.40	(0.32, 6.17)
Receiving care support (baseline; ref: no support)	0.23	(0.05, 1.04)	1.86	(0.14, 24.61)	3.60	(0.38, 33.87)	–	–
Loss of family/friend (ref: no loss)	0.75	(0.44, 1.30)	0.95	(0.46, 1.97)	1.23	(0.61, 2.47)	0.91	(0.58, 1.42)
Housing damage: affected (ref: no damage)	1.09	(0.61, 1.94)	1.67	(0.78, 3.59)	0.63	(0.28, 1.42)	0.76	(0.48, 1.21)
Housing damage: Minor (ref: no damage)	3.34	(0.84, 13.25)	–	–	1.42	(0.33, 6.09)	0.96	(0.43, 2.13)
Housing damage: Major (ref: no damage)	1.13	(0.25, 5.10)	0.48	(0.08, 2.86)	2.37	(0.39, 14.38)	–	–
Housing damage: Destroyed (ref: no damage)	2.28	(0.41, 12.82)	1.37	(0.19, 10.02)	0.51	(0.11, 2.42)	1.06	(0.28, 3.93)
Drop in subjective economic status (ref: stable or better)	1.17	(0.63, 2.16)	1.67	(0.69, 4.03)	1.06	(0.45, 2.47)	0.99	(0.54, 1.81)
Job loss (ref: no loss)	0.80	(0.40, 1.59)	1.09	(0.38, 3.11)	1.80	(0.70, 4.64)	1.05	(0.60, 1.85)
Interruption in internal medicine care (ref: no)	1.67	(0.34, 8.15)	0.87	(0.19, 3.98)	0.46	(0.11, 1.92)	0.78	(0.23, 2.65)

Estimated using multiple imputation.

(2) **Delayed onset of PTSS**: Drop in subjective economic status due to the disaster was significantly associated with the risk of delayed onset (as opposed to remaining free of PTSS) (OR 2.13, 95%CI 1.34–3.39). Pre-disaster depressive symptoms were also strongly associated with the risk of delayed onset (OR 2.56, 95% CI 1.67–3.93).

3.2. Depression trajectories

Table 3 shows the results of models testing the trajectories of depressive symptoms.

3.3. Trajectories among individuals with pre-disaster depression

(1) **Persistent depressive symptoms**: Among survivors who already reported significant depressive symptoms before 2011, traumatic experiences related to the disaster (e.g., housing damage, loss of relatives/friends, drop in subjective economic status, job loss, interruption in internal medicine care) did not predict symptom persistence at 5.5 year follow-up.
(2) **Fluctuating symptoms**: Again, the overall impression was that disaster-related traumatic experiences do not strongly predict a fluctuating trajectory of symptoms. Rather, the predictors of depressive symptom trajectories appeared to be more linked to well-established protective factors, such as marital status. Married people were less likely to have fluctuating symptoms compared to the recovered group (OR 0.25; 95%CI 0.09–0.70).

3.4. Trajectories among individuals free of depressive symptoms before disaster

(1) **Persistent depressive symptoms**: Disaster-related experiences did not consistently predict persistent symptoms at 5.5 years, e.g., no dose-response between severity of housing damage. Only gender was associated with persistent depressive symptoms (i.e., women were less likely to have persistent depressive symptoms compared to men (OR 0.47; 95%CI 0.23–0.97)).
(2) **Delayed onset**: Again, none of the disaster-related experiences were predictive of delayed onset of depressive symptoms. Older survivors (aged 75 years or older) were 2.06 times (95%CI 1.32–3.20) more likely than younger survivors to experience delayed onset.

4. Discussion

Previous reports in 2013 from the Iwanuma Study documented the incidence of depressive symptoms and PTSS in the wake of the 2011 earthquake & tsunami (Hikichi et al., 2016; Tsuboya et al., 2016). In the present study, we described the trajectories of depressive symptoms and PTSS after the disaster (Aim 1), and explored the risk factors of the persistence or delayed onsets of these mental health problems up to 5.5 years post disaster (Aim 2).

Although we found that depressive symptoms "persisted" among 29% of the population 5.5 years later, disaster trauma does not predict these cases. Hence, we believe the risk factors driving persistence are factors that have little to do with the actual experiences of disaster. Counterfactually, these people might have been depressed even if the disaster did not happen.

The trajectories of PTSS suggest a more lingering pattern of mental health burden. Even though around 60% of PTSS cases recovered, 40% still persisted by 5.5 years, while 5% experienced delayed onset. Moreover, disaster-related economic hardship (i.e., drop in subjective economic status and job loss due to the disaster) predicted lasting PTSS. Hence, unlike the case of depressive symptoms, PTSS seems to leave a lasting footprint on survivors' mental health status.

Finally, the pattern we found (i.e., disaster-related experiences do not predict trajectories of depression, while economic hardships continue to be associated with PTSS) indicates a difference from the pattern described by Norris et al. among Hurricane survivors at 30-month follow-up (Norris et al., 2002). The apparently conflicting findings might be due to the lack of the pre-disaster data in previous studies. For example, if we did not have pre-disaster data in Iwanuma, we would have ascribed the 30% prevalence of depressive symptoms in the community to the lingering impacts of the disaster.

4.1. Trajectory patterns (aim 1)

Although lifetime prevalence of PTSD is very low in the Japanese population (around 1.3%) (Kawakami et al., 2014), we found an incidence of 11% after the 2011 disaster in 2013. Our finding is almost identical to the reported prevalence of PTSS among older survivors of the Hanshin-Awaji earthquake in January 1995 (i.e., 11%), using the same screening instrument (Sakano et al., 1996). Our finding of a 58% remission rate by 5.5 years' follow-up is also in line with previous reports. In their systematic review of 42 studies, Morina et al. (2014)

reported that the mean remission rate of PTSD following disaster trauma was 60.0% (mean follow-up duration of 40 months), which was remarkably consistent with our findings (Morina et al., 2014). Finally, Raker et al. (2019) reported that 3% of survivors reported delayed onset of PTSS at twelve years post-Hurricane Katrina, while we found that 5.4% experienced delayed onset 5.5 years after the disaster (Raker et al., 2019).

A notable finding in our sample is that 29.2% of the Iwanuma population reported significant depressive symptoms predating the 2011 disaster. This reported prevalence seems very high, especially in comparison with the <10% prevalence of clinical depression (based on diagnostic interview) in Japan according to the World Mental Health Survey (Demyttenaere et al., 2004). However, our data on the community prevalence of depressive symptoms is actually quite consistent with other studies of the older Japanese population using the same instrument (GDS) and the same cut-off point (e.g., Wada et al. reported a prevalence of 33.5%, Sasaki et al. reported between 21.5% and 36.2%, and Yoshii et al. reported 33.1%) (Sasaki et al., 2015; Wada et al., 2004; Yoshii, 2010).

An important implication of our study is that although 14% of survivors developed new onset of depressive symptoms 2.5 years post-disaster, these new "cases" occurred against a backdrop of already high prevalence in the community predating the disaster.

4.2. Predictors of trajectory patterns (aim 2)

4.2.1. PTSS

We found that job loss due to the disaster was associated with persistent PTSS 5.5 years after the disaster. In addition, drop in subjective economic status due to the disaster predicted delayed onset of PTSS. Pre-disaster depressive symptoms predicted both persistent PTSS as well as delayed onset of PTSS.

We previously reported that housing damage was associated with an increased risk of *short-term onset* (2.5 years post-disaster) of PTSS (Hikichi et al., 2016). Interestingly, at the 5.5 year mark, we did not find any lingering impact of housing damage on PTSS. Previous studies of disaster survivors, e.g., the Indian Ocean tsunami, also suggest that posttraumatic stress reactivity was significantly linked to traumatic experiences (such as loss of kin and property damage) in the 1–2 year follow-up period (Frankenberg et al., 2008). Raker et al. also concluded that housing damage was a significant predictor of PTSS in the earlier follow-up of Hurricane Katrina victims while it was not a predictor in the long-term (Raker et al., 2019). Our findings also support the evidence that disaster-related traumatic experiences (such as loss of loved ones, housing damage) predict PTSS for up to 2.5 years, but that the effect fades by 5.5 years. On the other hand, the risk factors that predict persistent PTSS and delayed onset seem to be lingering economic circumstances, such as job loss and subjective financial hardship. This finding seems to converge with a recent study about the influence of COVID-19 pandemic on PTSS, which pointed a large impact of the expectation of economic hardship on mental health (Guo et al., 2020).

We found a very strong association between pre-disaster depressive symptoms and persistent/delayed onset PTSS, which is very consistent with previous literature (Norris et al., 2002). Several reviews have also found that lack of social support is a predictor of long-term PTSD (Brewin et al., 2000; Galea et al., 2008b; Steinert et al., 2015). In the Iwanuma Study, people receiving more emotional support prior to the disaster appeared to be at lower risk of PTSS persistence & delayed onset, although the estimates were imprecise due to sample size (Table 2).

4.2.2. Depressive symptoms

We found that none of the disaster-related traumatic experiences were associated with the trajectory of depressive symptoms. Previously, we reported that individual experiences of trauma, especially housing damage, do predict higher depressive symptoms – but only at the 2.5

year post-disaster follow-up, when people were still living in pre-fabricated temporary housing (Sasaki et al., 2020). By 2016, housing damage was no longer correlated with depressive symptoms, which may be because by then people had been re-settled into permanent housing provided by the municipality. Remarkably, loss of loved ones was not correlated with depressive symptoms at any follow-up wave, which seems to suggest that after an initial period of intense grief, people tend to recover. In addition, other disaster-related experiences such as drop in subjective economic status, job loss, and interruption in internal medicine care did not predict depressive symptoms 5.5 years after the disaster. A potential explanation for this finding is that people who were already depressed before the disaster were unlikely to have their trajectory altered by experiencing adversity, i.e., there was a ceiling effect on depressive symptoms.

On the other hand, the predictors of depressive symptoms trajectories in our study appeared to be the same predictors as reported outside the context of disaster, e.g., lack of emotional support and marital status. For example, being married was a significant predictor of recovery (as opposed to fluctuated depressive symptoms) in 2016. In addition, even though half of the people who reported being depressed in 2013 still had persistent symptoms in 2016, their experiences of the disaster were generally unrelated to the trajectories of their symptoms. This implies that unrelated life events that occurred in the intervening interval were responsible for persisting symptoms. We also found that disaster experiences do not predict the 8% of people who developed "delayed onset" depression, suggesting that we were capturing the natural history (or background incidence) of depressive symptoms in the community. Therefore, the label of "delayed" onset might be a misnomer.

4.2.2.1. Strengths and limitations.
The strength of this study is that we collected information about pre-disaster depressive symptoms. This enabled us to examine the accurate trajectory of depressive symptoms following the disaster (Galea et al., 2008a), and allowed us to test the lingering impact of disaster-related experiences on those trajectories. Furthermore, our study tracked the same population over 5.5 years, which enabled us to assess the long-term trajectories of mental health problems.

Although we have outstanding strengths, we also note that there were some limitations of this study. Firstly, the response rate at the baseline survey was 59.0%, although this rate is comparable to other surveys of community-dwelling older adults. We have confirmed that the demographic characteristics of the baseline survey were quite comparable to the 2010 National Census population data from the city (Hikichi et al., 2016). Secondly, we do not assess PTSS prior to the disaster. Therefore, we could not fully characterize the trajectories for PTSS. Thirdly, sample sizes were small for some analyses, therefore, estimates might be imprecise. Fourthly, all the information relied on self-report. Lastly, there is a possibility of selection bias due to loss to follow up. Especially, people who were most depressed or had severe PTSS may have selectively dropped out, and hence there is a possibility of inflating the recovery rates, although we had very high response rates at the follow-up surveys (i.e., 82.1% for the 2nd survey, and 84.6% for the 3rd survey).

5. Conclusions

In conclusion, the experience of job loss and drop in subjective economic status exert a lasting influence on the trajectories of PTSS among survivors from the 2011 Great East Japan earthquake and tsunami. On the other hand, disaster-related experiences were largely unrelated to trajectories of depressive symptoms at 5.5 years' follow-up, suggesting that the long-term impacts of disaster differ according to the specific type of psychopathology. Worsening economic situation due to the disaster rather than the uncontrollable disaster experience itself

affects post-traumatic symptoms, suggesting that chronic mental health problems after the disaseter would be addressable by economic support.

CRediT authorship contribution statement

Declaration of competing interest

The authors declare that they do not have any conflict of interest with respect to this research study and paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychires.2020.08.016.

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