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Longitudinal course of disaster-related PTSD among a prospective sample of adult Chilean natural disaster survivors

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Abstract

Background: With an increasing number of individuals surviving natural disasters, it is crucial to understand who is most at risk for developing post-traumatic stress disorder (PTSD). The objective of this study was to prospectively examine the role that pre-existing psychopathology plays in developing PTSD after a disaster.

Methods: This study uses data from a prospective 5-wave longitudinal cohort (years 2003–11) of Chilean adults from 10 health centres ($N = 1708$). At baseline, participants completed the Composite International Diagnostic Interview (CIDI), a comprehensive psychiatric diagnostic instrument. In 2010, the sixth most powerful earthquake on record struck Chile. One year later, a modified version of the PTSD module of the CIDI was administered. Marginal structural logistic regressions with inverse probability censoring weights were constructed to identify pre-disaster psychiatric predictors of post-disaster PTSD.

Results: The majority of participants were female (75.9%) and had a high-school/college education (66.9%). After controlling for pre-disaster PTSD, pre-existing dysthymia [odds ratio (OR) = 2.21; 95% confidence interval (CI) = 1.39–3.52], brief psychotic disorder (OR = 2.67; 95% CI = 1.21–5.90), anxiety disorders (not including PTSD; OR = 1.49; 95% CI = 1.27–1.76), panic disorder (OR = 2.46; 95% CI = 1.37–4.42), agoraphobia (OR = 2.23; 95% CI = 1.22–4.10), social phobia (OR = 1.86; 95% CI = 1.06–3.29), specific phobia (OR = 2.07; 95% CI = 1.50–2.86) and hypochondriasis (OR = 2.10; 95% CI = 1.05–4.18) were predictors of post-disaster PTSD. After controlling for pre-disaster anxiety disorders, dysthymia, and non-affective psychotic disorders, individuals with pre-disaster PTSD (vs those without pre-disaster PTSD) had higher odds of developing post-disaster PTSD (OR = 2.53; 95% CI = 1.37–4.65).

Conclusions: This is the first Chilean study to demonstrate prospectively that pre-disaster psychiatric disorders, independent of a prior history of other psychiatric disorders, increase the vulnerability to develop PTSD following a major natural disaster.

Key words: PTSD, natural disaster, Latin America, longitudinal cohort, Chile, adult

Key Messages

- With an increasing number of individuals surviving natural disasters, it is crucial to understand who is most at risk for developing post-disaster PTSD.
- The objective of this study was to prospectively examine the role that pre-existing psychopathology plays in developing PTSD after a disaster.
- After controlling for pre-disaster anxiety disorders, dysthymia and non-affective psychotic disorders, results indicated that individuals with pre-disaster PTSD (vs those without pre-disaster PTSD) had higher odds of developing post-disaster PTSD (OR = 2.53; 95% CI = 1.37-4.65).
- This is the first study to demonstrate prospectively that pre-disaster psychiatric disorders, independent of a prior history of other psychiatric disorders, increase the vulnerability to developing PTSD following a major natural disaster in Chile.

Introduction

Between 2001 and 2010, there was an average of 384 natural disasters each year, affecting 232 million victims worldwide.¹ However, because catastrophes are unpredictable, the vast majority of studies examining their psychological impacts, such as PTSD, do not have pre-disaster psychiatric data.² Therefore, post-disaster-only designs ignore the effect of pre-existing psychopathologies on the incidence and prevalence of subsequent PTSD.³⁻⁵ Additionally, the majority of information on disaster-related PTSD is based on cross-sectional studies only and typically on convenience samples.⁶ These limitations have resulted in few advances in understanding the effects of previous psychiatric events on post-disaster PTSD, leading to a lack of clarity on appropriate secondary prevention interventions for disaster victims most at risk of developing adverse psychological outcomes.⁷ With an increasing number of individuals surviving natural disasters in the general population, it is critical to determine who is at elevated risk for developing PTSD when faced with a trauma, with the overall goal of reducing the incidence of PTSD.⁸⁻¹¹

On 27 February 2010, the sixth most powerful earthquake on record since 1900, measuring 8.8 on the Richter Scale, struck the coast of central Chile.¹² This disaster resulted in at least 523 deaths and left 24 people missing, 12 000 injured, 800 000 displaced and hundreds of thousands of buildings damaged or destroyed.¹² The province of Concepción was the major urban centre that experienced the most damage. In addition to the earthquake, a 2.35 meter tsunami wave hit Talcahuano, causing further

damage.¹² As the Chilean disaster occurred in the midst of an existing longitudinal prospective cohort study, the current analysis provides a rare opportunity to study adults located at the epicentre of the disaster who had undergone a structured diagnostic psychiatric interview before exposure to a major traumatic event.

The main objective of this study was to identify the strongest pre-disaster psychiatric predictors of post-disaster PTSD.¹³⁻²² We had three hypotheses: (i) individuals with pre-disaster PTSD will have a higher probability of developing post-disaster PTSD, compared with those with no pre-disaster PTSD; (ii) pre-existing psychiatric disorders will increase the risk for post-disaster PTSD, independent of a previous history of PTSD; and (iii) individuals with pre-disaster PTSD will have a higher probability of developing post-disaster PTSD (compared with those with no pre-disaster PTSD), independent of a previous history of other psychiatric disorders.

Methods

The PREDICT study

The PREDICT study took place in six European and one Latin American country (Chile), with the aim of developing a multi-factor risk index to predict onset of depression among primary care attendees.²³⁻²⁵ In Chile, a sample of 3000 adults were recruited by the University of Concepción from 10 primary care centres from the national health care service (used by ~75% of the population) in Concepción and Talcahuano.²³ Participants were consecutively selected

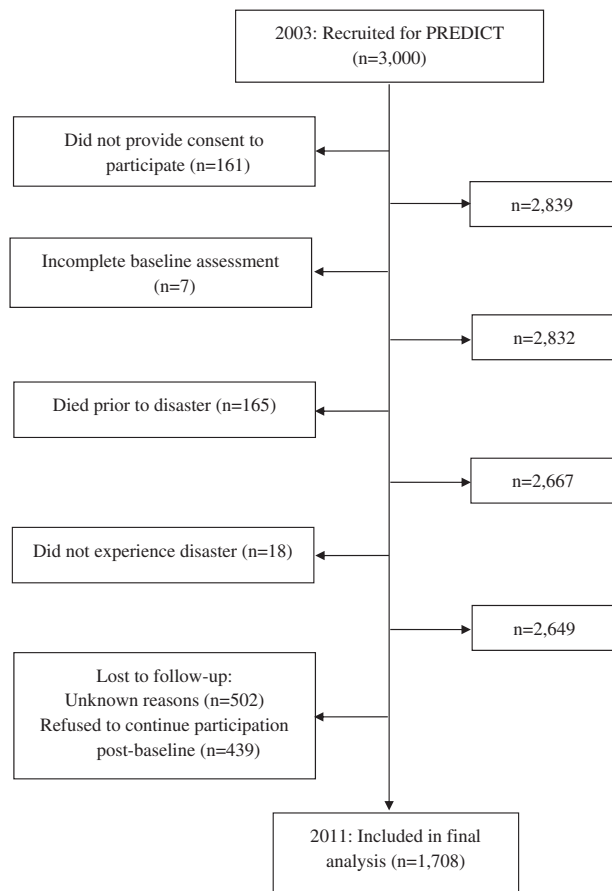


Figure 1. Flow diagram of excluded/ineligible individuals: The PREDICT study (2003-2011).

from daily patient logs based on the age and gender distribution of the primary care centres.²³ Of the 3000 participants that initially agreed to participate, 2839 completed the baseline assessment (94.6%). Wave 1 (baseline) occurred in 2003, and included a comprehensive psychiatric assessment [Composite International Diagnostic Interview (CIDI), Spanish version 2.1²⁶]. Waves 2-4 occurred 6-24 months later but either did not include PTSD assessments or involved subsamples only. Wave 5 occurred in 2011 (1 year after the disaster), and included a post-disaster PTSD assessment. Data from Waves 1 (hereinafter referred as 'pre-disaster data') and 5 (hereinafter referred as 'post-disaster data') will be used for the current analyses.

Study design

The current study used pre- and post-disaster data from the PREDICT study ($N=1708$). A flow chart of how the analytical sample was obtained is illustrated in Figure 1. The institutional review board (IRB) at the University of Concepción approved this study.

Measurements

Dependent variable: post-disaster PTSD

One year after the disaster, a modified version of the PTSD module of the CIDI (described below) Spanish version 2.1²⁶ was used as the primary outcome (hereinafter referred to as 'post-disaster PTSD'). This interview assessed all 21 PTSD symptoms from the DSM-IV-TR,²⁷ and was tailored such that the only potentially traumatic event that could be endorsed was if the participant was involved in the 2010 disaster. All questions were anchored to the 2010 disaster as the point of reference. For example, the questions that assessed for avoidance was: 'Were you trying to force yourself to not think or talk about the earthquake/tsunami?'. No other modules from the CIDI were used in the post-disaster assessment.

Independent variables: pre-disaster psychiatric disorders

The majority of pre-disaster psychiatric disorder information was measured via the CIDI Spanish version 2.1.²⁶ The CIDI is a comprehensive, fully structured psychiatric diagnostic instrument that generates lifetime and current Axis I mental disorders by means of computerized algorithms according to ICD-10 and DSM-IV criteria.²⁸ The CIDI has good psychometric properties, with excellent inter-rater reliability, good test-retest reliability and good validity.²⁹ It is the most widely used interview in large psychiatric epidemiological studies worldwide. The CIDI is administered by lay interviewers, does not use outside informants or medical records and does not assume the presence of a current disorder.³⁰ The Chilean CIDI is an official World Health Organization (WHO) Spanish version.^{31,32} A validation study of this instrument indicated an overall kappa statistic of 0.94 (with anxiety disorders having a kappa of 0.85).³³

In the current study, a lifetime pre-disaster PTSD diagnosis was the primary exposure of interest (hereinafter referred to as 'pre-disaster PTSD'). This PTSD module assessed all 21 PTSD symptoms from the DSM-IV-TR,²⁷ and a PTSD diagnosis could be a result of a variety of potentially traumatic events (e.g. combat, rape). The only pre-disaster disorder not based on the CIDI was substance misuse. Participants who had an elevated score (≥ 8) from the Alcohol Use Disorders Identification Test³⁴ or reported ever using illicit drugs were categorized as having substance misuse.

Pre-disaster confounder variables

The potential pre-disaster confounder variables were based on background literature regarding known risk factors for PTSD:³⁵⁻³⁷ age, gender, educational attainment and family history of psychiatric disorders (i.e. if any self-reported

family members had mental illness or committed suicide). The demographic confounder variables were obtained from the baseline CIDI assessment. Family history of psychiatric disorders was obtained from a questionnaire designed specifically for the PREDICT study. Controlling for confounding did not change the effect estimates (results not shown); therefore, the more parsimonious models are presented.

Loss to follow-up

Sensitivity analysis

Due to the longitudinal design of the secondary data analysis, there is potential for selection bias due to differential loss to follow-up. A sensitivity analysis using χ^2 and multivariable logistic regression analyses was conducted to examine the participant characteristics of those who were lost to follow-up ($n=941$ [33.1%]; Figure 1). Of note, those who died before Wave 5 did not have higher levels of baseline PTSD (results not shown). Among the 941 individuals who were lost to follow-up, there were more females than males (69% vs 30%; $\chi^2=14.84$, $p < 0.001$), more individuals with a high-school/college education compared with lower levels of educational attainment (73.4% vs 26.6%; $\chi^2=11.89$, $p=0.001$), and more individuals who were not middle-aged relative to those who were middle-aged (45-55 years; 83.5% vs 16.5%; $\chi^2=4.71$, $p=0.03$). Additionally, among those lost to follow-up, there were no differences among those with pre-disaster PTSD vs those with no pre-disaster PTSD diagnosis (16.5% vs 83.5%; $\chi^2=0.03$, $p=0.87$). Multivariable logistic regression models predicting loss to follow-up replicated these findings (results not shown).

Inverse probability weights

To mitigate the potential selection bias due to differential loss to follow-up, stabilized inverse probability censoring weighting methods (IPCW) were used. Unlike standard regression models, IPCW re-weights the study population such that the contributions of individuals who share characteristics of those who dropped out, but who remain in the study, are increased.³⁸ If IPCW model specification is correct, potential biases arising due to selection bias are mitigated. A detailed description of this methodology is documented elsewhere.³⁸⁻⁴⁰ To estimate the weights, we modelled each participant's probability of not dropping out based on each participant's exposure (pre-disaster PTSD) and confounder values, using a logistic regression model. The confounders included in the weights were gender and age because they predicted loss to follow-up and were associated with both pre- and post-disaster PTSD. Although education also was a predictor of loss to follow-up, it was not included in the weights because subsequent analyses indicated that

education was not associated with both pre- and post-disaster PTSD (i.e. not a confounding variable). The formula for calculating the stabilized IPCW was as follows:

$$SW^C = [P(C=0)|A]/[P(C=0|A, L_1, L_2)]$$

where:

- C: Participant lost to follow-up (1 = yes, 0 = no)
- A: Pre-disaster PTSD (1 = yes, 0 = no)
- L₁: Gender (1 = female, 0 = male)
- L₂: Age [1 = middle age, 0 = not middle age]

The final set of weights can be described as the number of participants who are like individual i in terms of their exposure and confounder values, who would have been in the risk set at time t in the absence of dropout. Individuals are up-weighted if they do not drop out but have the highest probability (based on his/her exposure and confounder values) of dropout. In sum, the IPCW weights create a pseudo-population that would have been observed had dropout been random (with respect to exposure and confounder values). The stabilization of the weights was used to preserve the amount of information in the observed data and to minimize variability of the weights.⁴¹

Statistical analyses

We first calculated frequencies of baseline demographic variables and pre-disaster Axis I disorders. The prevalence of post-disaster PTSD was subsequently calculated in relation to each variable. Of note, age was collapsed into 'middle age' or 'not middle age' (i.e. 45-55 years vs other) because subsequent *post hoc* analyses only showed significant differences for these two age groups. Additionally, education was collapsed into 'illiterate/elementary school' or 'high-school/college', and alcohol misuse and illicit drugs were collapsed into 'substance misuse' for the same reason.

To identify the most robust pre-disaster predictors of post-disaster PTSD, marginal structural logistic models (with robust error variance estimators) were used, with post-disaster PTSD as the outcome. Independent variables that were associated with post-disaster PTSD (after controlling for pre-disaster PTSD) and had sufficient sample sizes were used in the final marginal structural logistic models to determine if pre-disaster PTSD remained an independent predictor after controlling for other pre-disaster Axis I disorders. Although several individual anxiety disorders were associated with post-disaster PTSD, these were collapsed into a single category 'anxiety disorders', to maintain statistical power and because controlling for the disorders individually did not substantially change the odds ratio coefficients. STATA MP version 12 and SAS version 9.22 were used for data management and statistical analyses.^{42,43}

Results

Description of sample

The majority of the sample was female (75.9%), not middle-aged (80.1%) and had a high-school/college education (66.9%; Table 1). The majority of the sample had at least one lifetime pre-disaster psychiatric disorder (62.3%). Approximately 11.5% ($n=196$) of the total sample had pre-disaster PTSD, 10.2% ($n=175$) of individuals had post-disaster PTSD and 2% ($n=34$) of the sample had both pre-disaster and post-disaster PTSD. The most common pre-disaster disorder categories were mood disorders (30.4%) and anxiety disorders (not including PTSD; 41.4%), whereas the least common pre-disaster disorder categories were eating disorders (1%) and non-affective psychotic disorders (2.6%). Among those with post-disaster PTSD, most had a pre-disaster anxiety disorder (58.9%), followed by pre-disaster mood disorders (38.9%).

Marginal structural logistic regression models

Table 2 displays the predictors associated with developing post-disaster PTSD, after weighing the sample by gender and age. Dysthymia, non-affective psychotic disorders, any anxiety disorder (not including PTSD), panic disorder, agoraphobia, social phobia and specific phobia were associated with post-disaster PTSD. Compared with those with no diagnosis, individuals with pre-disaster PTSD had higher odds of developing post-disaster PTSD.

After controlling for pre-disaster PTSD in the marginal structural logistic models, the following pre-disaster disorders/diagnostic categories remained predictors of post-disaster PTSD: dysthymia, brief psychotic disorder, anxiety disorders (not including PTSD), panic disorder, agoraphobia, social phobia, specific phobia, and hypochondriasis.

Pre-disaster disorders that were predictors in all models from Table 2 and had sufficient sample sizes were included in the final marginal structural logistic regression models. *Post hoc* false detection rate adjustment tests^{44–46} indicated that the findings from Table 2 were not due to Type I errors (results not shown).

Final marginal structural logistic regression models

Table 3 displays the marginal structural logistic regression analyses predicting post-disaster PTSD, with pre-disaster PTSD as the main independent variable of interest. All models indicate that individuals with pre-disaster PTSD, relative to those with no disorder, had the highest odds of developing post-disaster PTSD. When pre-disaster anxiety

disorders (not including PTSD), dysthymia and non-affective psychotic disorders were added to the models, the PTSD odds ratio coefficients became slightly attenuated.

Discussion

The current study takes advantage of a rare opportunity to examine the effects of a natural experiment by studying adults who had undergone a structured psychiatric diagnostic interview in a large sample before being exposed to one of the most powerful earthquakes in history, thus providing a clearer understanding of the pre-existing psychiatric risk factors for developing disaster-related PTSD. The major findings include: (i) several pre-disaster Axis I psychiatric disorders predicted the development of disaster-related PTSD; and (ii) individuals with pre-disaster PTSD had the highest odds of developing post-disaster PTSD relative to individuals with no pre-disaster diagnosis, even after taking into account other pre-disaster Axis I disorders. These results produce valuable insights into which pre-existing psychopathologies are associated with developing disaster-related PTSD, as well as cross-national variations in the risk of developing disaster-related PTSD.

There have been few studies examining whether pre-existing PTSD predicts subsequent PTSD longitudinally in civilian samples.^{47,48} In our study, pre-disaster PTSD predicted post-disaster PTSD even after controlling for other pre-disaster Axis I disorders. Results support the stress sensitization hypothesis, which suggests that individuals who have experienced previous PTSD have greater vulnerability to subsequent traumas.^{47,49} Besides earlier psychiatric history, there are several other vulnerabilities that may also have influenced the increased risk and maintenance of post-disaster PTSD: genetics,⁵⁰ predisposition to a pathological reaction to stressors,⁴⁷ pre- and post-trauma psychosocial stressors (e.g. childhood poverty),³⁶ acute biological/emotional reactions after the traumatic event (e.g. peritraumatic dissociation),^{36,47,48} other personal vulnerabilities (e.g. poor coping mechanisms),^{47,49} environmental factors (e.g. relationship with family of origin²⁰), occupational/financial stressors⁵² and contextual risk factors (e.g., property destruction.⁵³ Although these variables were not included in the present study, they merit additional investigation in future longitudinal studies.

It is worth noting the lack of association between pre-disaster major depressive disorder (MDD) and post-disaster PTSD, which contradicts previous findings.^{35,54} *Post hoc* analyses indicated that MDD and PTSD were comorbid at the pre- and post-disaster assessment (results not shown). However, most of the individuals with comorbid (lifetime) MDD-PTSD at baseline were not the same individuals who had comorbid (12-month) MDD-PTSD at

Table 1. Demographic and psychiatric information of 2010 Chilean disaster victims: the PREDICT study (2003-11)

Pre-disaster characteristic	Total sample (n = 1708)		Individuals with post-disaster PTSD (n = 175)	
	n	%	n	%
Gender				
Male	412	24.1	25	14.3
Female	1296	75.9	150	85.7
Age				
45-54	340	19.9	51	29.1
< 45 and 55+	1368	80.1	124	70.9
Education				
High school/college	1142	66.9	112	64.0
Illiterate/elementary school	564	33.0	63	36.0
Unknown	2	0.1	-	-
Family history of psychiatric disorders/suicide				
Yes	305	17.9	37	21.1
No	1403	82.1	138	78.9
Pre-disaster potentially traumatic events				
Combat				
Yes	12	0.7	2	1.1
No	1692	99.1	173	98.9
Rape				
Yes	118	6.9	12	6.9
No	1586	92.9	163	93.1
Missing	4	0.2	-	-
Molested				
Yes	239	14.0	29	16.6
No	1465	85.8	146	83.4
Missing	4	0.2	-	-
Life-threatening accident				
Yes	363	21.3	32	18.3
No	1341	78.5	143	81.7
Missing	4	0.2	-	-
Disaster				
Yes	377	22.1	40	22.9
No	1327	77.7	135	77.1
Missing	4	0.2	-	-
Witness others' injury/death				
Yes	517	30.3	54	30.9
No	1187	69.5	121	69.1
Missing	4	0.2	-	-
Physically assaulted/attacked				
Yes	378	22.1	49	28.0
No	1326	77.6	126	72.0
Missing	4	0.2	-	-

(Continued)

Table 1. Continued

Pre-disaster characteristic	Total sample (n = 1708)		Individuals with post-disaster PTSD (n = 175)	
	n	%	n	%
Threatened with weapon/kidnapped				
Yes	175	10.3	21	12.0
No	1529	89.5	154	88.0
Missing	4	0.2	-	-
Tortured				
Yes	16	0.9	1	0.6
No	1688	98.8	174	99.4
Missing	4	0.2	-	-
Other				
Yes	115	6.7	11	6.3
No	1589	93.0	164	93.7
Missing	4	0.2	-	-
Childhood psychological abuse				
Yes	541	31.7	71	40.6
No	1165	68.2	104	59.4
Missing	2	0.1	-	-
Childhood physical abuse				
Yes	658	38.5	77	44.0
No	1048	61.4	98	56.0
Missing	2	0.1	-	-
Childhood sexual abuse				
Yes	161	9.4	18	10.3
No	1545	90.5	157	89.7
Missing	2	0.1	-	-
Any Pre-disaster disorder				
Yes	1064	62.3	142	81.1
No	644	37.7	33	18.9
Pre-disaster lifetime psychiatric diagnosis				
Eating disorders				
Yes	17	1.0	2	1.1
No	1691	99.0	173	98.9
Anorexia				
Yes	0	0	0	0
No	1706	99.9	175	100.0
Unknown	2	0.1	-	-
Bulimia				
Yes	17	1.0	2	1.1
No	1691	99.0	173	98.9
Mood disorders				
Yes	520	30.4	68	38.9
No	1888	69.6	107	61.1
Major depressive disorder				
Yes	417	24.4	46	26.3
No	1284	75.2	129	73.7
Unknown	7	0.4	-	-

(Continued)

Table 1. Continued

Pre-disaster characteristic	Total sample (n = 1708)		Individuals with post-disaster PTSD (n = 175)	
	n	%	n	%
Bipolar I				
Yes	36	2.1	7	4.0
No	1672	97.9	168	96.0
Bipolar II				
Yes	0	0	0	0
No	1697	99.4	175	100.0
Unknown	11	0.6	–	–
Dysthymia				
Yes	133	7.8	28	16.0
No	1557	91.2	146	83.4
Unknown	18	1.1	1	0.6
Non-affective psychotic disorders				
Yes	45	2.6	10	5.7
No	1658	97.1	165	94.3
Unknown	5	0.3	–	–
Schizophrenia				
Yes	6	0.4	1	0.6
No	1632	95.6	164	93.7
Unknown	70	4.1	10	5.7
Schizophreniform				
Yes	1	0.1	0	0
No	1692	99.1	175	100.0
Unknown	15	0.9	–	–
Schizoaffective				
Yes	2	0.1	0	0
No	1686	98.7	174	99.4
Unknown	20	1.2	1	0.6
Delusional				
Yes	0	0	0	0
No	1657	97.0	170	97.1
Unknown	51	3.0	5	2.9
Brief psychotic				
Yes	37	2.2	9	5.1
No	1581	92.6	157	89.7
Unknown	90	5.3	9	5.1
Anxiety disorders (not including PTSD)				
Yes	707	41.4	103	58.9
No	1001	58.6	72	41.1
Obsessive compulsive disorder				
Yes	24	1.4	2	1.1
No	1603	93.9	162	92.6
Unknown	81	4.7	11	6.3
PTSD				
PTSD	196	11.5	34	19.4
Any diagnosis except PTSD	868	50.8	108	61.7

Table 1. Continued

Pre-disaster characteristic	Total sample (n = 1708)		Individuals with post-disaster PTSD (n = 175)	
	n	%	n	%
No diagnosis	644	37.7	33	18.9
Panic				
Yes	75	4.4	17	9.7
No	1622	95.0	154	88.0
Unknown	11	0.6	4	2.3
Agoraphobia				
Yes	70	4.1	15	8.6
No	1613	94.4	155	88.6
Unknown	25	1.5	5	2.9
Social phobia				
Yes	90	5.3	17	9.7
No	1595	93.4	155	88.6
Unknown	23	1.4	3	1.7
Generalized anxiety				
Yes	20	1.2	4	2.3
No	1684	98.6	171	97.7
Unknown	4	0.2	–	–
Specific phobia				
Yes	659	38.6	98	56.0
No	1044	61.1	77	44.0
Unknown	5	0.3	–	–
Somatoform disorders				
Yes	177	10.4	25	14.3
No	1531	89.6	150	85.7
Somatization				
Yes	1	0.1	0	0
No	1705	99.8	175	100.0
Unknown	2	0.1	–	–
Conversion				
Yes	89	5.2	13	7.4
No	1491	87.3	145	82.9
Unknown	128	7.5	17	9.7
Pain				
Yes	104	6.1	14	8.0
No	1467	85.9	144	82.3
Unknown	137	8.0	17	9.7
Hypochondriasis				
Yes	57	3.3	11	6.3
No	1645	96.3	164	93.7
Unknown	6	0.4	–	–
Substance misuse				
Yes	231	13.5	30	17.1
No	1477	86.5	145	82.9

Missing pre-disaster disorders were not counted in the grouped disorder categories; estimates presented are un-weighted.

(Continued)

Table 2. Marginal structural logistic regression models predicting post-disaster PTSD in Chilean disaster victims ($N = 1708$): the PREDICT study (2003-11)

	Pre-disaster independent variable	Age and gender weighted*			Age and gender weighted,* adjusted for pre-disaster PTSD		
		OR	95% CI	<i>p</i>	OR	95% CI	<i>p</i>
Model 1:	Education						
	High school/college	0.86	0.62-1.19	0.354	0.87	0.63-1.21	0.419
	Illiterate/elementary school	1.0	–	–	1.0	–	–
Model 2:	Family history of psychiatric disorders/suicide						
	Yes	1.27	0.86-1.87	0.229	1.16	0.78-1.72	0.460
	No	1.0	–	–	1.0	–	–
Model 3:	Any diagnosis						
	Yes	2.90	1.96-4.30	0.000	2.67	1.78-4.00	0.000
	No	1.0	–	–	1.0	–	–
Model 4:	Eating disorders						
	Yes	1.20	0.27-5.28	0.813	1.02	0.23-4.52	0.981
	No	1.0	–	–	1.0	–	–
Model 5:	Bulimia						
	Yes	1.20	0.27-5.28	0.813	1.02	0.23-4.52	0.981
	No	1.0	–	–	1.0	–	–
Model 6:	Mood disorders						
	Yes	1.54	1.12-2.13	0.009	1.40	1.01-1.96	0.046
	No	1.0	–	–	1.0	–	–
Model 7:	Major depressive disorder						
	Yes	1.13	0.79-1.62	0.488	1.06	0.74-1.53	0.752
	No	1.0	–	–	1.0	–	–
Model 8:	Bipolar I						
	Yes	2.16	0.93-5.01	0.073	1.83	0.79-4.23	0.158
	No	1.0	–	–	1.0	–	–
Model 9:	Dysthymia						
	Yes	2.56	1.63-4.02	0.000	2.21	1.39-3.52	0.001
	No	1.0	–	–	1.0	–	–
Model 10:	Non-affective psychotic disorders						
	Yes	2.72	1.32-5.59	0.007	2.42	1.17-5.02	0.017
	No	1.0	–	–	1.0	–	–
Model 11:	Schizophrenia						
	Yes	2.03	0.24-17.51	0.519	1.73	0.23-12.94	0.593
	No	1.0	–	–	1.0	–	–
Model 12:	Brief psychotic disorder						
	Yes	3.02	1.40-6.53	0.005	2.67	1.21-5.90	0.015
	No	1.0	–	–	1.0	–	–
Model 13:	Anxiety disorders (not including PTSD)						
	Yes	2.23	1.62-3.07	0.000	2.07	1.49-2.87	0.000
	No	1.0	–	–	1.0	–	–
Model 14:	Obsessive compulsive						
	Yes	0.82	0.19-3.50	0.784	0.65	0.15-2.85	0.570
	No	1.0	–	–	1.0	–	–
Model 15:	PTSD						
	PTSD	3.99	2.40-6.65	0.000	–	–	–
	Any diagnosis except PTSD	2.67	1.78-4.00	0.000	–	–	–
	No diagnosis	1.0	–	–	–	–	–

(Continued)

Table 2. Continued

	Pre-disaster independent variable	Age and gender weighted*			Age and gender weighted,* adjusted for pre-disaster PTSD		
		OR	95% CI	<i>p</i>	OR	95% CI	<i>p</i>
Model 16:	Panic						
	Yes	2.86	1.62-5.04	0.000	2.46	1.37-4.42	0.003
	No	1.0	–	–	1.0	–	–
Model 17:	Agoraphobia						
	Yes	2.61	1.44-4.74	0.002	2.23	1.22-4.10	0.009
	No	1.0	–	–	1.0	–	–
Model 18:	Social phobia						
	Yes	2.18	1.25-3.79	0.006	1.86	1.06-3.29	0.032
	No	1.0	–	–	1.0	–	–
Model 19:	Generalized anxiety						
	Yes	2.21	0.73-6.70	0.161	1.99	0.63-6.27	0.237
	No	1.0	–	–	1.0	–	–
Model 20:	Specific phobia						
	Yes	2.23	1.62-3.06	0.000	2.07	1.50-2.86	0.000
	No	1.0	–	–	1.0	–	–
Model 21:	Somatoform disorders						
	Yes	1.56	0.99-2.46	0.055	1.39	0.86-2.25	0.179
	No	1.0	–	–	1.0	–	–
Model 22:	Conversion						
	Yes	1.59	0.86-2.94	0.137	1.41	0.73-2.73	0.300
	No	1.0	–	–	1.0	–	–
Model 23:	Pain						
	Yes	1.48	0.82-2.68	0.191	1.35	0.74-2.48	0.333
	No	1.0	–	–	1.0	–	–
Model 24:	Hypochondriasis						
	Yes	2.23	1.13-4.39	0.021	2.10	1.05-4.18	0.035
	No	1.0	–	–	1.0	–	–
Model 25:	Substance misuse						
	Yes	1.38	0.91-2.10	0.134	1.32	0.86-2.03	0.208
	No	1.0	–	–	1.0	–	–

* All models are weighted by age and gender via stabilized inverse probability censoring weights with robust variance estimators.

Table 3. Marginal structural logistic regression models predicting post-disaster PTSD (*N* = 1708): the PREDICT study (2003-11)

Pre-disaster predictors	Model 1			Model 2			Model 3			Model 4		
	OR	95% CI	<i>p</i>	OR	95% CI	<i>p</i>	OR	95% CI	<i>p</i>	OR	95% CI	<i>p</i>
PTSD												
PTSD	3.99	2.40-6.65	0.000	3.16	1.77-5.64	0.000	2.73	1.50-4.98	0.001	2.53	1.37-4.65	0.003
Any diagnosis except PTSD	2.67	1.78-4.00	0.000	2.14	1.30-3.51	0.003	2.01	1.21-3.45	0.007	1.90	1.13-3.19	0.015
No diagnosis	1.0	–	–	1.0	–	–	1.0	–	–	1.0	–	–
Other anxiety disorders	–	–	–	1.39	0.93-2.06	0.104	1.41	0.95-2.09	0.092	1.46	0.98-2.18	0.065
Dysthymia	–	–	–	–	–	–	1.80	1.13-2.86	0.013	1.83	1.15-2.92	0.011
Non-affective psychotic disorder	–	–	–	–	–	–	–	–	–	2.05	0.99-4.26	0.055

All models weigh age and gender utilizing stabilized inverse probability censoring weights with robust variance estimators; Model 1 is repeated from Table 2 for ease of reading.

the post-disaster assessment. There are several speculations as to why this pattern emerged. First, the baseline interview assessed for a lifetime history of psychiatric disorders, compared with the post-disaster assessment which assessed for 12-month disorders. As a result, some participants during the pre-disaster assessment had to recall symptoms/diagnoses from years (or decades) previously, which may have led to memory biases. Second, the average age of onset of pre-disaster PTSD preceded pre-disaster MDD by a substantial amount of time, i.e., 46.7 years [standard deviation (SD) = 16.3] vs 20.7 (SD = 10), and the two disorders may have not occurred simultaneously. Third, the pre-disaster PTSD interview assessed PTSD symptoms due to a variety of potentially traumatic events, whereas the post-disaster PTSD interview only assessed symptoms relating to the disaster. We may have found the same individuals with comorbid PTSD-MDD at both waves if other post-disaster potentially traumatic events (e.g. combat, assault etc.) were assessed.

Surprisingly, an association between pre-disaster dysthymia (but not MDD) and post-disaster PTSD was found. There are several reasons why this finding may have occurred. First, *post hoc* analyses indicated that individuals with pre-disaster dysthymia had more pre-disaster psychiatric disorders (mean = 2.38; SD = 1.82; median = 2.0) than individuals with pre-disaster MDD (mean = 1.56; SD = 1.47; median = 1.0; results not shown). Additionally, individuals with pre-disaster dysthymia were significantly more likely to be illiterate/have an elementary school education (vs a high-school/college education) compared with those with pre-disaster MDD ($\chi^2 = 20.12$, $p = 0.000$). Together, these results suggest that the participants with pre-disaster dysthymia had a higher overall vulnerability to developing post-disaster PTSD compared with individuals with pre-disaster MDD.³⁵ Second, most disaster studies use checklists (instead of diagnostic interviews) to measure depressive symptoms, which do not differentiate between MDD and dysthymia. It is possible that dysthymia (a long-lasting chronic disorder), rather than MDD (a cyclical disorder) predicted PTSD in these studies.⁵⁵ Third, there was a significant relationship between pre-disaster lifetime MDD and pre-disaster lifetime dysthymia ($\chi^2 = 29.95$, $p = 0.000$), which is consistent with other studies demonstrating a significant symptom overlap between MDD and dysthymia.^{27,56} Further research examining the association between dysthymia and PTSD is warranted given the novelty of these results.

This study's findings have the potential to inform targeted public health interventions to reduce disaster-related PTSD. Natural disasters are a continuous threat to countries throughout the world, especially Chile, due to its geographical location.¹² In this study, we found that the

majority of individuals who developed post-disaster PTSD had symptoms for over a year (results not shown), illustrating the need for clinical interventions in future disasters. Although the majority of individuals exposed to a disaster will not develop PTSD nor need formal intervention, a minority will require acute post-disaster psychological support.³⁵ Fortunately, Chile uses primary prevention in the form of strict building codes, which is beneficial as several studies have found that building destruction, injury and death increase the risk of post-disaster PTSD. Public health disaster efforts can focus on triaging individuals with pre-existing PTSD and other comorbid disorders, in order to allocate resources to individuals most at risk for developing post-disaster PTSD. Because Chile has a national mental health care system, this process can be streamlined by completing a brief PTSD assessment during routine mental health visits, enabling the identification and treatment of those at risk for developing post-disaster PTSD. This will likely lead to the increased resiliency of the victims, reducing the burden of secondary functional impairment and costs to both the individual and the public.⁵⁷

The present study has some limitations that should be kept in mind when interpreting results. First, there is potential for non-differential misclassification of pre-disaster PTSD. As the baseline examination was administered 7 years before the disaster, new cases of PTSD may have been missed which occurred between the baseline assessment and the earthquake.

Second, we do not capture individuals who may have had PTSD after the disaster due to non-disaster traumatic events. Therefore, results should only be generalized to individuals with PTSD due to experiencing a natural disaster. Future studies should use multiple time points before and after a disaster to more accurately examine the longitudinal course of disaster-related PTSD.

Third, because this study recruited a non-psychiatric sample, some of the disorders had sparse sample sizes, leading to imprecision in those estimates.

Fourth, although data were collected in a longitudinal and prospective fashion, the results may not reflect a causal relationship between pre-disaster PTSD and post-disaster PTSD, due to residual confounding, unmeasured confounding and random error.

Fifth, several post-disaster moderators of post-disaster PTSD (e.g. destruction) were not included in the present analysis, as the preliminary focus was to examine the association between pre-disaster psychopathology and post-disaster PTSD.

Sixth, the pre-disaster disorders are lifetime accounts, which may be susceptible to memory biases.

Seventh, a substantial proportion of the sample was lost to follow-up, inducing potential selection bias. However,

we circumvented this bias with probability censoring weights.

Eighth, given the CIDI uses lay interviewers to collect diagnostic information, there is concern regarding the ability of this instrument to accurately assess non-affective psychotic disorders in US populations.^{58–62} However, there are insufficient data on Latin American populations to draw this conclusion.

Ninth, because the sampling was based on attendance at primary care clinics, we have an over-representation of females compared with the general Chile population, and it is possible that here the prevalence of psychiatric disorders is higher than those from a population-based sample.⁶³

Finally, the findings may not necessarily generalize to non-health-care seeking populations in Chile or populations outside Chile.

Despite its limitations, the current study has many strengths. It provides the unprecedented opportunity to examine PTSD before and after a natural disaster in a large sample, using a validated, cross-cultural diagnostic psychiatric interview, while simultaneously controlling for comorbid Axis I psychiatric disorders using a methodologically robust study design. This type of rich longitudinal data does not exist in the disaster literature.⁶⁴

Previous studies that have attempted to address these study questions have been severely limited by small convenience samples, lack of diagnostic instruments and lack of any pre-disaster information.^{20,64} The current study overcomes these limitations and this database allows for testing of hypotheses not previously possible. This information is critical to understanding variations in risk, course and diagnostic subtypes of disaster-related PTSD, with the overall goal of reducing the incidence of post-disaster PTSD. By determining who has PTSD after a disaster, one can more accurately determine the mechanisms of disaster-related PTSD in an understudied international population.^{65,66}

In conclusion, this study uses a methodologically robust design aimed at identifying the mechanisms of disaster-related PTSD, thereby furthering understanding of the longitudinal course of PTSD and facilitating the development of more appropriate interventions targeted to high-risk individuals. The analyses take advantage of a unique and rare opportunity to examine the effects of a natural experiment by studying adults who had undergone a structured psychiatric diagnostic interview in a large sample before being exposed to one of the most powerful earthquakes in history, thus providing a clearer understanding of the trajectory of disaster-related PTSD and its determinants among groups in whom PTSD resolves spontaneously and those in whom it persists in the long term. An increased knowledge regarding the variations of disaster-related PTSD is essential in order

to inform more sensitive treatment strategies, especially among international populations.

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