



## Research paper

# Longitudinal determinants of depression among World Trade Center Health Registry enrollees, 14–15 years after the 9/11 attacks



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## ABSTRACT

**Background:** Exposure to the September 11, 2001 (9/11) terrorist attacks has been found to be associated with posttraumatic stress disorder (PTSD) and comorbid PTSD and depression up to 10–11 years post-disaster. However, little is known about the longitudinal predictors of mental health conditions over time.

**Methods:** We examined longitudinal determinants of depression within strata of PTSD among 21,258 enrollees of the World Trade Center Health Registry who completed four questionnaires over 14 years of follow-up (Wave 1 in 2003–04; Wave 2 in 2005–06; Wave 3 in 2011–12; and Wave 4 in 2015–16). PTSD status was measured using the PTSD checklist on all four waves and defined as a score of  $\geq 44$ ; depression was assessed using the 8-item Patient Health Questionnaire at Waves 3 and 4 and defined as a score of  $\geq 10$ .

**Results:** Across Waves 3 and 4, 18.6% experienced depression, and it was more common among those who ever had PTSD (56.1%) compared with those who had not (5.6%). Across PTSD strata, predictors of depression included low income, unemployment, low social integration and support, post-9/11 traumatic life events, and chronic physical illness. These factors also decreased the likelihood of recovering from depression.

**Limitations:** Depression symptoms were not measured at Waves 1 and 2; data was self-reported.

**Conclusions:** These findings highlight the substantial burden of depression in a trauma-exposed population 14–15 years post-disaster, especially among those with PTSD. Similar life stressors predicted the course of depression among those with and without PTSD which may inform public health and clinical interventions.

## 1. Introduction

The catastrophic events of September 11, 2001 (9/11) resulted in both immediate and persistent psychological trauma among New York City survivors. The initial prevalence of posttraumatic stress disorder (PTSD) in the early wake of the disaster ranged between 7.5% and 20.0% (Galea et al., 2002; Schlenger et al., 2002), and estimates remained similar several years after 9/11, especially among those directly exposed to the attacks (Brackbill et al., 2009). Now more than a decade later, post-disaster studies have extensively documented the burden of PTSD as well as other mental health conditions such as major depression, although to a lesser extent (Neria et al., 2011).

While PTSD is the most common type of psychopathology following a traumatic exposure, it is also often comorbid with depression (Breslau et al., 2000; Campbell et al., 2007). The prevalence of depression among those with PTSD is estimated to be as high as 50% among traumatized populations, and even higher in clinical studies (Rytwinski et al., 2013). This burden is exacerbated by the increased symptom severity and functional impairment as well as reduced quality of life

among those with comorbid PTSD and depression compared with those with only one condition (Dekel et al., 2014; Ikin et al., 2010). Previous studies on 9/11 exposed populations have compared people with comorbid PTSD and depression to those with neither condition (Bowler et al., 2016; Caramanica et al., 2014; Dekel et al., 2017), but due to the overwhelming impact of PTSD in these trauma-exposed populations, this approach may obscure the unique determinants of depression (Campbell et al., 2007). Furthermore, to date, the studies on depression following 9/11 have mostly been cross-sectional in design (Ahern and Galea, 2006; Caramanica et al., 2014; Chiu et al., 2011; Galea et al., 2002; Stellman et al., 2008), with few studies examining the longitudinal course of depression and its predictors over time.

Among a cohort of individuals directly exposed to 9/11, this study serves to build upon the existing research on post-disaster mental health conditions by exploring longitudinal patterns of depression within strata of PTSD symptomology. In monitoring the burden of mental health morbidities and their predictors over time, findings may contribute to a better understanding of post-disaster psychopathology and thus inform clinical management and potential public health

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interventions. The overall purpose of this study was to assess the longitudinal determinants of depression over a period of several years, up to 15 years after 9/11. First, we estimated the prevalence of depression, among both those who had experienced PTSD and those who had not. Second, we identified factors associated with depression, again within strata of PTSD status. Lastly, we examined predictors of resolved depression compared with persistent depression among individuals who had experienced PTSD.

## 2. Methods

### 2.1. Study population

This study was conducted among enrollees of the World Trade Center Health Registry (Registry), a long-term cohort study of first responders, residents, area workers, and others present in downtown Manhattan on September 11, 2001. In 2003–04, 71,427 individuals were enrolled into the study and completed a baseline questionnaire (Wave 1), which was followed in subsequent years by Wave 2 (2006–07), Wave 3 (2011–12), and Wave 4 (2015–2016). Further details on this study have been previously published elsewhere (Brackbill et al., 2009; Farfel et al., 2008). The Registry protocol was approved by the institutional review boards of the Centers for Disease Control and Prevention and the New York City Department of Health and Mental Hygiene.

For this study, enrollees had to complete all four Waves and be at least 18 years old at Wave 1 ( $N = 28,138$ ). Those with pre-9/11 depression or PTSD diagnoses ( $N = 3252$ ) or missing information on diagnosed depression or PTSD ( $N = 358$ ); those missing PTSD symptoms at any Wave ( $N = 3247$ ); and those missing *both* Wave 3 and Wave 4 depression symptoms ( $N = 23$ ) were subsequently excluded, yielding a final study population of 21,258.

### 2.2. Mental health measures

Depressive symptoms were assessed using the Patient Health Questionnaire (PHQ)-8 (Kroenke et al., 2009) at Waves 3 and 4 only. This instrument consists of a sequence of eight questions that ask about the frequency of symptoms over the last two weeks, which are rated from 0 = *not at all* to 3 = *nearly every day*. These symptoms represent eight of the nine criteria that constitute the *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)* (American Psychiatric Association, 1994) diagnosis of depressive disorders, with the ninth item being thoughts about suicide or self-injury. This criterion was omitted due to the self-administered nature of the questionnaires and thus the inability to intervene; as well as its minimal impact on scoring due to its low rate of endorsement (Kroenke and Spitzer, 2002). Items were summed and scores  $\geq 10$  were considered to be indicative of depression, as this cut-off has shown to have a sensitivity and specificity of 0.88 for diagnosed major depression based on structured psychiatric interviews using *DSM-IV* diagnostic criteria (Kroenke et al., 2001). Because the PHQ-8 was administered at both Waves 3 and 4, those who had scores  $\geq 10$  at either or both waves were considered to have depression. More specifically, those with scores  $\geq 10$  at both waves were considered to have *persistent depression* and those with a score of  $\geq 10$  at Wave 3 but  $< 10$  at Wave 4 were considered to have *resolved depression*.

PTSD symptoms were assessed at each wave (Waves 1–4) using the stressor-specific PTSD Checklist (PCL)-17 (Blanchard et al., 1996; Ruggiero et al., 2003; Weathers et al., 1994), which contains direct references to the events of 9/11 in the re-experiencing and avoidance domains. The PCL is a self-administered questionnaire that queries the severity of PTSD symptoms based on *DSM-IV* criteria (American Psychiatric Association, 1994) in three domains: re-experiencing, avoidance, and hyperarousal. Enrollees rated the degree to which these symptoms bothered them over the last thirty days, ranging from 1 = *not at all* to 5 = *extremely*, and the scores from the 17 items were

summed. Total scores  $\geq 44$  were considered to be indicative of probable PTSD (hereafter referred to as PTSD) (Blanchard et al., 1996). PTSD status was summarized across time as ever (scores  $\geq 44$  at least one wave) and never (scores  $< 44$  at all waves).

### 2.3. Predictors

Questionnaires contained various details on social and demographic factors such as race and ethnicity, household income, education, marital status, and employment status. In addition, in Waves 1 and 2, questions were asked about various traumatic experiences on 9/11. Based on work by Adams and Boscarino (Adams and Boscarino, 2005), Brackbill et al. derived a composite score consisting of 11 questions about traumatic experiences such as: being in the North or South WTC towers at the time of the attack; witnessing three or more events (seeing planes hit the buildings, people fall or jump from buildings, people injured, or people running); fear of being injured or killed; and having a relative killed on 9–11 (Brackbill et al., 2013). A complete list of the exposures is listed in Supplemental Table 1. These items were then summed (range = 0–11) and the score was then categorized as none/low (0–1 exposures), medium (2–3), high (4–5), and very high ( $\geq 6$ ). Questions about other sources of trauma, both before and after 9/11, were also included (American Psychiatric Association, 1994), such as experiencing a serious accident (e.g., in a car or a fall), an intentional attack with or without a weapon, forceful unwanted sexual contact, and serious family or work problems. Enrollees were classified based on their endorsement of  $\geq 1$  traumatic experience. Traumas occurring before and after 9/11 were examined separately.

Questions about social integration and social support were asked at Waves 3 and 4. An abbreviated 5-item version of the Social Support Survey for the Medical Outcomes Study (Sherbourne and Stewart, 1991) was administered, including questions about how often someone is available to: take you to the doctor if you need to go; have a good time with; hug you; prepare your meals if you are unable; and understand your problems. These items were individually scored based on frequency ranging from 0 = *none of the time* to 4 = *all of the time* and subsequently summed. Scores were then categorized as follows: low (0–10), medium (11–14), and high ( $\geq 15$ ), with higher scores denoting a greater degree of social support. Questions about social integration were based on the RAND Social Health Battery (Donald and Ware, 1984) and asked about social functioning, mainly through social resources and contacts: visiting or talking with friends, attending religious services, being active in volunteer organizations, and having perceived close friends or relatives. The number of endorsed items were categorized as low (0–1 engagements), medium (2), and high ( $\geq 3$ ).

Finally, enrollees were asked at each wave about physician-diagnosed mental and physical health conditions. In this analysis, based on literature linking 9/11-related exposures, such as dust and debris exposure (Liroy et al., 2002), to certain diseases, those who reported that they had been diagnosed with at least one of the following: heart attack or heart disease (Jordan et al., 2011a, 2011b), asthma (Brackbill et al., 2009; Wheeler et al., 2007), gastroesophageal reflux disease (GERD) (Li et al., 2011; Webber et al., 2009) and/or cancer (Li et al., 2016, 2012; Solan et al., 2013; Zeig-Owens et al., 2011) were considered to have a chronic physical disease.

### 2.4. Statistical analysis

The prevalence of depression was calculated across Waves 3 and 4 (i.e., period prevalence) as well as at each individual wave (i.e., point prevalence). Study participants were stratified by depression status at Waves 3 and/or 4 within strata of ever-PTSD (Waves 1–4). Sociodemographic characteristics, 9/11-related exposures, self-report of physical and mental health diagnoses, social support and integration, and other covariates were compared across strata. Multivariable log binomial models were fit in order to identify predictors of depression

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