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Posttraumatic stress disorder and new-onset diabetes among adult survivors of the World Trade Center disaster

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ABSTRACT

Objective. To explore the temporal relationship between 9/11-related posttraumatic stress disorder (PTSD) and new-onset diabetes in World Trade Center (WTC) survivors up to 11 years after the attack in 2001.

Methods. Three waves of surveys (conducted from 2003 to 2012) from the WTC Health Registry cohort collected data on physical and mental health status, sociodemographic characteristics, and 9/11-related exposures. Diabetes was defined as self-reported, physician-diagnosed diabetes reported after enrollment. After excluding prevalent cases, there were 36,899 eligible adult enrollees. Logistic regression and generalized multilevel growth models were used to assess the association between PTSD measured at enrollment and subsequent diabetes.

Results. We identified 2143 cases of diabetes. After adjustment, we observed a significant association between PTSD and diabetes in the logistic model [adjusted odds ratio (AOR) 1.28, 95% confidence interval (CI) 1.14–1.44]. Results from the growth model were similar (AOR 1.37, 95% CI 1.23–1.52).

Conclusion. This exploratory study found that PTSD, a common 9/11-related health outcome, was a risk factor for self-reported diabetes. Clinicians treating survivors of both the WTC attacks and other disasters should be aware that diabetes may be a long-term consequence.

Introduction

Type 2 diabetes mellitus (diabetes) is a nationwide epidemic, affecting more than 8% of the adult United States population (Li et al., 2012). Diabetes can lead to a host of serious health complications, including heart disease, blindness, and kidney disease (Centers for Disease Control and Prevention, 2011b). It is estimated to have cost the United States health care system $245 billion in 2012 (American Diabetes Association, 2013a). The primary risk factors for type 2 diabetes include overweight/obesity, older age, family history, physical inactivity and black, Hispanic, and Asian race/ethnicity (American Diabetes Association, 2013b).

In addition to these well-established risk factors, psychological stress may lead to an increased susceptibility to diabetes. Numerous studies of trauma-exposed populations have found an association between PTSD and diabetes (Agyemang et al., 2012; Armenian et al., 1998; Boyko et al., 2010; Dedert et al., 2010; Goodwin and Davidson, 2005; Pietrzak et al., 2011; Trief et al., 2006). A study of asylum seekers in the Netherlands found that those with PTSD were more likely to have been diagnosed with type 2 diabetes (Agyemang et al., 2012). The National Epidemiologic Survey on Alcohol and Related Conditions observed an increased risk of diabetes in those with PTSD, although this relationship was attenuated when adjusting for number of lifetime traumatic events (Pietrzak et al., 2011). Most of these studies have been cross-sectional, and thus have not firmly established a temporal relationship between PTSD and diabetes. However, the Millennium Cohort Study of US military service members, one of the few longitudinal analyses of this relationship, found twofold increased odds of incident diabetes among those with PTSD after 3 years of follow-up of its military population (Boyko et al., 2010).

The World Trade Center (WTC) Health Registry, established in 2003, collects longitudinal information on individuals exposed to the WTC attack in 2001, providing an opportunity to examine the temporal relationship between PTSD and subsequent diabetes. As PTSD is one of the most common mental health outcomes observed in WTC-affected populations (Brackbill et al., 2009; Farfel et al., 2008), Registry enrollees may have an increased risk of diabetes. To our knowledge, however, no studies have examined diabetes in WTC-affected populations. In the current study, we examined the relationship between 9/11-related PTSD and new-onset diabetes in the WTC Health Registry's adult population up to 11 years after the disaster.

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Research design and methods

Registry population

From September 2003 to November 2004, the WTC Health Registry (Registry) enrolled 71,434 persons who were exposed to the September 11, 2001, disaster in New York City or who subsequently assisted in the rescue, recovery and cleanup effort. In addition to rescue/recovery workers, the Registry includes Lower Manhattan residents, area workers, school staff and students, and commuters and passersby on 9/11. The Registry's recruitment methods have been described previously (Brackbill et al., 2009; Farfel et al., 2008). At the time of enrollment, registrants completed a Wave 1 (W1) baseline computer-assisted telephone (95%) or in-person (5%) interview about their 9/11-related exposures and health following the disaster (Farfel et al., 2008). Two subsequent surveys have been conducted to obtain updated information on enrollees' health status, healthcare utilization, and well-being. Both employed mail, web and telephone survey modes. The Wave 2 (W2) survey was conducted from November 2006 through December 2007 with a response rate of 68% (Brackbill et al., 2009). Wave 3 (W3) was conducted from July 2011 through March 2012, with a response rate of 63%. The Registry protocol was approved by the Centers for Disease Control and Prevention (CDC) and New York City Department of Health and Mental Hygiene institutional review boards. Enrollees provided verbal informed consent to participate in the Registry.

Study outcome

Diabetes was defined as self-reported diabetes diagnosed after Registry enrollment, reported at either W2 or W3, by answering "yes" to the question, "Have you ever been told by a doctor or other health professionals that you had diabetes or sugar diabetes?" Additionally, the year of diagnosis had to have been ≥ the year of W1 completion. For those who reported diabetes at both W2 and W3, the year reported at W2 was used. The surveys did not specify type 1 or type 2 diabetes; however, as the study sample only included adults, and type 2 accounts for 90% to 95% of adulthood diabetes diagnoses (Centers for Disease Control and Prevention, 2011b), we assumed the vast majority of reported cases were type 2.

Study variables

The main predictor of interest for this study was PTSD at W1. We used a 9/11-specific PTSD Checklist (PCL), a validated, 17-item, event-specific scale, to assess symptoms of PTSD in the 30 days preceding the interview, with some questions specifically referencing the events of 9/11. The PCL has been reported to have a sensitivity of 94% and specificity of 86% (Blanchard et al., 1996; Weathers et al., 1993). PTSD was also measured at W2 and W3. Individual items were scored from 1 (not at all) to 5 (extremely), with total scores ranging from 17 to 85. PTSD was defined as a score of 44 or greater, with no items missing.

Additional covariates included sociodemographic variables and 9/11-related exposures. Data on sex, age, race/ethnicity, education, and smoking status were obtained at W1. Enrollees were categorized into one of the following mutually-exclusive, hierarchical eligibility groups based on the likelihood and intensity of exposure: rescue/recovery workers; lower Manhattan residents; lower Manhattan area workers; passersby; and school students and staff.

Weight and height were ascertained at W3, and BMI was calculated as: [weight (pounds) / height (inches)^2] × 703, rounded to the nearest tenth. The CDC's BMI guidelines for ages ≥15 years were used to exclude persons with biologically implausible values (Centers for Disease Control and Prevention, 2011a). Overweight was defined as a BMI between 25 and 29.9, and obese was a BMI of 30 or greater. We also considered respondent history of hypertension, which was queried at all three waves, and history of high cholesterol, assessed at W3 only.

To define 9/11-related exposure, we used a 12-item index, based on a tool created by Adams et al. (2006) and later modified based on Registry data by Brackbill et al. (2013). This scale included information on an enrollee's exposures on 9/11 and during the subsequent recovery and cleanup effort, loss of loved ones or coworkers, job loss due to 9/11, and damage to or loss of property or a home. The number of disaster-related events or conditions experienced was summed, and enrollees were categorized as having had none/low (0–1 experiences), medium (2–3), high (4–5), or very high (6 or more) exposure.

Study population

Of 71,434 Registry enrollees, we included participants who completed the W3 follow-up survey ($n = 43{,}134$). We excluded enrollees who were <18 years of age at 9/11 ($n = 739$), enrollees who reported having been diagnosed with diabetes before Registry enrollment (i.e., prevalent cases; $n = 2479$), and those missing a history of diabetes ($n = 456$). After removing those who were missing demographic or exposure data, 36,899 participants were included in this analysis.

Statistical analyses

The frequencies of sociodemographic and 9/11-exposure characteristics of persons with diabetes were compared with those of persons without diabetes in bivariate analyses. We also compared characteristics of the study population to W1-only participants who were not included in this analysis to assess possible bias from loss to follow-up. Logistic regression was used to calculate odds ratios (ORs) and 95% confidence intervals (CI) for the association between PTSD at W1 and new-onset diabetes. Multiple logistic regression models were adjusted for covariates that were significant in the bivariate analysis and that are commonly associated with diabetes, including age, sex, race/ethnicity, educational status at W1, hypertension, high cholesterol, and BMI at W3. Models that included smoking status at W1 and eligibility group were evaluated, but as the adjusted ORs (AORs) did not change substantially, these variables were not included in the final model. The 9/11 exposure index was no longer significant in the multivariable model and thus was not included in the final model. We tested for interactions between PTSD and other variables and found none. Model fit was assessed with the Hosmer–Lemeshow goodness of fit χ^2 test. Analyses used SAS version 9.2 (SAS Institute Inc., Cary, North Carolina).

We also conducted a three-wave, two-level hierarchical growth model, where PTSD was treated as a time-varying predictor. Measurements were nested within subjects. Due to the multilevel framework using repeated measurement occasions, missing data for PTSD did not result in pairwise deletion. This yielded a slightly larger study sample size compared with the single-level analysis, containing 37,856 subjects (level-2 units) and 113,568 measurement occasions. The same variables used in the single-level logistic regression were included, with the addition of a time factor. Age, race/ethnicity, sex, education, BMI, high cholesterol, and hypertension were all included as time-invariant predictors. Once an enrollee reported a diagnosis of diabetes, his or her PTSD status at subsequent waves was not included so as to not bias the temporal association between PTSD and new-onset diabetes. Data were prepared in SAS version 9.2 and multilevel analysis was conducted using HLM 7 (SSI International, Skokie, Illinois).

Results

Of 36,899 study participants, 2143 (5.8%) reported having been diagnosed with diabetes between Registry enrollment (2003–2004) and March 2012. Table 1 shows the sociodemographic characteristics and 9/11-related exposures of the study population. Persons with diabetes were more likely to be male, older, a race/ethnicity other than non-

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