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Posttraumatic Stress Symptoms, PTSD, and Risk Factors Among Lower Manhattan Residents 2–3 Years After the September 11, 2001 Terrorist Attacks

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Manhattan residents living near the World Trade Center may have been particularly vulnerable to posttraumatic stress disorder (PTSD) after the September 11, 2001 (9/11) terrorist attacks. In 2003–2004, the authors administered the PTSD Checklist to 11,037 adults who lived south of Canal Street in New York City on 9/11. The prevalence of probable PTSD was 12.6% and associated with older age, female gender, Hispanic ethnicity, low education and income, and divorce. Injury, witnessing horror, and dust cloud exposure on 9/11 increased risk for chronic PTSD. Postdisaster risk factors included evacuation and rescue and recovery work. The results indicate that PTSD is a continued health problem in the local community. The relationship between socioeconomic status and PTSD suggests services must target marginalized populations. Followup is necessary on the course and long-term consequences of PTSD.

Studies on the psychological sequelae of disasters have shown that those caused by human intent create severe mental health effects in communities that experience them (Norris et al., 2002). In particular, posttraumatic stress disorder (PTSD) imparts substantial functional impairment in the exposed and is often comorbid with conditions such as depression, generalized anxiety disorder and substance abuse (Kessler et al., 1999).

Data from general population surveys in New York City after the September 11, 2001 (9/11) terrorist attacks indicate substantial PTSD symptoms that declined within 6 months. Eight percent of Manhattan residents reported symptoms consistent with a diagnosis of PTSD at 5–8 weeks, whereas samples drawn at 4 and 6 months estimated 2% and less than 1% PTSD, respectively (Galea et al., 2003). Despite this downward trend, relatively little is known about the course of PTSD in the highly exposed area of lower Manhattan. Galea and colleagues (2002) found that residents living south of Canal Street were at higher risk for PTSD compared to other Manhattanites (20% vs. 7%) at 5–8 weeks postattack. Closer to the World Trade Center (WTC), a needs assessment of three neighborhoods found 39% of residents

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exhibited high levels of PTSD symptoms 6-weeks postattack (Kramer et al., 2002). To our knowledge, however, no empirical study to date has investigated the long-term prevalence of PTSD related to the terrorist attacks in lower Manhattan. Such residents may exhibit stronger and more persistent sequelae compared to the citywide population because of increased exposure to direct victimization, witnessing horror, bereavement, property damage, and financial strain; all of which are known to contribute to the disaster–psychopathology relationship (Rubonis & Bickman, 1991).

This study documents the long-term prevalence of PTSD symptoms and associated risk factors among 11,037 lower Manhattan residents living south of Canal Street on 9/11, an area within one mile of the WTC site. Participants were enrollees of the World Trade Center Health Registry (WTCHR), a longitudinal cohort established to monitor the long-term health effects of the attacks. We examined the prevalence of PTSD 2–3 years postattack by demographics and included potential risk factors for PTSD that have not been examined in-depth in previous 9/11 studies. Specifically, we assessed whether residential location and varying degrees of direct exposure intensity were associated with increased PTSD risk. We also assessed whether exposures largely unique to the postdisaster experience of lower Manhattan residents (e.g., evacuation, residential clean up, and relocation) were associated with an increased PTSD risk.

METHOD

Participants

The WTCHR is a nonmandated registry of 71,437 persons highly exposed to the 9/11 terrorist attacks. Individuals eligible for enrollment included residents who lived near the WTC, persons who were physically in lower Manhattan during the attacks, schoolchildren and staff in lower Manhattan, and persons involved in rescue and recovery work (Murphy et al., 2007).

The eligibility criterion for this analysis was having a permanent residence south of Canal Street on 9/11. Both active and passive recruitment methods were used over a 15-month enrollment period from September 5, 2003 through November 20, 2004 during which enrollees completed a baseline interview (Dolan, Murphy, Thalji, & Pulliam, 2006). Active recruitment involved contacting individuals from a list purchased from Genesys Sampling Systems (Fort Washington, PA), which contained all directory-listed addresses and telephone numbers active as of September 10, 2001 south of Canal Street. This list and others supplied by local tenant organizations were submitted to the U.S. Postal Services' National Change of Address and Telematch services before contact was attempted with potential enrollees. Passive recruitment involved self-identification through a toll-free number and Web site. Multiple strategies were implemented to increase enrollment including a multilingual media campaign, tailored letters/postcards/e-mails, door-to-door canvassing, deployment of field interviewers at outreach events, and up to 40 call attempts.

Recruitment efforts yielded a pre-enrollment database containing 34,087 names of potential lower Manhattan residents. The Registry made contact with 21,070 of these individuals (61.8%). Among those, 15,656 (74.3%) were determined to be eligible during the initial stage of the baseline interview, which asked respondents to supply their complete address on 9/11. Over 14,000 ($N = 14{,}665$, 93.7%) completed the interview including 3,850 from lists and 10,815 self-identified. Residents recruited through lists were more likely to be 18- to 24-years-old (11.3% vs. 2.5%), $\chi^2(3,\ N = 11{,}037) = 275.88,\ p < .001$), and female, 58.8% vs. 47.7%, $\chi^2(1,\ N = 11{,}037) = 114.29,\ p < .001$.

Measures

The Registry was granted a Federal Certificate of Confidentiality. Informed consent was obtained at the beginning of the interview before eligibility was determined. Data were collected using computer-assisted telephone interviewing (82.2%) and computer-assisted personal interviewing (17.8%). Residents were administered the 30-minute baseline interview in English (96.3%), Spanish (0.8%), Chinese (2.6%), and other languages (0.3%).

The interview included demographics and questions on 9/11 exposures, health symptoms and conditions before and after 9/11, and updated contact information for follow-up. Questions relevant to the current analysis were categorized according to predisaster demographics and within-disaster and postdisaster factors (Norris et al., 2002). Within-disaster items included residential proximity to the WTC and assessments of direct exposure intensity (e.g., being caught in the dust cloud from the collapse of the towers, being an occupant of the North or South Tower or another damaged or destroyed building, sustaining an injury, and witnessing horror, which included seeing an airplane hitting the WTC, a building collapsing, people running away from a cloud of dust and debris, anyone who was injured or killed, or people falling or jumping from the WTC towers). Postdisaster questions included whether respondents evacuated their home as a result of the disaster, when they returned or relocated since 9/11, whether they cleaned their home, or were involved in rescue and recovery work.

The PTSD Checklist–Civilian Version (PCL; Weathers, Litz, Herman, Huska, & Keane, 1993) was used to measure self-reported PTSD symptoms. The PCL consists of 17-items corresponding to the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (American Psychological Association, 1994) diagnostic criteria in three symptoms clusters: intrusive and reexperiencing, numbing and avoidance, and hyperarousal. The extent to which each symptom bothered the respondent in the last month was rated from *not at all* (1) to *extremely* (5). The severity threshold for symptom occurrence was *moderately* or more (3+). Each symptom reported was event-specific (as a result of the WTC disaster) and current (within the last 30 days). Missing responses in the PCL

Figure 1. Density map of lower Manhattan adult residents enrolled in the WTC Health Registry.

were imputed at the symptom cluster level by substituting the respondent's average cluster response for 4% of residents ($n = 441$) who answered at least 80% of the questions within each symptom cluster. This technique resulted in no statistically significant differences in prevalence. To facilitate comparisons across studies, PTSD prevalence was calculated three ways: (a) using *DSM-IV* diagnostic criteria (the presence of at least one reexperiencing symptom, three avoidance symptoms, and two hyperarousal symptoms), (b) a cutoff score of 44, which is advocated for use with civilians and provides one of the highest levels of diagnostic efficiency at .94 among commonly used instruments (Blanchard, Jones-Alexander, Buckley, & Forneris, 1996; Brewin, 2005; Ruggiero, Ben, Scotti & Rabalais, 2003), and (c) a combination of both. We acknowledge that we measure probable PTSD as symptoms determined through the use of a screening instrument do not necessarily indicate psychopathology (North & Pfefferbaum, 2002).

Data Analysis

We geocoded residential addresses on 9/11, calculated the distance in feet to the WTC using ArcView Version 8.3 (ESRI, Redlands, CA), and performed all statistical analyses using SAS Version 9.1 (SAS Institute, Cary, NC). Our analysis was limited to 11,037 adults (>18-years-old at the time of interview) with a valid geocoded residential distance and PTSD outcome. No population weights were used because recruitment included multiple sampling frames. However, we employed raking ratio estimation to evaluate the potential bias of nonparticipation on the reported prevalence of PTSD (Kalton & Kasprzyk, 1986; Skinner, 1991). Bivariate logistic regression identified associations between pre-, within- and postdisaster factors and probable PTSD. Covariates were considered for a multivariable logistic regression model if p values were $<.05$ in the bivariate analyses. We built the final model using forward and backward selection to ensure consistency, using the difference in the -2 log likelihood ratios to significantly improve model fit.

RESULTS

The median age at interview among WTCHR residents was 46 years (interquartile range: 35–57). Over half were women (55.4%) Most residents were White (62.1%), followed by Asian (19.2%), Hispanic (10.3%), and African American (5.1%). According to Census 2000 estimates, residents who completed an interview comprised 22% of the population living south of Canal Street (Murphy et al., 2007). Compared to Census 2000, WTCHR residents were more likely to be female (55.4% vs. 49.1%, χ^2 (2, $N = 11{,}037) = 24.28$, $p < .001$), and more likely to be White, but less likely to be Asian [62.1% vs. 48.9%, 19.2% vs. 35.3%, respectively, $\chi^2(4, N = 11{,}037) = 1271.97$, $p < .001$].

Table 1 presents the percentage of WTCHR residents experiencing posttraumatic stress symptoms arranged by *DSM-IV* symptom cluster. The prevalence was 43.6% for reexperiencing, 20.4% for avoidance, and 38.6% for hyperarousal. The three most common symptoms were hypervigilance, being upset by reminders of 9/11, and insomnia. The least reported symptoms were dreams/nightmares and psychogenic amnesia. Only 7.5% of respondents reported no posttraumatic stress symptoms.

The prevalence of current probable PTSD using the *DSM-IV* diagnostic criteria (16.1%) was similar to the prevalence based on the cutoff score (15.1%). Combining both criteria yielded a more conservative PTSD prevalence (12.6%) and was used in subsequent risk factor analyses.

Information on exposure is provided in Table 2. Fifty-two percent of WTCHR residents reported being caught in the dust cloud that resulted from the collapse of the towers and 60% personally witnessed horror on 9/11 (Table 2). Seven percent of respondents reported sustaining an injury on 9/11. A small group of residents reported being in the North or South Towers (0.9%) or another damaged/destroyed building (6.5%). Two thirds of residents (64.0%) reported evacuating their homes. Nine percent of respondents reported involvement in rescue and recovery efforts.

Mode of enrollment, demographics, and several within- and postdisaster experiences were important risk factors for probable PTSD in the bivariate models (Table 2). Self-identification was associated with a modest increase in risk, but in later analyses this potential bias did not significantly alter any of the odds ratios measuring associations between PTSD and disaster-related risk factors. Compared to Whites, an increased risk for PTSD was observed among African Americans, Hispanics, and other non-Asian minorities; Asian race was protective. Lower education and income were associated with an increased risk for PTSD, as were older age and female gender. Being divorced, widowed, or separated increased risk, but marriage was protective. Significant within-disaster risk factors, in order of magnitude, included sustaining an injury, witnessing horror, exposure to the dust cloud, being in a building that was damaged or destroyed on 9/11 (except for the WTC towers), and living less than 1000 ft from the WTC. Significant postdisaster risk factors included evacuation of home and involvement in rescue/recovery efforts. WTCHR residents who reported that they evacuated their home for longer periods of time were at increased risk for PTSD.

Among demographics, age, gender, race/ethnicity, income, education, and marital status remained significant predictors of PTSD in the final multivariable model (Table 2). Compared to the bivariate logistic model, the risk of PTSD increased for all age groups relative to the youngest residents. The risk was greatest in adults aged 45–64 years, whose prevalence was nearly 4 times higher than adults aged 24 years or younger. Women also remained at increased risk of PTSD.

In the multivariable model, the relationship of PTSD and ethnic minority status attenuated, but remained statistically significant. Compared to whites, the risk for PTSD was higher among Hispanics, African Americans, and other ethnicities, but lower among Asians. Being divorced, widowed, or separated was also associated with an elevated risk of PTSD compared to those who never married. Education and income continued to show an inverse relationship with probable PTSD. Residents earning <$25,000/year were nearly 4 times more likely to have probable PTSD than those earning $100,000+/year, and those who did not complete high school were twice as likely as those with postgraduate education to have probable PTSD.

Among within-disaster factors, measures of direct exposure intensity that remained significant predictors of PTSD in the multivariable model included injury, witnessing horror, and being caught in the dust cloud. After controlling for other factors, living within 1,000 ft of the epicenter and being in a damaged or destroyed building lost significance.

Significant postdisaster factors in the final multiple regression model included evacuation and involvement in rescue/recovery efforts. Compared to residents who did not evacuate, those who

Table 1. Probable, Current Posttraumatic Stress Symptoms 2–3 Years After September 11, 2001 Among Lower Manhattan Adult Residents Enrolled in the World Trade Center Health Registry

	n	% (95% CI)
Total cohort	11,037	100.0
DSM-IV PTSD Symptoms[a]		
Meets criteria for Group B: Reexperiencing	4814	43.6 (42.7–44.6)
Intrusive memories	2937	26.6 (25.8–27.4)
Dreams or nightmares	1178	10.7 (10.1–11.3)
Flashbacks	1719	15.6 (14.9–16.3)
Upset by reminders	3633	32.9 (32.1–33.8)
Physiological reactivity	1971	17.9 (17.2–18.6)
Meets criteria for Group C: Avoidance	2247	20.4 (19.6–21.1)
Avoids thoughts or feelings	2825	25.6 (24.8–26.4)
Avoids reminders	2180	19.8 (19.0–20.5)
Psychogenic amnesia	1198	10.9 (10.3–11.4)
Loss of interest	2017	18.3 (18.4–19.8)
Detachment or estrangement	1945	17.6 (16.9–18.3)
Restricted range of affect	1294	11.7 (11.1–12.3)
Sense of shortened future	2572	23.3 (22.5–24.1)
Meets criteria for Group D: Hyperarousal	4258	38.6 (37.7–39.5)
Insomnia	3621	32.8 (31.9–33.7)
Irritability or anger	2327	21.1 (20.3–21.9)
Difficulty concentrating	2542	23.0 (22.3–23.8)
Hypervigilance	4267	38.7 (37.8–39.6)
Jumpy or easily startled	3102	28.1 (27.3–29.0)
No PTSD symptoms reported	828	7.5 (7.4–7.6)
Probable PTSD using *DSM-IV* diagnostic criteria[b]	1780	16.1 (15.5–16.8)
Probable PTSD using PCL cutoff score[c]	1666	15.1 (14.4–15.8)
Probable PTSD using both *DSM-IV* diagnostic criteria and PCL cutoff score	1391	12.6 (12.0–13.2)

Note. CI = Confidence interval; *DSM-IV = Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*; PTSD = Posttraumatic stress disorder; PCL = Posttraumatic Stress Disorder Checklist.
[a]Symptom is endorsed if respondent reported *moderately or more*.
[b]The presence of at least one reexperiencing symptom, three avoidance symptoms, and two hyperarousal symptoms.
[c]Defined as score of ≥44.

evacuated and remained away longer or those who had not returned to their evacuated homes by the time of interview were more likely to have PTSD. Residents who reported involvement in rescue and recovery efforts were at increased risk for PTSD compared to other residents.

DISCUSSION

Our study found substantial long-term posttraumatic stress symptoms among a large group of lower Manhattan residents who enrolled in the WTCHR. The PTSD prevalence within the first year of other man-made disasters has ranged from 1%–11% in the general population (Havenaar et al., 1997; Palinkas, Petterson, Russell, & Downs, 1993; Smith, Christiansen, Vincent, & Hann, 1999) to 25%–75% among survivors (Brooks & McKinlay, 1992; Dooley & Gunn, 1995; Green, Lindy, Grace & Leonard, 1992; North et al., 1999; Selly et al., 1997). The prevalence in our study is between these ranges and likely due to the fact that lower Manhattan residents experienced both direct and indirect exposures to 9/11.

Other 9/11 studies have provided valuable documentation of the mental health consequences of the disaster in New York City up to 6 months postattack (Galea et al., 2002, 2003), but we know of no other studies that have examined the long-term impact of the disaster on local communities near the WTC. Although differences in time frames, inclusion criteria, instruments, and methodology

Table 2. Risk Factors Related to Probable, Current Posttraumatic Stress Disorder 2–3 Years After September 11, 2001 Among Lower Manhattan Adult Residents Enrolled in the World Trade Center Health Registry

	n (%)[a]	% PTSD	Crude OR (95% CI)[b]	Adjusted OR (95% CI)
Mode of enrollment				
List	3347 (30.3)	10.4	1.00	1.00
Self-identified	7690 (69.7)	13.6	1.35 (1.18–1.53)***	1.27 (1.10–1.46)**
		Predisaster factors		
Age on 9/11				
<25	1100 (10.0)	6.6	1.00	1.00
25–44	4731 (42.9)	11.4	1.81 (1.41–2.34)***	2.83 (2.13–3.77)***
45–64	3853 (34.9)	16.0	2.69 (2.09–3.46)***	3.99 (2.97–5.35)***
65+	1353 (12.3)	11.8	1.89 (1.41–2.52)***	2.00 (1.42–2.82)***
Gender				
Male	4918 (44.6)	10.1	1.00	1.00
Female	6119 (55.4)	14.6	1.53 (1.36–1.72)***	1.38 (1.21–1.56)***
Race/ethnicity				
White	6855 (62.1)	10.7	1.00	1.00
African American	567 (5.1)	20.6	2.18 (1.75–2.70)***	1.38 (1.08–1.76)**
Hispanic	1140 (10.3)	24.7	2.75 (2.36–3.21)***	1.72 (1.43–2.08)***
Asian	2123 (19.2)	8.9	0.82 (0.69–0.97)*	0.74 (0.61–0.91)**
Other	352 (3.2)	20.2	2.11 (1.61–2.77)***	1.75 (1.28–2.40)***
Income				
≥$100,000	1920 (17.4)	6.1	1.00	1.00
$75,000–$99,999	2222 (20.1)	8.9	1.51 (1.19–1.91)***	1.42 (1.10–1.82)**
$50,000–$74,999	1198 (10.9)	11.3	1.96 (1.51–2.54)***	1.65 (1.24–2.18)***
$25,000–$49,000	1546 (14.0)	15.7	2.86 (2.27–3.61)***	2.48 (1.91–3.22)***
<$25,000	2544 (23.1)	19.8	3.80 (3.08–4.69)***	3.72 (2.86–4.83)***
Unknown	1607 (14.6)	12.2	2.14 (1.69–2.72)***	1.96 (1.50–2.56)***
Education				
Postgraduate	2974 (27.1)	8.8	1.00	1.00
College graduate	3853 (35.2)	11.1	1.29 (1.09–1.51)**	1.30 (1.09–1.55)**
High school diploma/GED	2978 (27.2)	16.0	1.97 (1.68–2.32)***	1.43 (1.18–1.73)***
<High school diploma	1151 (10.5)	18.3	2.32 (1.91–2.83)***	1.96 (1.50–2.55)***
Marital status				
Never married	2898 (26.5)	12.4	1.00	1.00
Not married, living with partner	923 (8.4)	13.0	1.06 (0.85–1.32)	1.06 (0.83–1.35)
Divorced, widowed or separated	1888 (17.3)	21.5	1.94 (1.63–2.27)***	1.36 (1.12–1.64)**
Now married	5233 (47.8)	9.5	0.74 (0.64–0.86)***	0.85 (0.71–1.01)
		Within-disaster factors		
Distance of residence from epicenter				
4,000+ ft	1510 (13.7)	13.5	1.00	N/A
3,000–3,999 ft	2052 (18.6)	13.2	1.08 (0.88–1.31)	
2,000–2,999 ft	3411 (30.9)	10.9	0.87 (0.72–1.04)	
1,000–1,999 ft	1898 (17.2)	9.9	0.78 (0.63–0.96)	
<1,000 ft	2166 (19.6)	17.2	1.47 (1.21–1.77)***	
In North or South Tower on 9/11				
No	10933 (99.1)	12.6	1.00	N/A
Yes	104 (0.9)	16.4	1.36 (0.81–2.29)	

continued

Table 2. Continued

	n (%)[a]	% PTSD	Crude OR (95% CI)[b]	Adjusted OR (95% CI)
In other damaged or destroyed building on 9/11				
No	10321 (93.5)	12.2	1.00	N/A
Yes	716 (6.5)	18.7	1.66 (1.36–2.02)***	
Caught in the dust cloud on 9/11				
No	5315 (48.4)	7.7	1.00	1.00
Yes	5661 (51.6)	17.2	2.51 (2.22–2.84)***	1.57 (1.35–1.82)***
Injured on 9/11				
No	10236 (92.7)	10.6	1.00	1.00
Yes	801 (7.3)	38.0	5.15 (4.41–6.02)***	3.03 (2.53–3.62)***
Witnessed horror on 9/11				
No	4473 (40.5)	6.6	1.00	1.00
Yes	6564 (59.5)	16.7	2.83 (2.47–3.23)***	1.81 (1.54–2.12)***
Postdisaster factors				
Evacuation/time gone from residence				
Did not evacuate	3942 (36.0)	12.4	1.00	1.00
<1 month	4377 (40.0)	10.7	0.85 (0.74–0.97)*	1.17 (1.00–1.38)
1–3 months	1535 (14.0)	13.4	1.10 (0.92–1.31)	1.60 (1.27–1.92)***
>3 months	483 (4.4)	18.8	1.64 (1.28–2.10)***	2.20 (1.65–2.96)***
Never returned	607 (5.6)	18.3	1.58 (1.26–1.99)***	2.40 (1.84–3.14)***
Cleaned residence as result of 9/11				
No	482 (6.0)	11.0	1.00	N/A
Yes	7557 (94.0)	13.0	1.21 (0.90–1.62)	
New permanent residence as of 2003/2004				
No, same address as on 9/11	8158 (74.4)	12.9	1.00	N/A
Yes, within lower Manhattan	422 (3.9)	11.4	0.975 (0.70–1.35)	
Yes, outside lower Manhattan	2382 (21.7)	11.6	1.125 (0.98–1.30)	
Involved in rescue and recovery effort				
No	10005 (90.6)	11.9	1.00	1.00
Yes	1032 (9.4)	19.5	1.80 (1.52–2.11)***	1.50 (1.24–1.81)***

Note. PTSD = Posttraumatic stress disorder; OR = Odds ratio; CI = Confidence interval; GED = general equivalency diploma; N/A = Not applicable because variable did not contribute to the final multivariable model.

[a] $N = 11{,}037$. The sum of the following variables is not equal to the total due to missing values: education ($n = 81$), marital status ($n = 95$), dust cloud ($n = 61$), evacuation ($n = 93$), and cleaning ($n = 2998$), and permanent residence ($n = 75$).

[b] Crude odds ratios are presented for the bivariate logistic regression models where each potential risk factor was considered in unique models.

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

preclude our ability to make direct comparisons, we found more psychological burden among lower Manhattan residents 2–3 years after 9/11 compared to 6-month assessments of a much larger area of Manhattan and citywide (Galea et al., 2003). One potential explanation for this finding is that community members of lower Manhattan had constant reminders of the attack as a result of close proximity to the epicenter and had more disruption to their daily routine. We therefore believe these residents require more in-depth mental health monitoring, independent of the larger metropolitan area, which experienced more heterogeneous exposures.

Our findings support the literature on the association of social disadvantage with greater distress (Norris et al., 2002), and are consistent with findings from the National Comorbidity Study (Kessler et al., 1999) and other 9/11 studies (Galea et al., 2002; Galea et al., 2003). Hispanic and African American race/ethnicity were also strongly related to PTSD, but the odds ratio for Asians was protective. Most 9/11 studies have found similar relationships, (Adams & Boscarino, 2005; Norris et al., 2002). Residents with low educational attainment were at increased risk for PTSD and, although subject to reverse causality, lower income was among the strongest predictors of PTSD among residents in our final model.

At all stages of a disaster, marginalization may play an important role in access to social and economic resources, hindering optimal mental health.

Women were also at higher risk for PTSD even after controlling for other factors. Previous research has offered several explanations for the disparity including stronger perceptions of threat and loss of control, higher levels of peritraumatic dissociation, gender-specific emotional responses to trauma (i.e., anxiety and depression vs. behavioral problems), and greater stress from caregiving roles (Olff, Langland, Draijer, & Gersons, 2007; Pulcino et al., 2003; Tolin & Foa, 2006). Caregiving may also explain why middle-aged adults are at increased risk for PTSD as they often provide support to both children and parents, whereas an inoculation hypothesis has been put forth to account for the resilience often observed among older adults (Thompson, Norris, & Hanacek, 1993).

Associations between direct exposure severity and PTSD in our study were similar to those found among Oklahoma City bombing victims and citywide residents in NYC after 9/11 (Galea et al., 2003; North et al., 1999). Prior studies conducted with national cohorts after 9/11 have demonstrated an inverse relationship between residential distance to the WTC site and PTSD (Schlenger et al., 2002; Schuster et al., 2002). In our bivariate logistic analyses we found those living within 1,000 ft of the disaster site had elevated risk, but this risk did not remain significant in the full multivariable model. Potential explanations are that variations in distance may not have been sufficient to observe an elevated risk, or that distance could merely have been a proxy measure for exposures. For example, witnessing horror and sustaining an injury were both strongly associated with PTSD in the multivariable model; both exposures were also correlated with residential proximity to the WTC (data not shown). Other location characteristics such as having a direct line of site to the epicenter may play an important role, but such information was not obtained.

We did not find an increased risk for PTSD among a small group of residents who were in the WTC towers on 9/11 ($n = 104$). However, another study documented 36.7% PTSD since 9/11 among those in the WTC complex at a 6-month assessment (Galea et al., 2003). The prevalence among WTCHR residents who were also in the towers was 16.4%. Our finding that the PTSD prevalence for tower occupants was similar to other WTCHR residents supports our belief that local residents as a whole experienced substantial trauma on 9/11 in the form of threat or actual damage to one's home and daily reminders of the attack such as sight and smell.

Our study is one of few in the literature to examine the effect of evacuation as a post-disaster risk factor for PTSD. Longer duration of evacuation was associated with increased risk, potentially reflecting the adverse emotional, financial, and social impact of displacement. Corroborating this line of reasoning is a rapid assessment conducted soon after Hurricane Andrew in which relocation was associated with higher levels of ecological stress, isolation, and social disruption, each of which interacted to predict psychological symptoms (Burnett et al., 1997; Riad & Norris, 1996).

Finally, other studies have indicated that the prevalence of PTSD among rescue/recovery workers typically ranges from 5%–20% within the first year of a disaster, lower than among direct victims, but higher than the general population (Durham, McCammon, & Allison, 1985; Perrin et al., 2007). We found an increase in risk among lower Manhattan residents who participated in rescue or recovery work. Given that almost half of the WTCHR residents participating in rescue or recovery work were volunteers (18% with organizations such as the Red Cross and Salvation Army and 30% with no affiliation), the extent of training and postresponse mental health support should be investigated (Dyregrov, Kristoffersen, & Gjestad, 1996; Perrin et al., 2007).

Major strengths of this study are enrollment of over 11,000 lower Manhattan residents, an assessment period of 2–3 years after 9/11, the investigation of potential risk factors largely unexplored by other 9/11 studies, and the use of a widely used, internally consistent measure of PTSD (Blanchard et al., 1996).

Although use of the PCL did not allow for differentiation of risk factors associated with PTSD onset from those associated with the course of PTSD, it is likely that our outcome represents chronic PTSD that began shortly after 9/11. We have no direct evidence to this claim, but several prospective studies have suggested that PTSD symptoms lasting 3 months beyond a traumatic event should be considered chronic (Helzer, Robins, & McEvoy, 1987; Kessler et al., 1999; McFarlane, 1988; Shore, Vollmer, & Tatum, 1989). Specific to terrorism, a longitudinal study of Oklahoma City bombing victims determined that all PTSD was chronic with 89% unremitted between 6 and 17 months (North et al., 2004). Further, a longitudinal study of citywide residents after 9/11 reported 13% PTSD among the highly exposed both at one and two years post-event (Adams, Boscarino, & Galea, 2006).

This study has limitations including the potential for biases related to selection, nonresponse, recall, and measurement. First, the directories we used for active recruitment tend to exclude unlisted households typically headed by younger adults, frequent movers, or renters and may have affected our ability to claim a representative sample of lower Manhattan residents. However, we also used lists of residents from tenant organizations, canvassed residential buildings, and a toll-free number and Web site to encourage enrollment. Although these methods produced a large number of enrollees, they raised the possibility of self-selection bias. As expected, self-identification was associated with a moderate increase in PTSD and thus we controlled for it in our final analyses. Second, nonresponse bias may have occurred if individuals with severe stress symptoms were less likely to enroll in the WTCHR. This would have resulted in an underestimation of PTSD. However, respondents enrolled through active recruitment methods (i.e., list sampling), had a lower prevalence of PTSD so it is unlikely that stress symptoms were associated with nonresponse. Third, recall bias could have occurred if residents who felt worse were more likely to report negative experiences on 9/11. As is commonly the case in disaster research, information on exposures were collected

at the same time as our outcome so the effect of this potential bias is difficult to infer. However, persistent avoidance of stimuli associated with trauma is a major criterion of PTSD; therefore nonrespondents may have had worse symptoms and/or exposure severity resulting in underreporting. Fourth, although the PCL is a valid measurement that closely corresponds to *DSM* criteria, we acknowledge that findings from self-report instruments may not discriminate PTSD from other anxiety disorders (Engelhard, van der Hout, & McNally, 2008). The PCL may also overestimate PTSD prevalence as it does not include functional impairment as a criterion. Fifth, measures of pre-9/11 psychopathology and post-9/11 bereavement, social support, and utilization of mental health services were not included in the baseline interview, but have been incorporated in the WTCHR follow-up survey.

The WTCHR is the largest disaster registry in U.S. history to date, and results from this study have implications for policy and planning. Health care providers, researchers, and government officials need to continue to address the mental health needs of highly exposed groups such as local residents. This is particularly important in light of research that found the public was generally aware of 9/11 mental health initiatives, but there was little new utilization among those who were not already receiving care before 9/11, and lower income residents with probable PTSD or depression were least likely to seek professional help after the attack (Stuber, Galea, Boscarino, & Schlesinger, 2006). Brief crisis counseling and public education sessions were successfully administered to 1.2 million individuals after 9/11 (Rudenstine, Galea, Ahern, Felton, & Vlahov, 2003), but our findings suggest that chronic PTSD symptoms in key subpopulations will require treatment years after 9/11.

The WTC disaster has allowed researchers to learn more about the psychological sequelae associated with a large-scale urban disaster. Our results provide evidence that diverse experiences, including direct exposure and subsequent evacuation in local communities, should be taken into consideration when targeting interventions or developing mental health preparedness protocols to mitigate stress reactions in postdisaster settings. We have provided further evidence that PTSD is closely related to social and economic factors predisposing individuals to trauma-related psychopathology, an important finding relevant to the planning of responses to other urban disasters such as Hurricane Katrina, where the poor and minorities were disproportionately displaced. Although we are almost 7 years post-9/11, the full effect of the disaster is slowly emerging. Our findings should raise awareness among researchers, health care professionals, and the public that affected individuals may continue to present WTC-related trauma symptoms and ongoing surveillance and services are needed.

REFERENCES

Adams, R. E., & Boscarino, J. A. (2005). Differences in mental health outcomes among Whites, African Americans, and Hispanics following a community disaster. Psychiatry, 68, 250–265.

Adams, R. E., Boscarino, J. A., & Galea, S. (2006). Alcohol use, mental health status, and psychological well-being 2 years after the World Trade Center attacks in New York City. Journal of Drug and Alcohol Abuse, 32, 203–204.

American Psychiatric Association. (1994). Diagnostic and statistical manual of mental disorders (4th ed.). Washington, DC: Author.

Blanchard, E. B., Jones-Alexander, J., Buckley, T. C., & Forneris, C. A. (1996). Psychometric properties of the PTSD checklist (PCL). Behavior Research & Therapy, 34, 669–673.

Brewin, C. R. (2005). Systematic review of screening instruments for adults at risk of PTSD. Journal of Traumatic Stress, 18, 53–62.

Brooks, N., & McKinlay, W. (1992). Mental health consequences of the Lockerbie disaster. Journal of Trauma Stress, 5, 527–543.

Burnett, K., Ironson, G., Benight, C., Wynings, C. Greenwood, D., Carver, C.S., et al. (1997). Measurement of perceived disruption during rebuilding following Hurricane Andrew. Journal of Traumatic Stress, 10, 673–681.

Dolan, M., Murphy, J., Thalji, L., & Pulliam, P. (2006). World Trade Center Health Registry: Sample building and denominator estimation. Chicago: Research Triangle Institute. Retrieved August 20, 2007, from http://www.nyc.gov/html/doh/downloads/pdf/wtc/wtc-building-denominator.pdf

Dooley, E., & Gunn, J. (1995). The psychological effects of disaster at sea. British Journal of Psychiatry, 167, 233–237.

Durham, T. W., McCammon, S. L., & Allison Jr., E. J. (1985). The psychological impact of disaster on rescue personnel. Annals of Emergency Medicine, 14, 664–668.

Dyregrov, A., Kristoffersen, J. I., & Gjestad, R. (1996). Voluntary and professional disaster-workers: Similarities and differences in reactions. Journal of Traumatic Stress, 3, 541–555.

Engelhard, I. M, van den Hout, M. A., & McNally, R. J. (2008). Memory consistency for traumatic events in Dutch soldiers deployed to Iraq. Memory, 16, 3–9.

Galea, S., Ahern, J., Resnick, H., Kilpatrick, D., Bucuvalas, M., Gold, J., et al. (2002). Psychological sequelae of the September 11 terrorist attacks in New York City. New England Journal of Medicine, 346, 982–987.

Galea, S., Vlahov, D., Resnick, H., Ahern, J., Susser, E., Gold, J., et al. (2003). Trends of probable post-traumatic stress disorder in New York City after the September 11 terrorist attacks. American Journal of Epidemiology, 158, 514–524.

Green, B. L., Lindy, J. D., Grace, M. C., & Leonard, A. C. (1992). Chronic posttraumatic stress disorder and diagnostic comorbidity in a disaster sample. Journal of Nervous and Mental Disease, 180,760–766.

Havenaar, J. M., Rumyantzeva, G. M., Van den Brink, W., Poelijoe N.W., Van den bout, J., Van Engeland, H., et al. (1997). Long-term mental health effects of the Chernobyl disaster: An epidemiologic survey in two former Soviet regions. American Journal of Psychiatry, 154, 1605–1607.

Helzer, J. E., Robins, L. N., & McEvoy, L. (1987). Post-traumatic stress disorder in the general population. New England Journal of Medicine, 371, 1630–1634.

Kalton, G., & Kasprzyk, D. (1986). The treatment of missing survey data. Survey Methodology, 12, 1–16.

Kessler, R. C., Sonnega, A., Bromet, E., Hughes, M., Nelson, C. B., & Beslau, N. (1999). Epidemiological risk factors for trauma and PTSD. In R. Yehuda (Ed.), Risk factors for PTSD (pp. 23–60). Washington, DC: American Psychiatric Press.

Kramer, R., Hayes, R., Nolan, V., Cotenoff, S., Goodman, A., Daley, D. R., et al. (2002). Community needs assessment of lower Manhattan residents following the World Trade Center attacks [Special Issue]. Morbidity and Mortality Weekly Report, 51,10–13.

McFarlane A. C. (1988). The longitudinal course of posttraumatic morbidity. Journal of Nervous and Mental Disease, 192, 30–39.

Murphy J., Brackbill, R. M., Thalji, L., Dolan, M., Pulliam, P., & Walker, D. J. (2007). Measuring and maximizing coverage in the World Trade Center Health Registry. Statistics in Medicine, 26, 1688–701.

Norris, F. H., Friedman, M. J., Watson, P. J., Byrne, C. M., Dias, E., & Kaniasty, K. (2002). 60,000 disaster victims speak: Part I. An empirical review of the empirical literature, 1981–2001. Psychiatry, 65, 207–239.

North, C. S., Nixon, S. J., Shariat, S., Mallonee, S., McMillen, J. C., Spitznagel, E. L., et al. (1999). Psychiatric disorders among survivors of the Oklahoma City Bombing. Journal of the American Medical Association, 282, 755–762.

North, C. S., & Pfefferbaum, B. (2002). Research on the mental health effects of terrorism. Journal of the American Medical Association, 288, 633–636.

North, C. S., Pfefferbaum, B., Tivis, L., Kawasak, A., Chandrashekar, R., & Spitznagel, E. L. (2004). The course of posttraumatic stress disorder in a follow-up study of survivors of the Oklahoma City Bombing. Annals of Clinical Psychiatry, 16, 209–215.

Olff, M., Langeland, W., Draijer, N., & Gersons, B. P. R. (2007). Gender differences in posttraumatic stress disorder. Psychological Bulletin, 133, 183–204.

Palinkas, L. A., Petterson, J. S., Russell, J., & Downs, M. A. (1993). Community patterns of psychiatric disorders after the Exxon Valdez oil spill. American Journal of Psychiatry, 150, 1517–1523.

Perrin, M. P., DiGrande, L., Wheeler, K., Thorpe, L., Farfel, M., & Brackbill, R. (2007). Differences in PTSD prevalence and associated risk factors among World Trade Center Disaster rescue and recovery workers. American Journal of Psychiatry, 164, 1385–1394.

Pulcino, T., Galea, S., Ahern, J., Resnick, H., Foley, M., & Vlahov, D. (2003). Posttraumatic stress in women after the September 11 terrorist attacks in New York City. Journal of Women's Health, 12, 809–820.

Riad, J. K., & Norris, F. H. (1996). The influence of relocation on the environmental, social and psychological stress experienced by disaster victims. Environment and Behavior, 28, 163–182.

Rubonis, R. V., & Bickman, L. (1991). Psychological impairment in the wake of disaster: The disaster–psychopathology relationship. Psychological Bulletin, 109, 384–399.

Rudenstine, S., Galea, S., Ahern, J., Felton, C., & Vlahov, D. (2003). Awareness and Perceptions of a communitywide mental health program in New York City after September 11. Psychiatric Services, 54, 1404–1406.

Ruggiero, K. J., Ben, K. D., Scotti, J. R., & Rabalais, A. E. (2003). Psychometric properties of the PTSD Checklist–Civilian Version. Journal of Traumatic Stress, 16, 495–502.

Schlenger, W. E., Caddell, J. M., Ebert, L., Jordan, K., Rourke, K. M., Wilson, D., et al. (2002). Psychological reactions to terrorist attacks. Findings from the National Study of Americans' Reactions to September 11. Journal of the American Medical Association, 288, 581–588.

Schuster, M. A., Stein, B. D., Jaycox, L. H., Collins, R. L., Marshall, G. N., Elliott, M. N., et al. (2001). A national survey of stress reactions after the September 11, 2001, terrorist attacks. New England Journal of Medicine, 345, 1507–1512.

Selly, C., King, E., Peveler, R., Osola, K., Martin, N., & Thompson, C. (1997). Post-traumatic stress disorder and the Clapham rail accident. British Journal of Psychiatry, 171, 478–482.

Shore, J. H., Vollmer, V. M., & Tatum E. I. (1989). Community patters of posttraumatic stress disorders. Journal of Nervous and Mental Disease, 177, 681–685.

Skinner, C. J. (1991). On the efficiency of raking ratio estimation for multiple frame surveys. Journal of the American Statistical Association, 86, 779–784.

Smith, D. W., Christiansen, E. H., Vincent, R., & Hann, N. E. (1999). Population effects of the bombing of Oklahoma City. Journal of the Oklahoma State Medical Association, 92, 193–198.

Stuber, J., Galea, S., Boscarino, J. A., & Schlesinger, M. (2006). Was there unmet mental health need after the September 11, 2001 terrorist attack? Social Psychiatry and Psychiatric Epidemiology, 41, 230–240.

Tolin, D. F., & Foa, E. B. (2006). Sex differences in trauma and posttraumatic stress disorder: A quantitative review of 25 years of research. Psychological Bulletin, 132, 959–992.

Thompson, M., Norris, F., & Hanacek, B. (1993). Age differences in the psychological consequences of Hurricane Hugo. Psychology and Aging, 8, 606–616.

Weathers, F. W., Litz, B. T., Herman, D. S., Huska, J., & Keane, T. (1993, October). The PTSD Checklist (PCL): Reliability, validity, and diagnostic utility. Paper presented at the annual meeting of the International Society for Traumatic Stress Studies, San Antonio, TX.