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Original Contribution

Long-term Posttraumatic Stress Symptoms Among 3,271 Civilian Survivors of the September 11, 2001, Terrorist Attacks on the World Trade Center

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Although the September 11, 2001, terrorist attacks were the largest human-made disaster in US history, there is little extant research documenting the attacks' consequences among those most directly affected, that is, persons who were in the World Trade Center towers. Data from a cross-sectional survey conducted 2–3 years after the attacks ascertained the prevalence of long-term, disaster-related posttraumatic stress symptoms and probable posttraumatic stress disorder (PTSD) in 3,271 civilians who evacuated World Trade Center towers 1 and 2. Overall, 95.6% of survivors reported at least 1 current posttraumatic stress symptom. The authors estimated the probable rate of PTSD at 15.0% by using the PTSD Checklist. Women and minorities were at an increased risk of PTSD. A strong inverse relation with annual income was observed. Five characteristics of direct exposure to the terrorist attacks independently predicted PTSD: being on a high floor in the towers, initiating evacuation late, being caught in the dust cloud that resulted from the tower collapses, personally witnessing horror, and sustaining an injury. Working for an employer that sustained fatalities also increased risk. Each addition of an experience of direct exposure resulted in a 2-fold increase in the risk of PTSD (odds ratio = 2.09, 95% confidence interval: 1.84, 2.36). Identification of these risk factors may be useful when screening survivors of large-scale terrorist events for long-term psychological sequelae.

disasters; life change events; September 11 terrorist attacks; stress disorders, post-traumatic; terrorism

Abbreviations: CI, confidence interval; NIST, National Institute of Standards and Technology; PCL-S, PTSD Checklist, Stressor-Specific Version; PTSD, posttraumatic stress disorder; WTC, World Trade Center.

Posttraumatic stress disorder (PTSD) is a psychiatric disorder that occurs after experiencing or witnessing events that threaten death or serious injury and that involves intense feelings of fear, helplessness, or horror (1). National studies have demonstrated that 6.8% of adults develop PTSD in their lifetimes; 3.5% of adults have the condition in any given year, making PTSD the third most common anxiety disorder in the United States (2, 3). Although trauma exposure is a necessary component of PTSD, the presence of a traumatic event by itself does not sufficiently explain why PTSD develops. Substantial variability in the likelihood of developing PTSD after different events exists. For example, the prevalence of PTSD after rape has been estimated to be 55%; in contrast, the prevalence of PTSD after accidents has been estimated to be 7.5% (4).

Intentional disasters, particularly large-scale terrorist attacks, allow for the study of PTSD in unselected communities and circumvent confounding that can occur in community studies of the association of trauma with vulnerability to psychopathology (5, 6). It has been hypothesized that posttraumatic stress symptoms after such disasters may be long-lasting because of the high prevalence of factors known to contribute to the disaster-psychopathology relation (e.g., direct exposure, the witnessing of horror, experience or knowledge of extensive loss of life, relocation, and postdisaster financial strain) (7).

The magnitude and intensity of the attack on the World Trade Center (WTC) on September 11, 2001 (9/11), made it the worst human-made disaster in the history of the United States, with almost 3,000 fatalities, 71,000 jobs lost, and

labor and capital losses reaching $36 billion in the months after the attacks (8). Previous research documented a high prevalence of posttraumatic stress symptoms in national and New York City samples within 6 weeks of the attacks and attenuation of symptoms 5 months later (9–13). However, we are unaware of studies devoted exclusively to the psychological consequences among those under direct attack on 9/11: persons who were in the WTC towers. We sought to fill this gap in knowledge by assessing long-term stress reactions among civilians who escaped the WTC towers on the morning of 9/11. Our objectives were to 1) measure the prevalence of posttraumatic stress symptoms and probable PTSD in a large cohort of tower survivors 2–3 years after 9/11; 2) describe the range of direct exposures reported; and 3) assess the independent and collective relations between these exposures and the risk of probable PTSD. Because this study targets those with the greatest exposure, we hypothesized that the burden of posttraumatic stress would be higher than that documented in previous 9/11 studies and that there would be a positive relation between the number of direct exposures reported and the number of cases of posttraumatic stress observed.

MATERIALS AND METHODS

This study was conducted in conjunction with the World Trade Center Health Registry, which was established by the New York City Department of Health and Mental Hygiene and the Agency for Toxic Substances and Disease Registry to monitor the health impact of 9/11 (14). The registry contains interview data from over 71,000 individuals, including rescue/recovery workers and lower Manhattan residents, schoolchildren, building occupants, and passersby. Our study utilized interviews with 3,271 English-speaking, civilian survivors of the WTC attacks. Eligibility criteria included age $\geq$18 years, physical presence in one of the ''twin towers'' (1WTC and 2WTC) between the first plane impact and subsequent tower collapses, and no participation in WTC rescue/recovery activities. Psychological sequelae among rescue/recovery personnel, residents, and occupants of other buildings have been reported elsewhere (15–17).

Recruitment and data collection

Between September 2003 and November 2004, tower survivors whose names were gathered from employee lists were contacted as part of an extensive recruitment effort to register all lower Manhattan building occupants (18). Key informants, typically from human resources departments, provided employee names and distributed letters to staff that endorsed enrollment. Recruitment also included a Port Authority of New York and New Jersey list of individuals issued security badges for all 7 WTC buildings during the 5 years before 9/11.

Data collection, conducted concurrent with recruitment, was accomplished through the use of computer-assisted telephone interviews (94.5%) and personal interviews (5.5%). A standardized questionnaire was used, in which participants reported their exact building location on 9/11 after the participants provided informed consent and their eligibility was determined. This precaution, taken because of the sensitive subject matter, precluded our ability to compute outcome rates for tower survivors as opposed to all lower Manhattan building occupants. Contact, cooperation, and response rates for all occupants were 72.5%, 81.3%, and 58.9%, respectively (14). Our cohort's coverage was 21.2%, based on the 15,410 tower survivors estimated by the National Institute of Standards and Technology (NIST) (19).

Posttraumatic stress was assessed with the PTSD Checklist, Stressor-Specific Version (PCL-S) (20). Clinical interviews were not feasible given the participant volume, but the utility of the PCL-S has been verified in numerous studies of civilians exposed to assault, motor vehicle trauma, major illnesses, and terrorism, including the 9/11 attacks (21–25). The PCL-S assesses the full domain of *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition, posttraumatic stress symptoms in 3 clusters: 5 intrusive reexperiencing symptoms, 7 numbing and avoidance symptoms, and 5 hyperarousal symptoms. Each symptom's occurrence as a result of 9/11 was queried for the 4 weeks before the interview. Symptoms were considered endorsed as indicating PTSD at moderate disturbance or more ($\geq$3 on the 5-point scale). Frequencies of PCL-S item responses were determined, and the prevalence of probable PTSD (herein referred to as PTSD) was calculated according to a cutoff score of 50 (diagnostic efficiency = 0.94, sensitivity = 0.82, specificity = 0.86) (20).

Potential risk factors included demographic characteristics and 9/11 direct exposures, including physical location (i.e., in which tower the participant was located and the highest floor reached on 9/11), evacuation initiation, exposure to the dust cloud that resulted from the collapse of the towers, witnessing of horrific particulars of the attack, and injuries. Having witnessed a horror was coded as affirmative when a participant personally saw an airplane hitting the WTC, a building collapsing, people running away from a cloud of dust and debris, people who were injured or killed, or people falling or jumping from the WTC towers on 9/11. Having sustained an injury was coded affirmative when a participant reported a burn, broken bone, concussion, cut, sprain, strain, or other injury related to the attacks. We used an additional variable to characterize fatalities at companies for which participants worked, which was accomplished by extracting 9/11 WTC deaths from a publicly available website confirmed in conjunction with federal and local governments (26) and linking this information to the employer of each participant.

Statistical analyses

We performed 2-tailed chi-square tests to compare our cohort's characteristics with those of 803 telephone survey respondents in the NIST's study of occupant behavior, egress, and emergency communications (19). We also used chi-square tests to identify associations between each demographic or event-exposure variable and PTSD status, and we created bivariate logistic regression models to obtain strength of association. Significant risk factors from bivariate modeling ($P < 0.1$) were next considered for multivariable

logistic regression to determine which demographic and disaster-exposure variables independently predicted PTSD. Forward and backward selection were performed using the chi-square from the difference in –2 log likelihood estimates to determine which variables should be retained in the final model. We only retained explanatory variables that significantly improved model fit to obtain a parsimonious model ($P < 0.05$). To examine the cumulative effect of 9/11 direct exposures on PTSD, an exposure severity score was constructed as the sum of those exposures found to be predictive of PTSD in the multivariable regression model. We used stepwise logistic regression to assess the relation between cumulative exposure severity and risk of PTSD while accounting for demographic factors.

All analyses were completed with SAS software, version 9.2 (SAS Institute, Inc., Cary, North Carolina). Regression models included tests for interaction among demographic and exposure variables. Respondents with missing data were excluded from regression analyses ($n = 40$).

RESULTS

Table 1 displays the demographic characteristics of the cohort. Of the survivors, 58.8% were men and 68.2% were white. Most were college graduates (66.5%) and had an annual household income ≥$75,000 (59.8%). The demographic characteristics of the true population of WTC tower survivors are unknown. However, compared with the NIST's study of 803 survivors' egress patterns, our cohort's age distribution was similar (mean = 41 vs. 45; range, 19–75 vs. 21–74) but contained significantly more women (41% vs. 33%; $\chi^2 = 18.2$, $P < 0.001$).

Figure 1 displays the locations of tower survivors on the morning of 9/11 before the planes hit the towers. The distribution across towers was equal ($n = 1{,}666$ in 1WTC vs. 1,605 in 2WTC). Although the distribution by floor location of the true population of WTC tower survivors is unknown, there was no difference between our cohort and the NIST's cohort according to the agency's floor categories (52.8% vs 50.0% on floors <42, 29.6% vs. 33.4% on floors 43–75, and 17.7% vs. 16.0% on floors 75–110; $\chi^2 = 5.9$, $P = 0.05$).

Our cohort contained fewer survivors who were located at or above the impact zone of 1WTC ($n = 3$), the first tower attacked, than at or above the impact zone in 2WTC ($n = 370$). The vast majority of 2WTC survivors above the impact zone reported that they began evacuation after the first plane hit 1WTC ($n = 336$; 90.8%). Overall, 60.8% were caught in the dust cloud from the tower collapses. Ninety-four percent witnessed horror (range: 32.3% saw an airplane hit one of the towers to 74.2% saw people run away from a cloud of smoke). Thirty-two percent sustained an injury (range: 2.0% concussion to 17.6% sprain or strain). The overwhelming majority of survivors reported that the WTC was their usual place of work (95.8%). Sixty-seven percent worked for an employer that sustained fatalities on 9/11.

Table 2 shows the prevalence of posttraumatic stress symptoms. Almost all survivors had symptoms; only 145 (4.4%) reported none. The 2 most commonly experienced symptoms were in the group D hyperarousal symptom cluster: hypervigilance (50.4%) and being jumpy or easily startled (37.4%). Fifteen percent of survivors ($n = 492$) screened positive for PTSD. No significant differences were observed in prevalences of any symptom when results were stratified by tower.

Table 3 shows that gender, race/ethnicity, educational level, income, and marital status were significantly associated with PTSD in chi-square and bivariate logistic regression analyses. Significant event exposures included having been in the towers above the point of airplane impact, having initiated evacuation late, having been exposed to the dust cloud, having witnessed horror, and having sustained an injury. Survivors who worked for an employer that

Table 1. Demographic Characteristics of Study Participants ($n = 3{,}271$), 2003–2004

Characteristic	No. of Participants[a]	%
Gender		
Male	1,922	58.8
Female	1,349	41.2
Age on September 11, 2001, years		
Mean	40.8	10.9[b]
≥65	48	1.5
45–64	1,188	36.3
25–44	1,837	56.2
18–24	198	6.1
Race/ethnicity		
White	2,230	68.2
African-American	361	11.0
Hispanic	339	10.4
Asian	260	7.9
Multiracial/other	81	2.5
Educational level[c]		
Postgraduate degree	750	23.1
College graduate	1,412	43.4
High school graduate or equivalent	1,044	32.1
Some high school or less	47	1.4
Income per year[c]		
≥$100,000	702	24.2
$75,000–$99,999	1,031	35.6
$50,000–$74,999	483	16.7
$25,000–$49,999	522	18.0
<$25,000	161	5.6
Marital status[c]		
Married	2,026	62.2
Divorced/separated	280	8.6
Widowed	56	1.7
Not married	895	27.5

[a] Numbers may not add up to 3,271 because not all respondents answered all of the questions.
[b] Value is presented as standard deviation, not mean.
[c] Reported at the time of interview.

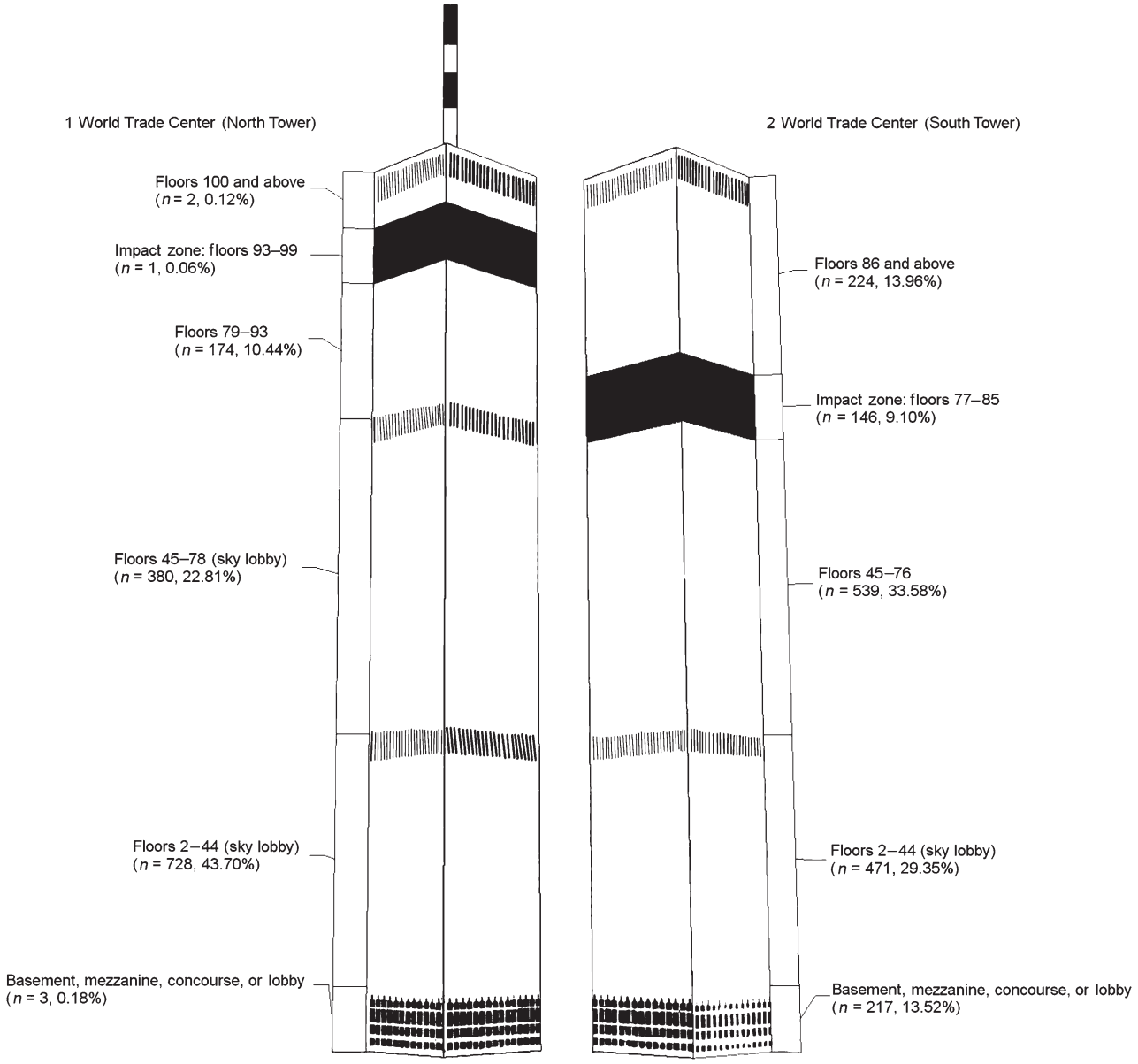

Figure 1. Location on September 11, 2001, reported by adult civilian survivors of the attacks on the World Trade Center. Total $n = 3,271$; missing $n = 11$.

experienced fatalities on 9/11 had a higher PTSD prevalence than did those who worked for an employer with no fatalities.

In the multivariable logistic regression model, gender, race/ethnicity, and income were associated with PTSD, but educational level and marital status were not significantly associated. Tests for interaction among gender, race/ethnicity, and income variables in the model resulted in no significance. Compared with whites, the risk of PTSD was highest among Hispanics (adjusted odds ratio = 1.80, 95% confidence interval (CI): 1.29, 2.52) and African Americans (adjusted odds ratio = 1.54, 95% CI: 1.11, 2.14). There was a strong inverse relation between income and PTSD. Specifically, survivors with incomes of <$25,000 per year were 8 times more likely to have PTSD than those earning ≥$100,000 per year (49.1% vs. 6.0%; adjusted odds ratio = 8.45, 95% CI: 5.04, 14.14).

Among 9/11 exposures, the following experiences indicating severe exposure were associated with PTSD in both bivariate and multivariable logistic regression models: having witnessed horror (adjusted odds ratio = 3.01, 95% CI: 2.39, 3.81), having sustained an injury (adjusted odds ratio = 2.72, 95% CI: 1.26, 5.86), having been exposed to the dust cloud (adjusted odds ratio = 1.78, 95% CI: 1.36, 2.35), having been above the impact zones rather than below (adjusted odds ratio = 1.77, 95% CI: 1.17, 2.67), and having

Table 2. Posttraumatic Stress Symptoms and Probable Posttraumatic Stress Disorder Among Adult Civilian Survivors of the Attacks on the World Trade Center ($n = 3,271$), 2003–2004

DSM-IV Posttraumatic Stress Disorder Symptom	Symptom Endorsement[a]	
	No. of Participants	%
No symptoms reported	145	4.4
DSM-IV group B: reexperiencing[b]	1,620	49.5
Intrusive memories	1,094	33.4
Dreams or nightmares	442	13.5
Flashbacks	592	18.1
Upset at reminders	1,217	37.2
Physiologic reactivity	768	23.5
DSM-IV group C: avoidance[c]	866	26.5
Avoidance of thoughts or feelings	1,029	31.5
Avoidance of reminders	848	25.9
Psychogenic amnesia	499	15.3
Loss of interest	691	21.1
Detachment	690	21.1
Restricted range of affect	484	14.8
Sense of shortened future	916	28
DSM-IV group D: hyperarousal[d]	1,490	45.5
Insomnia	1,033	31.6
Irritability or anger	829	25.3
Difficulty concentrating	830	25.4
Hypervigilance	1,648	50.4
Being jumpy or easily startled	1,223	37.4
Probable posttraumatic stress disorder[e]	492	15.0

Abbreviation: DSM-IV, *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition.

[a] Endorsement for each symptom required answering "moderately" to "quite a bit" (≥3) on the PTSD Checklist.

[b] Must have at least 1 of 5 symptoms at moderate or greater level.

[c] Must have at least 3 of 7 symptoms at moderate or greater level.

[d] Must have least 2 of 5 symptoms at moderate or greater level.

[e] Must have a PTSD Checklist, Stressor-Specific Version Score ≥50.

evacuated later rather than early (adjusted odds ratio = 1.39, 95% CI: 1.02, 1.88 during or after the plane's impact into 2WTC). Tests of interaction between significant demographic (i.e., gender, race/ethnicity, and income) and exposure variables resulted in no significance.

An exposure severity score was created to test the relation between cumulative exposure and PTSD. It included the following dichotomous variables: highest floor reached relative to the impact zone (below vs. at or above), initiation of evacuation (during or after the plane's impact into 1WTC vs. during or after the plane's impact into 2WTC), exposure to the dust cloud (no vs. yes), witnessing of any horror event (no vs. yes), and sustaining any injury (no vs. yes). The score, ranging from 0 to 5 (low to high), was normally distributed, and there was a positive, monotonic relation between the exposure severity score and the PCL-S score (Figure 2; mean PCL-S scores ranged from 25 at 0 exposures to 44 at 4 exposures).

Table 4 displays the stepwise logistic regression models that examined the relation between the exposure severity score and the risk of PTSD. In the unadjusted model, each increase in severity score yielded a 117% greater likelihood of a survivor's screening positive for symptoms (crude odds ratio = 2.17; 95% CI: 1.94, 2.42). When the score was controlled for demographic confounders, the relation between the score and PTSD was slightly attenuated. In the final model, each additional exposure was associated with a 109% greater likelihood of PTSD (adjusted odds ratio = 2.09, 95% CI: 1.84, 2.36).

DISCUSSION

In the largest cohort of civilian survivors of the WTC attacks assembled to date, we found that the majority of survivors experienced multiple 9/11-related posttraumatic stress symptoms 2–3 years after the attacks. Almost 1 in 6 participants screened positive for probable PTSD. This finding underscores the long-lasting mental health effects of mass violence but is lower than the rate reported in similar research on other terrorist attack survivors (6). Despite differences in levels of exposure, study design, screening instruments, and length of follow-up, assessments of bombings in France between 1982 and 1987 found PTSD rates of 31% and 18% among survivors 2–3 and 8 years later, respectively (27, 28). Six months after the 1987 bombing in Enniskillen, Northern Ireland, 50% of survivors were determined to have PTSD (28). In the United States, 34% of survivors of the 1995 bombing of the Alfred P. Murrah Federal Building in Oklahoma City had PTSD 6 months after the attack, and PTSD was chronic in 100% of cases, lasting ≥3 months (30). In a follow-up study 17 months after the bombing, 89% of cases were unremitted (31).

One explanation for the lower prevalence of PTSD documented here compared with the few other extant postterrorism studies is that many survivors of the attacks on the WTC did not realize that their lives were in extreme danger during the event. Reports from evacuees included descriptions of calm descent (32–34). Many survivors did not imagine that the towers would collapse, and it was not until after a safe evacuation that the magnitude of the situation was apparent. It is possible that awareness of life threat is a driver of high risk for PTSD (35), and the absence of such knowledge accounts for the lower prevalence documented here compared with other terrorism studies. Still, longitudinal study of WTC survivors to determine whether symptoms increase or decrease over time is warranted; research on the Oklahoma City bombing showed that symptoms and functional impairment of bombing survivors might not be diagnosable for years after an attack (31).

As expected, we estimated a higher prevalence of PTSD among tower survivors than among the general population after 9/11 (9–13). Although population studies demonstrated that rates of 9/11-related PTSD declined over time, they also found that those with the highest exposure burden experienced the worst mental health. For example, in a small

Table 3. Associations of Demographic Characteristics, Event Exposures, and Probable Posttraumatic Stress Disorder Among Adult Civilian Survivors of the Attacks on the World Trade Center ($n = 3,271$), 2003–2004

	Posttraumatic Stress Disorder		Chi-Square	Likelihood of Posttraumatic Stress Disorder			
	No.[a]	%	Test of Association	COR	95% CI	AOR[b]	95% CI
Demographic characteristics							
Gender							
Male	190	9.9	96.9***	1.00		1.00	
Female	302	22.4		2.63	2.16, 3.20***	1.67	1.31, 2.14***
Age on September 11, 2001, years							
≥65	3	6.3	7.12	1.00			
45–64	176	14.8		2.61	0.80, 8.48		
25–44	273	14.9		2.62	0.81, 8.48		
18–24	40	20.2		3.8	1.12, 12.84*		
Race/ethnicity							
White	234	10.5	137.7***	1.00		1.00	
African-American	103	28.5		3.41	2.61, 4.44***	1.54	1.11, 2.14*
Hispanic	96	28.3		3.37	2.57, 4.43***	1.80	1.29, 2.52**
Asian	41	15.8		1.60	1.11, 2.29*	1.56	1.02, 2.37*
Multiracial/other	18	22.2		2.44	1.42, 4.19**	1.39	0.69, 2.80
Educational level[c]							
Postgraduate degree	60	8.0	122.5***	1.00			
College graduate	163	11.5		1.50	1.10, 2.05*		
High school graduate or equivalent	249	23.9		3.60	3.67, 4.86***		
Some high school or less	17	36.2		6.52	3.40, 12.49***		
Income per year[c]							
≥$100,000	42	6.0	253.3***	1.00		1.00	
$75,000–$99,999	110	10.7		1.88	1.30, 2.72**	1.58	1.06, 2.36*
$50,000–$74,999	88	18.2		3.50	2.38, 5.16***	2.32	1.51, 3.57***
$25,000–$49,999	139	26.6		5.70	3.95, 8.24***	3.57	2.34, 5.46***
<$25,000	79	49.1		15.14	9.76, 23.48***	8.45	5.04, 14.14***
Marital status[b]							
Currently married	239	11.8	51.0***	1.00			
Divorced or separated	71	25.4		2.54	1.88, 3.43***		
Widowed	12	21.4		2.04	1.06, 3.92*		
Not married	167	18.7		1.72	1.38, 2.13***		
Event exposures							
Residence on September 11, 2001							
Manhattan	59	14.8	49.2***	1.00			
Bronx	27	24.1		1.83	1.09, 3.05*		
Brooklyn	86	19.9		1.42	0.99, 2.05		
Queens	84	20.2		1.45	1.01, 2.10*		
Staten Island	32	22.1		1.63	1.01, 2.63*		
Elsewhere in New York	50	9.1		0.57	0.38, 0.86		
New Jersey	131	12.9		0.85	0.61, 1.19**		
Other	14	11.5		0.75	0.40, 1.39		

Table continues

Table 3. Continued

	Posttraumatic Stress Disorder		Chi-Square	Likelihood of Posttraumatic Stress Disorder			
	No.[a]	%	Test of Association	COR	95% CI	AOR[b]	95% CI
Tower							
1 World Trade Center (North Tower)	263	15.8	1.5	1.00			
2 World Trade Center (South Tower)	229	14.3		0.89	0.73, 1.08		
Location on September 11, 2001, by airplane impact zone[d]							
Below	421	14.6	7.3*	1.00		1.00	
In impact zone	21	14.3		0.98	0.61, 1.57	1.43	0.83, 2.45
Above impact zone	48	21.2		1.58	1.13, 2.21**	1.77	1.17, 2.67**
Evacuation initiation[d]							
During or after plane's impact into 1 World Trade Center	372	14.0	18.7***	1.00		1.00	
During or after plane's impact into 2 World Trade Center	91	18.3		1.38	1.07, 1.77*	1.39	1.02, 1.88*
During or after collapse of 2 World Trade Center	28	27.5		2.33	1.49, 3.64**	1.67	0.96, 2.92
Exposure to dust and debris cloud that resulted from the collapse of the towers							
No	102	8.1	78.7***	1.00		1.00	
Yes	387	19.5		2.76	2.12, 3.47***	1.78	1.36, 2.35***
Witnessed horror[e]							
No	8	4.2	18.8***	1.00		1.00	
Yes	484	15.7		3.96	3.24, 4.83***	3.01	2.39, 3.81***
Sustained an injury[f]							
No	197	8.9	201.8***	1.00		1.00	
Yes	295	27.9		4.29	2.10, 8.76***	2.72	1.26, 5.86**
Usual place of work was the World Trade Center							
No	18	13.0	0.4	1.00			
Yes	470	15.1		1.18	0.71, 1.96		
Worked for an employer that sustained fatalities							
No	129	12.5	6.5*	1.00		1.00	
Yes	335	16.0		1.33	1.07, 1.64*	1.34	1.04, 1.74*

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; COR, crude odds ratio.

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.0001$.

[a] Numbers may not add up to 3,271 because not all respondents answered all the questions.

[b] Variables were considered for inclusion in the multivariable logistic regression model if their bivariate regression model results were significant at $P < 0.1$. Only variables that significantly contributed to final model fit were retained to present a parsimonious model.

[c] Reported at the time of interview.

[d] The plane impacts occurred at 8:46 AM between floors 93 and 99 for 1 World Trade Center and 9:02 AM between floors 77 and 85 for 2 World Trade Center. Two World Trade Center collapsed at 9:59 AM, and 1 World Trade Center collapsed at 10:28 AM.

[e] Includes personally seeing at least 1 of the following: an airplane hitting one of the World Trade Center towers, people falling or jumping from the World Trade Center, buildings collapsing, people running away from a cloud of smoke, or injured or dead individuals.

[f] Includes sustaining at least 1 of the following: broken bone, burn, concussion, cut, sprain or strain, or other injury.

group of individuals who were physically in any part of the WTC complex at the time of the attacks and part of a representative sample of New York City residents, 36.7% had PTSD within 6 months of 9/11 (13), and among primary care patients who reported being in the WTC or lower Manhattan on 9/11, 17.1% had PTSD 1 year after the attack (25).

We examined demographic risk factors and found that their relation supported the general association of social disadvantage with adverse mental health indicators (6). Our observations about female gender were consistent with findings from other post-9/11 studies (36), and could have been explained by women's higher prevalence of pretrauma psychological disorders, ancillary stressors, caretaking

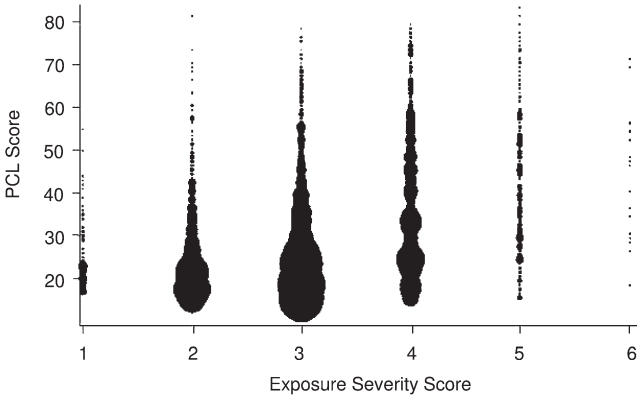

Figure 2. Relation of direct exposure and posttraumatic stress symptoms among adult civilian survivors of the attacks on the World Trade Center. Total $n = 3{,}271$; $n = 102$ and mean PTSD Checklist, Stressor-Specific Version (PCL-S) score = 25 at exposure severity score 0; $n = 691$ and mean PCL-S score = 28 at exposure severity score 1; $n = 1272$ and mean PCL-S score = 28 at exposure severity score 2; $n = 901$ and mean PCL-s score 32 at exposure severity score 3; $n = 248$ and mean PCL-S score = 44 at exposure severity score 4; and $n = 17$ and mean PCL score = 42 at exposure severity score 5.

responsibilities, and gender role expectations (37). African Americans and Hispanics were more likely to have PTSD than were whites, similar to what was seen in other studies (38). Explanations for this observation include differential vulnerability (39), pre-9/11 exposure (39), immigrant status (25), pre-9/11 mental health problems (39), lack of social supports, and perievent emotional reactions (39). However, by far the strongest demographic risk factor in our study was low income. We observed a pronounced dose-response relation between income and PTSD that was independent of other covariates. Potential explanations for this relation include findings that poor populations tend to avoid seeking (40) or receiving (41, 42) treatment from mental health specialists, as well as broader sociologic theories on the effect of marginalization, lack of resources, and powerlessness on coping with negative life events (25, 43–45).

It has been well-documented that the extent of exposure to a disaster is one of the most important factors in the development of disaster-related PTSD. However, most studies used relatively crude measures of exposure, often combining the loss of a loved one or property and participation in rescue efforts into one broad categorization of direct exposure. Our large cohort allowed us to focus on experiences by civilians. PTSD risk was greater among survivors whose experiences indicated severe life threat, as defined by location in the towers, time of evacuation initiation, or dust cloud exposure. We also found strong relations between having witnessed horror or having sustained injuries and PTSD, consistent with other studies on human-made disasters (12, 13, 46–48). One potential explanation as to why those who witness horror are more susceptible to PTSD might lie in a biologic understanding of PTSD etiology, as images of grotesque and unimaginable scenes are encoded into memory and may be relived upon stimuli.

We found an interesting relation between coworker casualties and PTSD. In a meta-analysis, Rubonis and Bickman (7) found that the number of human casualties clearly affects the relation between disasters and consequent psychological problems. It is possible that WTC fatalities within one's company indicated increased life threat for survivors, but bereavement for colleagues who perished may have also contributed to this finding (7, 46).

The cumulative effect of severe exposure was found to be significantly associated with PTSD in stepwise regression, demonstrating that although tower survivors may have shared a collective experience, individuals who were exposed to several of the most troubling and life-threatening events during the disaster were at the greatest risk of PTSD. This cumulative effect is an important observation that has implications for future disaster response and that warrants further attention. We are aware of only 1 prior study related to the WTC disaster that used a comparable measure of exposure severity (49). Brackbill et al. (50). found that residents with a very high exposure level (i.e., $\geq$6 of 14 events, including having been afraid of being killed, having a friend or relative killed, having been forced to move, having financial difficulties, etc.) were significantly more likely to screen positive for PTSD at a 1-year assessment.

Strengths of the present study include the procurement of a large cohort of civilians who survived the WTC attacks that had characteristics comparable to the NIST's smaller egress study, the use of a validated measure of PTSD, and detailed characterizations of 9/11 exposures that were not explored in previous studies. A central limitation to this study was the recruitment strategy, which may have produced selection bias and limited generalizability to all those who evacuated the towers on 9/11. The true effect of this bias is unknown because of the lack of information in the literature on all tower survivors, but if those most affected were more likely to participate in our study, our estimates would have been inflated. Alternatively, if those most affected avoided participation, true symptom prevalence would have been underestimated. Our findings were also based on a cross-sectional survey, which typically makes the temporal relation of exposures and outcomes unclear. However, exposures assessed here were ones that occurred on 9/11, and all stress symptoms were reported as occurring in the last 4 weeks before participation. This study relied on self-reporting, which could have affected the precision of true symptom prevalence. Although the PCL-S is one of the most widely used screening instruments today, it is inevitably less precise than a clinical interview. Confounding and effect modification could have led to nonrandom error in our risk factor analyses: Lack of information on preevent psychological functioning and trauma, subjective appraisal of life threat, bereavement, social support, and mental health services may account for some of the observed relations between the risk factors examined here and PTSD (6). Further, our data collection instrument did not include other psychiatric disorders, such as depression, generalized anxiety disorder, or substance abuse, that are commonly observed after trauma (12, 30).

As the long-term effects of the WTC disaster emerge (50, 51), the results from this study suggest that some survivors of the WTC disaster will continue to report psychological symptoms years after their exposure to the events of 9/11.

Table 4. Stepwise Regression Models Demonstrating the Association Between Severity of Direct Exposure During the 9/11 Attacks and Probable Posttraumatic Stress Disorder, 2003–2004

	Step 1		Step 2		Step 3		Step 4	
	COR	95% CI	AOR	95% CI	AOR	95% CI	AOR	95% CI
Exposure severity score[a]	2.17	1.94, 2.42***	2.12	1.90, 2.37***	2.06	1.84, 2.30***	2.09	1.84, 2.36***
Gender								
Male			1.00		1.00		1.00	
Female			2.47	2.01, 3.03***	2.12	1.72, 2.63***	1.83	1.45, 2.32***
Race/ethnicity								
White					1.00		1.00	
African-American					2.43	1.82, 3.23***	1.53	1.12, 2.10**
Hispanic					2.78	2.08, 3.72***	1.86	1.35, 2.57***
Asian					1.62	1.11, 2.36*	1.49	0.99, 2.23
Other					2.05	1.16, 3.62*	1.19	0.60, 2.40
Income per year								
≥$100,000							1.00	
$75,000–$99,999							1.47	1.00, 2.17*
$50,000–$74,999							2.28	1.50, 3.44***
$25,000–$49,999							3.27	2.18, 4.92***
<$25,000							8.24	5.06, 13.43***
Adjusted R^2	0.11		0.15		0.18		0.25	

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; COR, crude odds ratio.

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.0001$.

[a] The direct exposure severity score included the following dichotomous variables: highest floor reached according to impact zone (below vs. at or above impact zone), time of initiation of evacuation (during or after the plane's impact into 1 World Trade Center vs. during or after the plane impact into 2 World Trade Center), exposure to the dust and debris cloud (no or yes), having witnessed any horror event (no or yes), and having sustained any injury (no or yes).

The implication of this finding is that the impact of terrorism on survivors, particularly those in low socioeconomic positions, could be substantial, as PTSD is known to be comorbid with other disorders and harmful behaviors that affect daily functioning, wellness, and relationships (52).

As disaster literature moves toward understanding long-term risks in the general population, this study reminds us that the relation between direct exposures and PTSD is clear and suggests potential avenues for planning policy to reduce the burden of terrorism-related psychopathology. Disaster preparedness training for the civilian workforce should incorporate disclosure of potential experiences that contribute to PTSD risk such as evacuation, injury, and personally witnessing the horrors of death and destruction. The additive effect of such direct exposures should also be taken into consideration during postdisaster treatment.

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