

ORIGINAL RESEARCH

Trends in Probable PTSD in Firefighters Exposed to the World Trade Center Disaster, 2001–2010



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ABSTRACT

Objective: We present the longest follow-up, to date, of probable posttraumatic stress disorder (PTSD) after the 2001 terrorist attacks on the World Trade Center (WTC) in New York City firefighters who participated in the rescue/recovery effort.

Methods: We examined data from 11 006 WTC-exposed firefighters who completed 40 672 questionnaires and reported estimates of probable PTSD by year from serial cross-sectional analyses. In longitudinal analyses, we used separate Cox models with data beginning from October 2, 2001, to identify variables associated with recovery from or delayed onset of probable PTSD.

Results: The prevalence of probable PTSD was 7.4% by September 11, 2010, and continued to be associated with early arrival at the WTC towers during every year of analysis. An increasing number of aerodigestive symptoms (hazard ratio [HR] 0.89 per symptom, 95% confidence interval [CI] 0.86-.93) and reporting a decrease in exercise, whether the result of health (HR 0.56 vs no change in exercise, 95% CI 0.41-.78) or other reasons (HR 0.76 vs no change in exercise, 95% CI 0.63-.92), were associated with a lower likelihood of recovery from probable PTSD. Arriving early at the WTC (HR 1.38 vs later WTC arrival, 95% CI 1.12-1.70), an increasing number of aerodigestive symptoms (HR 1.45 per symptom, 95% CI 1.40–1.51), and reporting an increase in alcohol intake since September 11, 2001 (HR 3.43 vs no increase in alcohol intake, 95% CI 2.67-4.43) were associated with delayed onset of probable PTSD.

Conclusions: Probable PTSD continues to be associated with early WTC arrival even 9 years after the terrorist attacks. Concurrent conditions and behaviors, such as respiratory symptoms, exercise, and alcohol use also play important roles in contributing to PTSD symptoms.

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Key Words: World Trade Center, mental health, posttraumatic stress disorder, psychological symptoms, firefighters

The terrorist attacks on the World Trade Center (WTC) towers on September 11, 2001 (9/11) killed 2974 residents and workers in lower Manhattan, including 343 rescue workers (341 firefighters and 2 paramedics) from the Fire Department of the City of New York (FDNY). After the towers collapsed, rescue/recovery workers endured hazardous and chaotic working conditions for up to 10 months.

Since 9/11, posttraumatic stress disorder (PTSD) has been of major interest because it is arguably one of the most prevalent and debilitating consequences of terrorism-related incidents.¹ Among WTC rescue/recovery workers, the prevalence of probable PTSD has been reported to be anywhere from 11% to 19.5%, depending on the screening instrument that was used and the time interval between 9/11 and data collection.²⁻⁴ We use the term “probable PTSD” here and in subsequent analyses to indicate that the outcome is determined through a screening instrument rather than a diagnostic interview.

In WTC-exposed populations, PTSD symptoms have been associated with heavy alcohol use.⁵ In another study of survivors after a mass shooting in Killeen, Texas, PTSD symptoms were associated with seeking mental health treatment immediately after the event,⁶ and a study of US military veterans found co-occurring PTSD symptoms and respiratory disease.⁷ The first major longitudinal study of PTSD trends after the WTC attacks found that 8.7% of all rescue workers and volunteers demonstrated chronic PTSD symptoms, 10.8% demonstrated delayed onset symptoms (present at follow-up in 2006-2007 but not enrollment in 2003-2004), and 3.5% demonstrated resolved symptoms (present at enrollment but not at follow-up).⁴

We present the longest follow-up, to date, of PTSD related to the WTC attacks among FDNY firefighters. We update our previous work of PTSD trends among the FDNY population⁸ by extending our cross-sectional analyses of probable PTSD by year, through September 11, 2010. Furthermore, we perform multivariable analyses in 2 longitudinal cohorts to identify factors as-

sociated with recovery from probable PTSD and factors associated with delayed onset of probable PTSD.

METHODS

After 9/11, a formal medical monitoring program (FDNY-WTC-MMP) was implemented for all FDNY rescue/recovery workers. Monitoring visits, which are ongoing and occur once every 18 months, include physical examinations and self-administered questionnaires that collect information on exposure to the WTC site and physical and mental health symptoms. Study participation required written consent and was approved by the institutional review board at Montefiore Medical Center, New York.

Data Sources

Demographic data and work status (active or retired) were obtained from the FDNY employee database. For each participant, the number of firefighters in his or her firehouse who died on 9/11 was obtained from the FDNY Counseling Service Unit. Physical and mental health symptom variables were collected from FDNY-WTC-MMP questionnaires.

Participants

The FDNY WTC uniformed workforce consisted of 12 267 firefighters hired before the close of the WTC site on July 25, 2002. We excluded 1238 firefighters who arrived at the site more than 14 days after the rescue/recovery effort began because of differences in demographics and in PTSD risk (both real and perceived) and 23 female firefighters because of their small numbers. The final analytic sample consisted of 11 006 firefighters who completed 40 672 questionnaires during the 9 years post-9/11.

WTC Exposure

We used the FDNY-WTC-MMP Exposure Intensity Index to determine exposure to the WTC site based on initial arrival time, as previously described.⁹ Those who first arrived during the morning of 9/11 (day 1) were categorized as “arrival group 1”; those who arrived during the afternoon of 9/11 were categorized as “arrival group 2”; those who arrived on day 2 were categorized as “arrival group 3”; and those who arrived at any time between days 3 through 14 were categorized as “arrival group 4.”

Probable PTSD

The study outcome was current symptoms indicative of probable PTSD. In years 6 through 9, probable PTSD was evaluated by the PTSD Checklist (PCL)-Civilian Version.¹⁰ The PCL is a 17-item self-report survey corresponding to the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV)*¹¹ diagnostic criteria for PTSD and linking symptoms to a specific traumatic experience (in this case, “the WTC attacks”). Symptoms were grouped into 3 clusters—reexperiencing, avoidance, and hyperarousal—experienced during the 30 days before the survey. Respondents reported experiencing each symptom on a 5-point Likert scale, with responses consisting of “not at all” (1), “a little bit” (2), “moderately” (3), “quite a bit” (4), and “extremely” (5). Symptom occurrence was

defined by answering “moderately” or more (3+). Individuals met the criteria for probable PTSD if they attained a summative score of ≥ 44 (out of 85) and if they fulfilled *DSM-IV* diagnostic criteria (affirming at least 1 reexperiencing symptom, at least 3 avoidance symptoms, and at least 2 hyperarousal symptoms). Combining the 2 criteria yielded a more conservative estimate of probable PTSD, which has been used previously.¹²

In years 1 through 4, we evaluated probable PTSD with a modified version of the PCL, the use of which in this population has been validated and described.^{8,13} The modified PCL included 14 of the 17 symptoms, and respondents answered on a binary scale (whether they did or did not experience each symptom) instead of on a Likert scale. Individuals met the criteria for probable PTSD if they attained a total score of ≥ 9 (out of 14) and if they fulfilled *DSM-IV* diagnostic criteria as described above.

Comparison of the Modified and Unmodified PCL

Because the FDNY modified PCL was replaced by the unmodified PCL in 2005, no individuals took both versions of the questionnaire during the same visit. We performed a comparison study of the 2 versions by examining responses from 5458 individuals who completed the unmodified PCL during the first 2 years of its administration (2005-2007). First, we scored the responses using the unmodified PCL criteria stated above; participants met the criteria for probable PTSD if they had a summative score ≥ 44 and fulfilled diagnostic criteria. Second, we scored responses as though we were simulating the modified PCL: We removed the 3 symptoms in the reexperiencing domain not in our modified version, and we used the cutoff of “moderately” or more (3+) to indicate symptom presence vs absence. Participants met the criteria for probable PTSD if they had a total score ≥ 9 and fulfilled diagnostic criteria. Agreement between the 2 scoring versions was high, as evaluated by the kappa statistic (0.85). The Cronbach alpha values for the unmodified PCL and the modified PCL were 0.95 and 0.91, respectively. The Cronbach alpha values for individual domains were 0.87 and 0.81 for arousal, 0.90 and 0.85 for avoidance, and 0.90 and 0.75 for reexperiencing, respectively. Therefore, we present prevalence estimates from either version across the 9 years of follow-up.

PTSD Risk Factors

Variables considered to be possible risk factors for PTSD included change in alcohol intake (since 9/11), change in exercise (since the individual’s last questionnaire), and smoking status (at the time of the questionnaire).¹⁴ In addition, we asked whether each participant had prior experience responding to natural or human-made disasters other than fires. Finally, to assess physical comorbidity, we created an aerodigestive symptom score as the unweighted sum of 6 symptoms that each individual reported experiencing (unrelated to seasonal allergies or the common cold) at the time of the questionnaire (sore throat, nasal congestion/drip, wheeze, shortness of breath, cough, and gastroesophageal reflux).

TABLE 1

Demographic Information for Firefighters Who Completed Surveys at Each Year

	Year 1 (n = 8669)	Year 2 (n = 1159)	Year 3 (n = 2816)	Year 4 (n = 4161)	Year 6 (n = 4343)	Year 7 (n = 6041)	Year 8 (n = 6588)	Year 9 (n = 6895)
Arrival group								
1	1417 (16.4)	193 (16.7)	425 (15.1)	654 (15.7)	681 (15.7)	862 (14.3)	987 (15.0)	1010 (14.7)
2	5538 (63.9)	754 (65.1)	1918 (68.1)	2822 (67.8)	2791 (64.3)	3737 (61.9)	4082 (62.0)	4288 (62.2)
3	1036 (12.0)	122 (10.5)	311 (11.0)	433 (10.4)	512 (11.8)	831 (13.8)	883 (13.4)	917 (13.3)
4	678 (7.8)	90 (7.8)	162 (5.8)	252 (6.1)	359 (8.3)	611 (10.1)	636 (9.7)	680 (9.9)
Race/ethnicity*								
White	8147 (94.0)	1091 (94.1)	2635 (93.6)	3932 (94.5)	4057 (93.7)	5677 (94.2)	6167 (93.8)	6468 (93.9)
African American	203 (2.3)	32 (2.8)	62 (2.2)	75 (1.8)	92 (2.1)	136 (2.3)	162 (2.5)	162 (2.4)
Hispanic	294 (3.4)	34 (2.9)	111 (3.9)	139 (3.3)	165 (3.8)	198 (3.3)	229 (3.5)	234 (3.4)
Other	25 (0.3)	2 (0.2)	8 (0.3)	15 (0.4)	17 (0.4)	19 (0.3)	20 (0.3)	23 (0.3)
Mean age on 9/11	39.5 ± 7.4	40.3 ± 7.5	37.6 ± 6.8	37.0 ± 6.7	38.9 ± 7.9	40.3 ± 8.8	40.6 ± 8.7	40.6 ± 8.6

Values are presented as N (%) or mean ± standard deviation.

*41 people with missing race/ethnicity.

TABLE 2

Cross-Sectional Prevalence of Probable Posttraumatic Stress Disorder From Years 6-9 After the Attacks, by Arrival Group at the World Trade Center

	2006-2007 n = 4343	2007-2008 n = 6041	2008-2009 n = 6588	2009-2010 n = 6895
Overall	7.7 (333/4343)	6.3 (381/6041)	7.1 (467/6588)	7.4 (511/6895)
Arrival group				
1	14.0 (95/681)	10.9 (94/862)	12.8 (126/987)	13.4 (135/1010)
2	6.7 (187/2791)	5.7 (213/3737)	6.5 (265/4082)	6.5 (279/4288)
3	6.5 (33/512)	4.9 (41/831)	5.2 (46/883)	6.5 (60/917)
4	5.0 (18/359)	5.4 (33/611)	4.7 (30/636)	5.4 (37/680)

Values presented as % (numerator/denominator).

Data Analysis

In serial cross-sectional analyses, we estimated the annual prevalence of probable PTSD for years 6 through 9 post-9/11 (September 12, 2006-September 11, 2010) because results from years 1 through 4 have already been published.⁸ Prevalence estimates for each year include data from firefighters who took questionnaires during that year. We omitted year 5 (September 12, 2005-September 11, 2006) data from cross-sectional analyses because during that year we limited participation to implement an expanded version of the mental health questionnaire. If a participant took more than 1 questionnaire in a given year, then only data from the first questionnaire was used. We assessed the association between arrival group and probable PTSD using marginal logistic regression models.

In separate prospective analyses using data from years 1 through 9, we created 2 cohorts in which to examine the progression of probable PTSD. In 1 cohort of 807 individuals who met the criteria for probable PTSD at year 1 (October 2, 2001-September 11, 2002) and completed at least 1 follow-up survey thereafter, we used Cox regression models to analyze demographic and other risk factors in

relation to time to recovery from probable PTSD. In a second cohort of 7542 individuals who did not meet the criteria for probable PTSD at year 1 and completed at least 1 follow-up survey thereafter, we modeled the same factors in relation to time to delayed onset of probable PTSD. All of the firefighters in both cohorts were active (not retired) at the time of initial survey. Follow-up started after the date of an individual's survey during year 1. For those with probable PTSD at year 1, time to recovery was defined as the date of the first survey during follow-up in which a participant failed to meet the criteria for probable PTSD. For those without probable PTSD at year 1, time to delayed onset was defined as the date of the first survey during follow-up in which a participant met the criteria for probable PTSD. Individuals were censored at the date of their last survey (up to year 9).

Alcohol intake, exercise practices, smoking status, and aerodigestive symptom score were analyzed as time-dependent variables to account for possible changes in responses over time. The question for alcohol intake was included in questionnaires only beginning at year 5, and therefore, we created a dummy variable for analysis

FIGURE

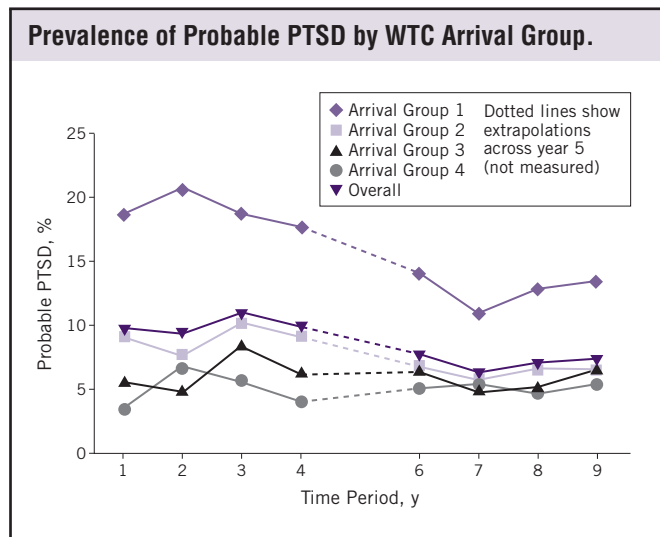


TABLE 3

Using Cox Regression to Model Recovery of Probable Posttraumatic Stress Disorder Among the Cohort That Met the Criteria for Probable Posttraumatic Stress Disorder During Year 1

	Hazard Ratio (95% CI), Adjusted Only for Age	Hazard Ratio (95% CI), Adjusted for All Other Variables in Table
Arrival group (ref = groups 3 and 4)		
1	.76 (.58-1.00)	.74 (.56-.99)
2	.97 (.75-1.25)	.85 (.66-1.11)
≥1 death at firehouse on 9/11	.84 (.71-1.00)	.87 (.73-1.04)
Received counseling during year 1	.89 (.76-1.04)	.98 (.83-1.15)
Each concurrent aerodigestive symptom	.87 (.84-0.90)	.89 (.86-.93)
Concurrent alcohol intake (ref = no increase since 9/11)*		
Increased since 9/11	.77 (.53-1.12)	.83 (.56-1.22)
Increased since 9/11, now back to pre-9/11 levels	.95 (.76-1.18)	1.01 (.81-1.27)
Concurrent exercise (ref = no change since last questionnaire)		
Decreased since last questionnaire	.74 (.62-.88)	.76 (.63-.92)
Decreased since last questionnaire for health reasons	.38 (.28-.52)	.56 (.41-.78)
Increased since last questionnaire	.95 (.77-1.18)	.92 (.74-1.14)
Concurrent smoking status (ref = never smoker)		
Current	1.03 (.81-1.32)	1.04 (.81-1.33)
Former	.91 (.76-1.08)	.95 (.79-1.15)
Experience with prior disaster	.82 (.69-.96)	.86 (.73-1.02)
Nonwhite race/ethnicity	.98 (.70-1.36)	1.05 (.75-1.46)
Age on 9/11		1.02 (1.01-1.04)

N=807; 708 recovered (87.7%).
 *Only included in questionnaire at years 6-9; dummy variable included in analysis for earlier surveys.

of earlier surveys. The reference for arrival group combined both groups 3 and 4 because of the small numbers of people in arrival group 4. We excluded 9 individuals (1.1%) from the recovery cohort and 50 individuals (0.7%) from the delayed onset cohort because of missing values for counseling use, exercise, smoking status, or aerodigestive symptom score. All of the statistical analyses were performed using SAS version 9.2 (SAS Institute, Cary, NC).

RESULTS

Prevalence of Probable PTSD in Serial Cross-Sectional Analyses

We analyzed 4343 questionnaires in year 6 (September 12, 2006-September 11, 2007); 6041 in year 7 (September 12, 2007-September 11, 2008); 6588 in year 8 (September 12, 2008-September 11, 2009); and 6895 in year 9 (September 12, 2009-September 11, 2010). Table 1 shows demographic information for the firefighters who took questionnaires during each year, beginning at year 1. Repeated observations on the same participants are not independent across years; however, the composition of each group remains relatively similar from year to year.

Our previous analyses of years 1 through 4 showed the overall prevalence of probable PTSD to be around 10%. Table 2 shows the cross-sectional prevalence estimates for years 6 through 9 by arrival group. The Figure shows the prevalence of probable PTSD for years 1 through 9. Overall prevalence declined to its lowest level of 6.3% in year 7 and was 7.4% in year 9.

The prevalence of probable PTSD was significantly associated with arrival group in all 4 years of analyses ($P < .0001$ in marginal logistic regression models). Arrival group 1 continued to demonstrate the highest prevalence in all years, ending at 13.4% in year 9. The remaining arrival groups had substantially lower prevalence values, ultimately converging to be around 6%; by year 9, the prevalence was 6.5%, 6.5%, and 5.4% in groups 2 through 4, respectively.

Prospective Analyses

Recovery From Probable PTSD

A total of 807 firefighters who met the criteria for probable PTSD at year 1 were included in this analysis, of whom 708 (87.7%) recovered at some point during their follow-up. Recovery occurred on average 3.9 ± 2.2 (mean \pm standard deviation) years after 9/11. Of the 99 (12.3%) individuals who did not recover from probable PTSD, mean follow-up time was 7.0 ± 2.0 years after 9/11.

A total of 31 individuals met the criteria for probable PTSD at year 1 but were not included in the analysis because they had no follow-up survey. When they were compared with individuals included in the analysis, there were no significant differences between the 2 groups in arrival group, race/ethnicity, mean age on 9/11, or mean PCL score at year 1.

Table 3 shows hazard ratios for demographic and other risk factors in relation to recovery, both adjusted only for age and adjusted for all of the other covariates in the table. Firefighters in arrival group 1 were less likely to recover from probable PTSD in

both the age-adjusted model and the fully adjusted model (hazard ratio [HR] 0.76, 95% confidence interval [CI] 0.58-1.00 and HR 0.74, 95% CI 0.56-.99, respectively). Fully adjusted analysis showed that each additional aerodigestive symptom was significantly associated with an 11% lower likelihood of recovery from probable PTSD (HR 0.89, 95% CI 0.86-.93). Smoking status and increases in alcohol intake since 9/11 had no significant relation to recovery; however, reporting a decrease in exercise because of health reasons was strongly associated with a lower likelihood of recovery from probable PTSD (HR 0.56, 95% CI 0.41-.78), compared to no change in exercise levels. Reporting a decrease in exercise because of other reasons was also associated with a lower likelihood of recovery (HR 0.76, 95% CI 0.63-.92), compared to no change in exercise levels.

Delayed Onset of Probable PTSD

Table 4 shows HRs for risk factors in relation to delayed onset of probable PTSD. We analyzed information from 7542 firefighters who did not initially meet the criteria for probable PTSD. Of these, 974 (12.9%) experienced delayed onset during follow-up, which occurred on average 4.3 ± 2.3 years after 9/11. Of the 6568 (87.1%) who never met the criteria for probable PTSD, mean follow-up time was 7.8 ± 1.3 years after 9/11.

A total of 208 individuals did not meet the criteria for probable PTSD at year 1 and were not included in the analysis because of the lack of a follow-up survey. There were no significant differences in race/ethnicity or initial mean PCL score between those who were and those who were not included in the analysis; however, individuals not included in the analysis were more likely to be in arrival groups 3 or 4 than those who were included (18.8% vs 12.4% and 24.0% vs 7.9% respectively, $P < .0001$) and were on average older on 9/11 (44.0 ± 6.3 vs 39.3 ± 7.4 years old, respectively, $P < .0001$).

Arrival group was significantly associated with delayed onset of probable PTSD, with individuals in arrival group 1 more likely to experience delayed onset of probable PTSD as compared with individuals in arrival groups 3 and 4 (fully adjusted HR 1.38, 95% CI 1.12-1.70). Aerodigestive symptom score and reporting a decrease in exercise, whether because of health or other reasons, also were positively associated with delayed onset of probable PTSD, consistent with being inversely associated with recovery in the previous models. Reporting an increase in alcohol intake since 9/11 was positively associated with delayed onset of probable PTSD (HR 3.43, 95% CI 2.67-4.43) as was reporting an increase followed by a return to pre-9/11 levels (HR 2.06, 95% CI 1.71-2.47). Former smokers were more likely than never smokers to develop delayed onset of probable PTSD after adjusting for other variables (HR 1.23, 95% CI 1.06-1.42); however, current smoking was not associated with delayed onset of probable PTSD (HR 1.07, 95% CI 0.85-1.35).

DISCUSSION

Nine years after the WTC attacks, in the longest longitudinal study to date, we found that about 7% of the WTC-exposed firefight-

TABLE 4

Using Cox Regression to Model Delayed Onset of Probable Posttraumatic Stress Disorder Among the Cohort That Did Not Meet the Criteria for Probable Posttraumatic Stress Disorder During Year 1

	Hazard Ratio (95% CI), Adjusted Only for Age	Hazard Ratio (95% CI), Adjusted for All Other Variables in Table
Arrival group (ref = groups 3 and 4)		
1	2.21 (1.80-2.70)	1.38 (1.12-1.70)
2	1.16 (.98-1.39)	.90 (.75-1.08)
≥ 1 death at firehouse on 9/11	1.31 (1.12-1.54)	1.11 (.95-1.31)
Received counseling during year 1	2.02 (1.74-2.35)	1.59 (1.36-1.85)
Each concurrent aerodigestive symptom	1.62 (1.56-1.67)	1.45 (1.40-1.51)
Concurrent alcohol intake (ref = no increase since 9/11)*		
Increased since 9/11	5.85 (4.56-7.52)	3.43 (2.67-4.43)
Increased since 9/11, now back to pre-9/11 levels	2.95 (2.46-3.55)	2.06 (1.71-2.47)
Concurrent exercise (ref = no change since last questionnaire)		
Decreased since last questionnaire	2.65 (2.27-3.09)	1.69 (1.44-1.97)
Decreased since last questionnaire for health reasons	4.20 (3.53-4.99)	3.19 (2.64-3.86)
Increased since last questionnaire	1.13 (.91-1.41)	.92 (.74-1.14)
Concurrent smoking status (ref = never smoker)		
Current	1.13 (.90-1.42)	1.07 (.85-1.35)
Former	1.24 (1.07-1.43)	1.23 (1.06-1.42)
Experience with prior disaster	1.29 (1.13-1.48)	1.11 (.96-1.27)
Nonwhite race/ethnicity	1.20 (.94-1.54)	1.37 (1.07-1.75)
Age on 9/11		1.00 (.99-1.01)

N = 7542; 974 experienced delayed onset (12.9%).

* Only included in questionnaire at years 6-9; dummy variable included in analysis for earlier surveys.

ers met the criteria for current probable PTSD, a decrease from the almost 10% prevalence in the first year post-9/11. By comparison, the most current National Comorbidity Survey Replication, administered from 2001 to 2003, found the 12-month prevalence of PTSD in the US male population to be 1.8%.¹⁵ Although the National Comorbidity Survey Replication diagnoses were based on diagnostic interviews (the World Mental Health Survey Initiative Version of the World Health Organization Composite International Diagnostic Interview¹⁶), we believe that the higher prevalence found in our exposed firefighter population is noteworthy because we used a stringent screening definition of probable PTSD and defined current symptoms as those present within the past 4 weeks; both definitions would make our estimates conservative. Furthermore, the prevalence of current probable PTSD in unexposed firefighters who were hired after the close of the WTC site was well under 1% in all years, although we note that the firefighters were considerably younger than the WTC-exposed population. This is not surprising because someone choos-

ing this career would, through self-selection and training, have reduced susceptibility toward fire-related stressors. In fact, based on numerous interviews with firefighters, we believe that only extraordinary events such as the fire-related death of a child or co-worker or deaths occurring in large numbers are likely to cause psychological trauma.

We also found that, 9 years after 9/11, the cross-sectional prevalence of probable PTSD continued to show an association with early arrival at the WTC. The persistence of disturbing memories and psychological distress in people who have been most directly and intensely exposed to traumatic events has been well documented.¹⁷⁻¹⁹ PTSD persistence also has been associated with severe physical injury during the disaster²⁰ and greater exposure to traumatic events during the disaster,²¹ both of which were more likely to occur to firefighters who arrived during the morning of 9/11, when the towers collapsed. Previous studies tracking the trajectory of PTSD after an event have ended within 6 years of follow-up.^{2,4,12,22} Our work shows that the association between experiencing trauma and PTSD may persist well beyond that time frame.

Results from the prospective analyses corroborated the serial cross-sectional findings, because firefighters who arrived on the morning of 9/11 were more likely than later-arriving firefighters to report delayed onset of probable PTSD and less likely to recover from probable PTSD. In the cohort in which we examined delayed onset, the relation of arrival group was attenuated but still significant after adjusting for other covariates. We also found significant relations between arrival group and other variables that were associated with the delayed onset of probable PTSD, such as alcohol intake, exercise, and aerodigestive symptom score (results not shown). These results suggest that the association between arrival group and probable PTSD may be mediated partially by these other risk factors.

The relation between these other risk factors and probable PTSD remains consistently significant. We found that as the number of aerodigestive symptoms increased, the likelihood of recovery decreased, while the likelihood of delayed onset of probable PTSD increased. Other studies have also documented the overlapping relation between mental and physical health symptoms, such as the association between PTSD and respiratory health.²³⁻²⁶ Specifically, in a study of firefighters, McFarlane et al found significantly higher rates of cardiovascular, respiratory, musculoskeletal, and neurological symptoms in individuals who experienced PTSD vs those who did not.²⁷ A study in Australia of young adults also found associations between mental health disorders and asthma, suggesting that the comorbidity may not be limited to trauma victims.

Alcohol intake, smoking, and exercise were also associated with PTSD symptoms, especially with delayed onset of probable PTSD. We analyzed these variables as time-dependent covariates, evaluated at the same time as the outcome was evaluated, because responses to these variables could have changed over time. Therefore, we could not determine whether these variables were predictors or consequences of recovery from or delayed onset of

probable PTSD. Other research has found similar relations between behavioral change and mental health. One study documented an increased use of cigarettes, alcohol, or marijuana among New York City residents following 9/11, and found that people who increased cigarette smoking were more likely to report PTSD symptoms in the past month than people who did not increase smoking.²⁸ This increased substance use following 9/11 may thus be a negative coping strategy, with further detrimental effects on mental health in addition to physical health, especially in this cohort with documented respiratory concerns.²⁹

A decrease in exercise was both inversely associated with recovery from and positively associated with delayed onset of probable PTSD. Exercise has been associated with better functioning and well-being and decreased symptoms in those suffering from anxiety or depression.^{30,31} In a study of Vietnam War veterans with PTSD, participation in an exercise program was associated with positive lifestyle and psychological changes, such as reduced anger levels and increased mental awareness.³² Our results suggest that reductions in exercise habits may analogously contribute to the persistence as well as the delayed onset of PTSD symptoms in the WTC-exposed population.

Our study has potential limitations. First, we used 2 different screening instruments to establish probable PTSD, 1 used during years 1 through 4 after the attacks and another used during years 6 through 9. Although the agreement (as measured by the kappa statistic) was high, we cannot rule out the possibility that the 2 versions may have produced minor inconsistencies in probable PTSD prevalence. In addition, because feasibility concerns required a screening rather than a diagnostic instrument for PTSD, there may be some lack of correspondence between "probable" and actual PTSD; however, we used a high symptom threshold that would improve specificity rather than sensitivity to reduce the likelihood of unduly overestimating prevalence values. Further research should investigate sub-threshold levels of illness that inherently exist with any instrument using a threshold score to determine risk. Also, time to recovery and time to delayed onset may be inflated because some individuals may not have come in for monitoring examinations during regular intervals, and thus their recovery or delayed onset would have been recorded only at the time at which they did complete a questionnaire. We also did not have information on exposure to additional traumas that could have occurred after 9/11, the result of which could have increased rates of delayed-onset probable PTSD attributed to 9/11. Finally, we did not have information on the treatment of PTSD, which could have influenced recovery or delayed onset of symptoms.

CONCLUSIONS

Our study found that 9 years after 9/11, PTSD continues to be a significant concern in the WTC-exposed FDNY population. Factors associated with the persistence or onset of PTSD symptoms include early arrival at the WTC site, decreases in exercise, increases in alcohol intake, and concurrent symptoms of respiratory or gastroesophageal illness. PTSD may thus persist or may arise not solely because of the intensity of the event experienced but also because

of physical injuries or illnesses sustained during the event and changes in health behaviors after the event. A fully comprehensive treatment approach that addresses the physical, behavioral, and mental health consequences of WTC exposure is of critical importance.

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