

# Co-occurring Lower Respiratory Symptoms and Posttraumatic Stress Disorder 5 to 6 Years After the World Trade Center Terrorist Attack

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Respiratory illness<sup>1–9</sup> and posttraumatic stress disorder (PTSD)<sup>6,7,9–12</sup> are 2 of the most commonly reported health outcomes related to the September 11, 2001 terrorist attacks on the New York City World Trade Center (WTC). Only recently, however, have studies addressed their co-occurrence among 9/11 disaster-exposed individuals.<sup>13</sup> Comorbidity is increasingly seen as the norm rather than the exception in primary care settings<sup>14</sup> and can significantly affect diagnosis, treatment, and prognosis of a given disease,<sup>15</sup> including respiratory illness.<sup>16–20</sup> Co-occurring physical illness may also affect the diagnosis, treatment, and prognosis of PTSD. Therefore, understanding the epidemiology of co-occurring respiratory illness and PTSD can have important implications for ongoing public health outreach and treatment efforts aimed at individuals exposed to the 9/11 disaster as well as individuals in the general population with respiratory or mental illness.

The burden of co-occurring respiratory illness and PTSD among individuals directly exposed to the 9/11 disaster is likely to be high because of shared 9/11-related risk factors<sup>6</sup> and because of the close, reciprocal association between PTSD and physical health. Individuals with PTSD are at greater risk for long-term physical illness<sup>20–30</sup> partly because of lifestyle and health behaviors associated with PTSD and partly because of physiological dysregulation linked to PTSD.<sup>30</sup> The latter might also underlie the well-documented association between PTSD and somatization.<sup>31</sup> Because symptoms can arise from interacting physical and psychological factors, a single, causative disease might not be found,<sup>15</sup> highlighting the importance of examining comorbid conditions and symptomatology in 9/11-exposed individuals.

**Objectives.** We have described the epidemiology of co-occurring lower respiratory symptoms (LRS) and probable posttraumatic stress disorder (PTSD) 5 to 6 years after exposure to the 9/11 disaster.

**Methods.** We analyzed residents, office workers, and passersby (n = 16 363) in the World Trade Center Health Registry. Using multivariable logistic regression, we examined patterns of reported respiratory symptoms, treatment sought for symptoms, diagnosed respiratory conditions, mental health comorbidities, quality of life, and unmet health care needs in relation to comorbidity.

**Results.** Among individuals with either LRS or PTSD, 24.6% had both conditions. The odds of comorbidity was significantly higher among those with more severe 9/11 exposures. Independent of 9/11 exposures, participants with LRS had 4 times the odds of those without it of meeting criteria for PTSD, and those with PTSD had 4 times the odds of those without it of meeting criteria for LRS. Participants with comorbidity had worse quality of life and more unmet mental health care needs than did all other outcome groups.

**Conclusions.** Respiratory and mental illness are closely linked in individuals exposed to 9/11 and should be considered jointly in public health outreach and treatment programs. (*Am J Public Health.* 2012;102:1964–1973. doi:10.2105/AJPH.2012.300690)

In this study we have described the prevalence, risk factors, and severity of illness associated with co-occurring lower respiratory symptoms (LRS) and probable PTSD 5 to 6 years after the 9/11 disaster among lower Manhattan residents, area workers, and passersby enrolled in the World Trade Center Health Registry. To better understand the burden of undiagnosed illness, we focused on symptoms. We hypothesized that severe dust cloud exposure and returning to homes or workplaces with dust or damage from the disaster would be associated with co-occurring LRS and PTSD. We also hypothesized that (1) independent of these risk factors LRS and PTSD would be risk factors for each other, (2) individuals with LRS who had comorbid PTSD would have worse respiratory illness and a higher prevalence of diagnosed asthma than would those with LRS alone, (3) those with PTSD who had co-occurring LRS would report more PTSD

symptoms and have greater odds of comorbid mental health conditions than would those with PTSD alone, and (4) co-occurring LRS and PTSD would be associated with worse health-related quality of life (QOL) and more unmet health care needs after controlling for diagnosed respiratory and mental health conditions.

## METHODS

The Registry, a longitudinal cohort of persons exposed to the September 11, 2001, WTC terrorist attacks, has been described in detail elsewhere.<sup>6,7,32</sup> Briefly, 68 444 adults enrolled and completed computer-assisted telephone interviews (95.0%) or personal interviews (5.0%) between September 2003 and November 2004 at wave 1. Of the participants, 70% (“self-identified”) enrolled in the Registry in response to media campaigns, whereas 30% (“list identified”) were contacted from lists

provided by employers and government agencies. More than two thirds (42 602; 68.1% response rate) completed wave 2 surveys via mail, Web, and computer-assisted telephone interviews between November 2006 and December 2007.<sup>6</sup> Computer-assisted telephone interviews at wave 2 were administered to enrollees who did not respond to paper or Web survey requests. The surveys are publically available.<sup>32</sup>

### Study Population

We analyzed data from lower Manhattan residents, area workers, and passersby who completed both wave 1 and wave 2 surveys ( $n = 16\,363$ ). We excluded rescue and recovery workers because their exposure patterns are substantially different. We will report their comorbidity experience separately. Area workers ( $n = 10\,749$ ) had a usual workplace south of Chambers Street in lower Manhattan and were present south of Canal Street between the first attack and noon on 9/11. Residents ( $n = 41\,27$ ) lived in lower Manhattan south of Canal Street. Passersby ( $n = 1487$ ) were in lower Manhattan during the attacks but were not area workers, residents, or involved in the rescue and recovery effort. We excluded those who reported pre-9/11 respiratory diagnoses (asthma, reactive airway disease, or chronic bronchitis); pre-9/11 shortness of breath, wheezing, or persistent cough; and pre-9/11 PTSD diagnoses. We excluded participants who were missing PTSD and respiratory symptom data.

### Study Variables

We analyzed 4 outcome groups: those with LRS alone, PTSD alone, both LRS and PTSD, and neither.

**Lower respiratory symptoms.** We considered individuals to have LRS if they reported at least 1 of 3 symptoms—shortness of breath, persistent cough, or wheezing—for the first time at wave 1 (i.e., post-9/11) and for 8 or more days (consecutive or nonconsecutive) in the 30 days before completing wave 2. We refer to these as new onset, recurrent symptoms. We used the 8-day duration to approximate the symptom criteria for partly controlled asthma<sup>33</sup> as well as for consistency with the definition of persistent new onset respiratory symptoms used by Reibman et al.<sup>5</sup>

**Posttraumatic stress disorder.** Participants completed the PTSD Checklist-Civilian Version (PCL)<sup>34,35</sup> at both waves. The PCL is a 17-item self-reported symptom scale derived from the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV)*<sup>36</sup> diagnostic criteria in 3 symptom clusters: intrusive and reexperiencing, numbing and avoidance, and hyperarousal. All reexperiencing and half of the numbing and avoidance symptom items contained event-specific wording (e.g., “as a result of the WTC disaster”). Each item is scored from 1 (not at all) to 5 (extremely). We summed responses to the 17 items and defined probable PTSD as meeting a wave 2 cutoff score of 44 and the presence of at least 1 reexperiencing symptom (*DSM-IV* criterion B), 3 avoidance or numbing symptoms (*DSM-IV* criterion C), and 2 hyperarousal symptoms (*DSM-IV* criterion D). We used the dual criteria to obtain a more conservative estimate of probable PTSD.<sup>11</sup> We have used “PTSD” to denote probable PTSD determined as described.

**Demographics, psychiatric history, lifestyle factors.** Demographic variables included age, gender, race/ethnicity (Asian, including Hawaiian and Pacific Islander; Hispanic; non-Hispanic Black; American Indian, Alaskan, or mixed race; or White), and education level at wave 1. A psychiatric history variable indicated the presence or absence of pre-9/11 anxiety disorder other than a PTSD or depression diagnosis. Lifestyle factors included marital status at wave 2, social support, and smoking status. Table 1 describes how we categorized each variable.

**Reported exposures** Exposures included being caught in the dust cloud and returning to dust-contaminated homes or workplaces, measures previously linked to both post-9/11 asthma and PTSD.<sup>6</sup> Those with severe or some dust cloud exposure reported dust cloud exposure at wave 1. Participants with severe exposure also reported 1 or more of the following while in the dust cloud: trouble seeing, trouble walking, sought shelter, covered head to toe with dust, or could not hear anything.

At wave 2 all participants reported whether they returned to a workplace after the disaster and found a heavy coating of dust on surfaces; residents responded whether they returned to a home with a heavy coating of dust on surfaces. For those who had workplaces or

residences below Chambers St. in lower Manhattan, we created a combined variable, “heavy dust exposure at home or work,” indicating returning to either a workplace or a home with heavy dust.

**Symptoms, diagnoses, medication, and counseling.** Among participants meeting criteria for LRS, we calculated proportions of those with or without PTSD, recurrent ( $\geq 8$  days in the past 30 days at wave 2) shortness of breath, wheezing, or cough. For all outcome groups, we calculated the proportions reporting ever having sought care for these symptoms and, for those who sought care, the proportions reporting asthma diagnosed after 9/11 and inhaler use (prescribed for any breathing problem) in the previous 12 months at wave 2.

For all outcome groups, we calculated the proportions reporting each frequency category of PTSD symptoms, diagnosed PTSD, depression or anxiety after 9/11, taking a medication or talking to a professional for a mental or emotional problem in the 12 months before wave 2, and nonspecific psychological distress as measured by the Kessler-6 scale. We categorized nonspecific psychological distress as none to mild (1–7), mild to moderate (8–12), or serious ( $\geq 13$ ).<sup>37</sup> Scoring 13 or higher on the Kessler-6 scale is highly predictive of meeting diagnostic criteria for a *DSM-IV* anxiety or mood disorder.<sup>37</sup>

**Quality of life and health care.** We assessed health-related QOL at wave 2 with 4 “healthy days” measures from the Centers for Disease Control and Prevention Behavioral Risk Factor Surveillance System.<sup>38</sup> Participants rated their general health status as poor, fair, good, very good, or excellent and reported the numbers of days their physical health was not good in the previous 30 days; they rated their mental health in the same way. They also reported days of activity lost in the past 30 days because of poor health. At wave 2, participants reported whether they needed health care but did not get it in the prior 12 months and whether this included outpatient or mental health care or counseling.

### Statistical Analysis

We calculated the prevalences of LRS, PTSD, and co-occurring LRS and PTSD in relation to other variables. In bivariate multinomial logistic regression analyses, we tested

**TABLE 1—Characteristics of Participants (n = 16 363) With LRS, PTSD, Both, or Neither 5–6 Years After 9/11: World Trade Center Health Registry, New York City, 2006–2007**

Characteristic	No LRS, No PTSD, No. (%)	LRS Only, No. (%)	PTSD Only, No. (%)	LRS and PTSD, No. (%)	LRS Only, OR (95% CI)	PTSD Only, OR (95% CI)	LRS and PTSD, OR (95% CI)
<b>Gender</b>							
Female	6281 (50.1)	840 (56.2)	783 (56.2)	550 (58.3)	1.3 (1.1, 1.4)	1.3 (1.2, 1.5)	1.4 (1.2, 1.6)
Male	6250 (49.9)	655 (43.8)	610 (43.8)	394 (41.7)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Total	12 531	1495	1393	944			
<b>Age at enrollment, y</b>							
≥ 65	520 (4.1)	122 (8.2)	34 (2.4)	43 (4.6)	3.9 (2.6, 6.0)	0.6 (0.4, 0.9)	2.0 (1.2, 3.3)
45–64	5365 (42.8)	775 (51.8)	583 (41.9)	504 (53.4)	2.4 (1.7, 3.4)	1.0 (0.7, 1.3)	2.2 (1.5, 3.4)
25–44	6096 (48.7)	565 (37.8)	715 (51.3)	374 (39.6)	1.5 (1.1, 2.2)	1.1 (0.8, 1.4)	1.5 (1.0, 2.3)
18–24	550 (4.4)	33 (2.2)	61 (4.4)	23 (2.4)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
<b>Race/ethnicity</b>							
Asian	1016 (8.1)	89 (6.0)	115 (8.3)	56 (5.9)	0.9 (0.7, 1.1)	1.2 (1.0, 1.4)	1.0 (0.7, 1.3)
Hispanic	1034 (8.3)	193 (12.9)	220 (15.8)	197 (20.9)	1.8 (1.5, 2.2)	2.2 (1.9, 2.6)	3.4 (2.8, 4.1)
Non-Hispanic Black	1388 (11.1)	259 (17.3)	158 (11.3)	157 (16.6)	1.8 (1.5, 2.1)	1.2 (1.0, 1.4)	2.0 (1.7, 2.4)
American Indian, Alaskan, or mixed race	317 (2.5)	61 (4.1)	56 (4.0)	41 (4.3)	1.9 (1.4, 2.5)	1.8 (1.4, 2.5)	2.3 (1.6, 3.2)
White	8776 (70.0)	893 (59.7)	844 (60.6)	493 (52.2)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
<b>Education</b>							
College or postgraduate degree	8819 (70.6)	811 (54.2)	820 (59.3)	415 (44.1)	0.5 (0.4, 0.6)	0.6 (0.5, 0.7)	0.3 (0.2, 0.3)
Some college	2045 (16.4)	376 (25.2)	313 (22.6)	259 (27.5)	1.0 (0.8, 1.2)	1.0 (0.8, 1.2)	0.8 (0.6, 0.9)
≤ high school diploma	1622 (13.0)	308 (20.6)	251 (18.1)	268 (28.5)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
<b>Pre-9/11 depression or anxiety</b>							
Yes	1091 (8.8)	118 (8.1)	193 (14.5)	103 (11.7)	0.9 (0.7, 1.1)	1.7 (1.5, 2.1)	1.4 (1.1, 1.7)
No	11 256 (91.2)	1335 (91.9)	1141 (85.5)	775 (83.3)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
<b>Current smoker, wave 2</b>							
Yes	1271 (10.2)	250 (16.7)	239 (17.2)	223 (23.7)	1.8 (1.5, 2.1)	1.8 (1.6, 2.1)	2.7 (2.3, 3.2)
No	11 229 (89.8)	1243 (83.3)	1150 (82.8)	718 (76.3)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
<b>Marital status, wave 2</b>							
Widowed, divorced, or separated	1504 (12.1)	291 (19.6)	254 (18.3)	255 (27.3)	1.8 (1.5, 2.0)	1.7 (1.4, 1.9)	2.9 (2.4, 3.4)
Never married	2627 (21.1)	282 (19.0)	289 (20.9)	186 (19.9)	1.0 (0.9, 1.1)	1.1 (0.9, 1.3)	1.2 (1.0, 1.4)
Married, living with partner	8309 (66.8)	912 (61.4)	842 (60.8)	494 (52.8)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
<b>Social support<sup>a</sup></b>							
Lower	262 (2.1)	55 (3.7)	115 (8.3)	95 (10.3)	1.8 (1.3, 2.5)	4.8 (3.8, 6.0)	6.0 (4.7, 7.7)
Higher	12 173 (97.9)	1425 (96.3)	1266 (91.7)	830 (89.7)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
<b>Recruitment</b>							
Self-identified	9570 (76.4)	1248 (83.5)	1158 (83.1)	837 (88.7)	1.6 (1.4, 1.8)	1.5 (1.3, 1.8)	2.4 (2.0, 3.0)
List identified	2961 (23.6)	247 (16.5)	235 (16.9)	107 (11.3)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
<b>Response mode, wave 2</b>							
Mail	5016 (40.0)	691 (46.2)	518 (37.2)	419 (44.4)	1.4 (1.2, 1.7)	1.5 (1.2, 1.9)	2.0 (1.6, 2.7)
Web	6022 (48.1)	660 (44.2)	774 (55.6)	464 (49.2)	1.1 (0.9, 1.4)	1.9 (1.5, 2.4)	1.9 (1.4, 2.5)
Computer-assisted telephone interview	1493 (11.9)	144 (9.6)	101 (7.3)	61 (6.5)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
<b>Dust cloud exposure<sup>b</sup></b>							
Intense	3856 (30.9)	704 (47.2)	692 (50.1)	623 (66.3)	2.1 (1.9, 2.5)	2.4 (2.1, 2.7)	4.6 (3.8, 5.6)
Some	3595 (28.8)	405 (27.2)	335 (24.3)	169 (18.0)	1.4 (1.2, 1.6)	1.2 (1.1, 1.5)	1.4 (1.1, 1.7)
None	5023 (40.3)	381 (25.6)	354 (25.6)	147 (15.7)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)

*Continued*

TABLE 1—Continued

Heavy dust exposure at home or work <sup>c</sup>							
Yes	1107 (10.2)	236 (17.8)	240 (20.2)	218 (27.1)	1.7 (1.5, 2.0)	2.0 (1.7, 2.3)	2.7 (2.3, 3.3)
No	9767 (89.8)	1090 (82.2)	951 (79.9)	587 (72.9)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)

Note. CI = confidence interval; LRS = lower respiratory symptoms; OR = odds ratio; PTSD = posttraumatic stress disorder.

<sup>a</sup>“Lower” indicates individual reported no close friends and did not visit or communicate via letters or e-mail with friends and relatives more than once a month; “higher” indicates individual reported at least 1 friend and visited or communicated at least 2–3 times per month in the previous 12 mo.

<sup>b</sup>We adjusted ORs associated with dust cloud exposure for all variables in the table except gender and heavy dust exposure at home or work.

<sup>c</sup>We adjusted ORs associated with heavy dust exposure at home or work for all variables in the table except gender.

whether there were demographic, psychiatric history, lifestyle factors, or recruitment and mode covariates that affected the odds of comorbid status differently from LRS or PTSD alone (with respect to the no LRS, no PTSD group). We considered odds ratios (ORs) with nonoverlapping confidence intervals (CIs) between the groups with comorbidity, with LRS alone, and with PTSD alone significantly different. We tested dust cloud exposure, adjusting for significant variables identified in the bivariate analyses, and heavy dust at home or work, adjusting for those variables plus dust cloud exposure. In multivariable logistic models, we tested LRS as a predictor of PTSD after adjusting for age, race/ethnicity, pre-9/11 anxiety or depression, marital status, social support, smoking status, recruitment, and mode covariates—factors associated with PTSD in the initial bivariate analysis.

We tested PTSD as a predictor of LRS, adjusting for the same variables with the exception of pre-9/11 anxiety and depression, as they were not associated with LRS in the initial bivariate analysis. For each respiratory symptom, respiratory diagnosis, and inhaler use, we used logistic regression to calculate crude ORs (CORs) and adjusted ORs (AORs), indicating the odds of reporting each measure among participants with comorbidity versus those reporting LRS alone. We adjusted for variables that were different between groups with LRS and groups with comorbidity. We conducted the Mann-Whitney 2-sample test to determine the difference in median PCL scores between individuals with and those without comorbidity with PTSD. For each mental health measure, we used logistic regression to calculate CORs and AORs for each predictor among participants with comorbidity versus those with PTSD alone, adjusting for

variables that were different between PTSD and groups with comorbidity. We tested the same models, controlling for dust at home or work (and thus limited to those with residences and offices below Chambers Street), but we have not shown the results, as they do not change. For each QOL and health care measure, we used multinomial logistic regression to compare the odds of reporting each measure across the groups with LRS, PTSD, and comorbidity in relation to the no LRS, no PTSD group. We controlled factors shown to be associated with QOL in the general population<sup>39</sup> and prevalences of diagnosed conditions between groups with and those without comorbidity. For all bivariate models, we conducted the Hosmer-Lemeshow goodness of fit test to determine significant deviation from good fit to the logistic function; all such tests were nonsignificant ( $P > .05$ ).

## RESULTS

Of the 16 363 who met inclusion criteria, 944 (5.8%) experienced comorbidity, 1495 (9.1%) met criteria for LRS alone, and 1393 (8.5%) met criteria for PTSD alone (Table 1). The group with comorbidity constituted 38.7% of all participants with LRS, 40.4% of all participants with PTSD, and 24.6% of participants with LRS, PTSD, or both.

Multinomial logistic regression analyses revealed that the odds of comorbidity versus LRS or PTSD alone (relative to no LRS, no PTSD) were higher among participants of Hispanic ethnicity; widowed, separated, or divorced; smokers; and those who self-identified into the Registry (Table 1) and were lower among the more highly educated. We found increased odds of LRS, regardless of PTSD status, for participants of older age and non-

Hispanic Black race. Factors associated with PTSD, regardless of comorbid LRS, were pre-9/11 anxiety and depression and social support. Wave 2 response mode was significantly associated with LRS, PTSD, and comorbidity, but we found the same magnitude and direction of the effect for all 3 groups.

Multinomial logistic regression revealed that participants reporting intense dust cloud exposure had higher odds of co-occurring LRS and PTSD (AOR = 4.6; 95% CI = 3.8, 5.6 vs neither condition; Table 1) than of having LRS alone (AOR = 2.1; 95% CI = 1.9, 2.5 vs neither condition) or PTSD alone (AOR = 2.4; 95% CI = 2.1, 2.7 vs neither condition). Participants who reported returning to a home or workplace with heavy dust contamination had higher odds of co-occurring LRS and PTSD (AOR = 2.7; 95% CI = 2.3, 3.3 vs neither condition; Table 1) than of having LRS alone (AOR = 1.7; 95% CI = 1.5, 2.0 vs neither condition) and PTSD alone (AOR = 2.0; 95% CI = 1.7, 2.3 vs neither condition).

Participants with LRS were 4.2 times more likely to report PTSD (AOR = 4.2; 95% CI = 3.8, 4.7; not shown in table). Participants with PTSD were 4.3 times more likely to report LRS (AOR = 4.3; 95% CI = 3.8, 4.8; not shown in table).

### Comorbidity vs Lower Respiratory Symptoms Alone

Participants with comorbidity were significantly more likely to report recurrent shortness of breath and wheezing than were participants with LRS alone (AOR = 2.6; 95% CI = 2.1, 3.2 and AOR = 1.7; 95% CI = 1.4, 2.1, respectively; Table 2). They were also significantly more likely to have ever sought treatment for shortness of breath and wheezing than were participants with LRS alone (AOR = 2.1; 95% CI = 1.7, 2.5 and AOR = 1.6; 95% CI = 1.3,

**TABLE 2—Association Between Comorbidity, Symptoms, Treatment Sought for Symptoms, Diagnosed Asthma, Chronic Bronchitis, and Inhaler Use 5–6 Years After 9/11: World Trade Center Health Registry, New York City, 2006–2007**

Variable	No LRS, No PTSD, No. (%)	PTSD Only, No. (%)	LRS Only, No. (%)	LRS and PTSD, No. (%)	LRS and PTSD vs LRS Only, AOR <sup>a</sup> (95% CI)
<b>Recurrent lower respiratory symptoms<sup>b</sup></b>					
Shortness of breath					
Yes	250 (2.0)	92 (6.7)	832 (57.1)	725 (78.4)	2.6 (2.1, 3.2)
No	12 163 (98.0)	1282 (93.3)	626 (42.9)	200 (21.6)	1.0 (Ref)
Total	12 413	1374	1458	925	
Wheezing					
Yes	121 (1.0)	53 (3.9)	469 (32.3)	433 (47.5)	1.7 (1.4, 2.1)
No	12 298 (99.0)	1312 (96.1)	984 (67.7)	479 (52.5)	1.0 (Ref)
Total	12 419	1365	1453	912	
Persistent cough					
Yes	633 (5.6)	121 (9.1)	946 (65.3)	569 (62.0)	0.9 (0.7, 1.0)
No	10 659 (94.4)	1205 (90.9)	502 (34.7)	349 (38.0)	1.0 (Ref)
Total	11 292	1326	1448	918	
<b>Ever sought treatment for</b>					
Shortness of breath					
Yes	1726 (14.0)	419 (30.7)	896 (60.8)	720 (77.3)	2.1 (1.7, 2.5)
No	10 618 (86.0)	945 (69.3)	578 (39.2)	211 (22.7)	1.0 (Ref)
Total	12 344	1364	1474	931	
Wheezing					
Yes	1067 (8.7)	229 (17.1)	671 (46.0)	536 (58.4)	1.6 (1.3, 1.9)
No	11 244 (91.3)	1114 (82.9)	787 (54.0)	382 (41.6)	1.0 (Ref)
Total	12 311	1343	1458	918	
Persistent cough					
Yes	2331 (18.7)	352 (25.4)	762 (51.3)	492 (52.5)	1.1 (0.9, 1.3)
No	10 158 (81.3)	1035 (74.6)	724 (48.7)	446 (47.5)	1.0 (Ref)
Total	12 489	1387	1486	938	
<b>Asthma and inhaler use<sup>c</sup></b>					
Diagnosed with asthma					
Yes	379 (10.5)	85 (13.2)	335 (27.9)	232 (27.9)	0.9 (0.8, 1.3)
No	3246 (89.5)	559 (86.8)	864 (72.1)	600 (72.1)	1.0 (Ref)
Total	3625	644	1199	832	
Inhaler use in the past 30 d					
Yes	369 (10.2)	73 (11.4)	370 (31.1)	275 (33.4)	1.1 (0.9, 1.4)
No	3239 (89.8)	565 (88.6)	819 (68.9)	548 (66.6)	1.0 (Ref)
Total	3608	638	1189	823	

Note. AOR = adjusted odds ratio; CI = confidence interval; LRS = lower respiratory symptoms; PTSD = posttraumatic stress disorder.

<sup>a</sup>Adjusted for age, race/ethnicity, education, smoking status, social support, pre-9/11 anxiety or depression, marital status, dust cloud exposure, recruitment, and survey mode at wave 2.

<sup>b</sup>Occurring 8 or more days in the past 30 days at wave 2.

<sup>c</sup>Post-9/11 asthma diagnoses and reported inhaler users are among those who reported ever seeking treatment of shortness of breath, wheezing, or persistent cough.

1.9, respectively) but not for reporting or seeking treatment of persistent cough. Among participants with LRS only and those with LRS and PTSD who had reported ever seeking treatment of any of the 3 symptoms, we found no differences in the odds of reporting medically diagnosed asthma (AOR = 0.9; 95% CI = 0.8,

1.3) or inhaler use in the previous month at wave 2 (AOR = 1.1; 95% CI = 0.9, 1.4).

### Comorbidity vs Posttraumatic Stress Disorder Alone

Participants with PTSD alone had a significantly lower median PCL score of 54 (Q1 = 48,

Q3 = 61) versus participants with comorbidity (median PCL score = 58; Q1 = 51, Q3 = 67) on the basis of the Mann-Whitney test ( $t = 9.8$ ;  $P < .001$ ; Table 3). Participants with comorbidity reported more PTSD symptoms after adjustment. They were more likely to report a new medical diagnosis of PTSD (AOR = 1.3;

**TABLE 3—Association Between Comorbidity, PTSD Severity, Diagnosed Mental Health Conditions, and Mental Health Treatment 5–6 Years After 9/11: World Trade Center Health Registry, New York City, 2006–2007**

Variable	No LRS, No PTSD, No. (%)	LRS Only, No. (%)	PTSD Only, No. (%)	LRS and PTSD, No. (%)	LRS and PTSD vs PTSD, AOR <sup>a</sup> (95% CI)
<b>PCL symptoms reported</b>					
Reexperiencing, no.					
5	97 (0.8)	32 (2.1)	398 (28.6)	442 (46.8)	2.0 (1.6, 2.6)
3–4	653 (5.2)	170 (11.4)	576 (41.4)	311 (32.9)	1.1 (0.9, 1.4)
1–2	3026 (24.1)	537 (35.9)	419 (30.1)	191 (20.2)	1.0 (Ref)
0	8755 (69.9)	756 (50.6)	0	0	
Total	12 531	1495	1393	944	
Avoidance, no.					
6–7	44 (0.4)	21 (1.4)	559 (40.1)	477 (50.5)	1.6 (1.3, 1.9)
5	107 (0.9)	24 (1.6)	265 (19.0)	181 (19.2)	1.4 (1.1, 1.8)
3–4	959 (7.7)	203 (13.6)	569 (40.9)	286 (30.3)	1.0 (Ref)
0–2	11 421 (91.1)	1247 (83.4)	0	0	
Total	12 531	1495	1393	944	
Arousal, no.					
5	254 (2.0)	94 (6.3)	715 (51.3)	576 (61.0)	1.4 (1.2, 1.6)
2–4	2776 (22.2)	590 (39.5)	678 (48.7)	368 (39.0)	1.0 (Ref)
0–1	9501 (75.8)	811 (54.2)	0	0	
Total	12 531	1495	1393	944	
<b>Diagnosed mental health conditions</b>					
PTSD					
Yes	1162 (9.3)	220 (14.8)	545 (40.2)	433 (47.6)	1.3 (1.1, 1.6)
No	11 311 (90.7)	1262 (85.2)	812 (59.8)	477 (52.4)	1.0 (Ref)
Total	12 473	1482	1357	910	
Depression					
Yes	1041 (9.0)	224 (16.3)	527 (44.4)	451 (55.9)	1.5 (1.2, 1.8)
No	10 510 (91.0)	1150 (83.7)	660 (55.6)	356 (44.1)	1.0 (Ref)
Total	11 551	1374	1187	807	
Anxiety disorder					
Yes	788 (6.6)	153 (10.8)	413 (32.5)	358 (41.7)	1.4 (1.1, 1.7)
No	11 169 (93.4)	1266 (89.2)	858 (67.5)	500 (58.3)	1.0 (Ref)
Total	11 957	1419	1271	858	
<b>Nonspecific psychological distress</b>					
Severe	283 (2.3)	104 (7.0)	534 (38.6)	525 (56.3)	2.6 (2.0, 3.4)
Moderate	1571 (12.6)	377 (25.5)	575 (41.6)	314 (33.7)	1.5 (1.2, 2.0)
None to mild	10 572 (85.1)	997 (67.5)	273 (19.8)	94 (10.1)	1.0 (Ref)
Total	12 426	1478	1382	933	
<b>Mental health treatment</b>					
Medication for mental or emotional condition					
Yes	1345 (10.8)	177 (11.9)	445 (32.0)	364 (38.8)	1.3 (1.1, 1.6)
No	11 128 (89.2)	1312 (88.1)	947 (68.0)	575 (61.2)	1.0 (Ref)

Continued

TABLE 3—Continued

Total	12 743	1489	1392	939	
Talked to a professional for mental or emotional problem					
Yes	2150 (17.2)	269 (18.1)	591 (42.5)	418 (44.6)	1.1 (0.9, 1.3)
No	10 340 (82.8)	1220 (81.9)	799 (57.5)	519 (55.4)	1.0 (Ref)
Total	12 490	1489	1390	937	

Note. AOR = adjusted odds ratio; CI = confidence interval; LRS = lower respiratory symptoms; PCL = PTSD Checklist-Civilian Version; PTSD = posttraumatic stress disorder. Median PCL score (Q1, Q3): for No LRS, No PTSD = 24 (20, 31); for LRS only = 31 (24, 38); for PTSD only = 54 (48, 61); and for LRS and PTSD = 58 (51, 67).

<sup>a</sup>Adjusted for age, race/ethnicity, education, smoking status, marital status, dust cloud exposure, recruitment, and mode at wave 2.

95% CI = 1.1, 1.6), depression (AOR = 1.5; 95% CI = 1.2, 1.8), or anxiety (AOR = 1.4; 95% CI = 1.1, 1.7); have symptoms of severe nonspecific psychological distress (AOR = 2.6; 95% CI = 2.0, 3.4); and report medication use for a mental or emotional condition than were those participants with PTSD alone (AOR = 1.3; 95% CI = 1.1, 1.6). They were not more likely to report talking to a professional for a mental or emotional problem in the prior year.

### Quality of Life

Participants with comorbidity reported fair or poor health significantly more often (AOR = 8.6; 95% CI = 7.2, 10.2). This association was less pronounced but still significant among participants with LRS alone (AOR = 3.6; 95% CI = 3.1, 4.2) and those with PTSD alone (AOR = 3.4; 95% CI = 2.9, 3.9). Participants with comorbidity were between 6 and 10 times more likely to report at least 14 days of poor physical or mental health during the previous month (Table 4). Participants with comorbidity were significantly more likely to report unmet health care needs than were those with LRS or PTSD alone (Table 4). All 3 groups reported significantly greater unmet health care needs than did enrollees with neither condition.

### DISCUSSION

Five to 6 years after the 9/11 attacks more than one fourth of participants who either reported new onset LRS or screened positive for 9/11-related PTSD had both conditions. Enrollees with comorbidity comprised approximately 6% of the total study population, far greater than the expected probability of

co-occurring LRS and PTSD if the 2 conditions had been independent (approximately 2%).

Co-occurrence of LRS and PTSD arises in part from shared risk factors, including 9/11-related exposures. Participants with severe dust cloud and heavy dust exposure in the home or workplace after 9/11 had greater risk for co-occurring LRS and PTSD than for LRS or PTSD alone, independent of demographic risk factors. In previous studies, asthma and PTSD have been separately linked to dust cloud exposure and heavy damage at home or work,<sup>6</sup> and risk for psychopathology was greater the closer individuals were to the disaster.<sup>40</sup>

Our observations also suggest, however, that LRS and PTSD are closely associated, independent of shared risk factors. Even after controlling for demographics and 9/11-related exposures, participants with LRS were more than 4 times more likely to have met criteria for PTSD, and participants with PTSD were more than 4 times more likely to have met criteria for LRS. Although the rates of reporting shortness of breath and wheezing as well as treatment sought for these symptoms were significantly greater among participants who met criteria for both LRS and PTSD than LRS alone, the prevalence of medically diagnosed asthma was the same between the 2 groups. We also observed that comorbid LRS among those with PTSD is associated with worse mental health status, as indicated by a greater likelihood of severe nonspecific psychological distress (a measure predictive of *DSM-IV* mood or anxiety disorders<sup>37</sup>) and comorbid diagnosed mental health conditions, such as depression and anxiety, independent of demographics, lifestyle, and 9/11 disaster exposures.

Our results are consistent with past studies on PTSD and physical health and more broadly with the growing body of literature illustrating the close association between trauma, mental health, and physical illness. Gulf War veterans,<sup>22,25</sup> Australian Vietnam veterans,<sup>23</sup> and primary care patients with PTSD<sup>27-29</sup> have a greater risk for physical illness, independent of trauma severity. Asthmatics with PTSD in the 6 months after 9/11 in New York City were more likely to report more severe illness and seek treatment more frequently for their symptoms<sup>41</sup> than were those without. Several reports in veteran and non-veteran populations also indicate that physical illnesses, including respiratory illnesses, are associated with reduced mental health status.<sup>16,17,42-44</sup>

Previous studies have provided support for a physiologic link between stress physiology and respiratory illness.<sup>45</sup> Relatively recent studies have discovered neural circuitry linking emotional states with exacerbation of asthma symptoms.<sup>46,47</sup> Although our observations are consistent with these findings, we lack sufficient evidence to draw meaningful conclusions regarding the causal relationship between LRS and PTSD. Their association could to a certain extent be related to somatization, a feature of PTSD. LRS and PTSD could also be associated via other comorbid mental health conditions, such as anxiety or mood disorder<sup>47,48</sup> and particularly panic disorder, in which shortness of breath is a diagnostic feature.<sup>49</sup> Additional studies with more detailed clinical assessments are clearly required.

Participants with comorbidity have worse QOL, a powerful predictor of premature mortality,<sup>50</sup> and more unmet health care needs

**TABLE 4—Quality of Life and Self-Reported Unmet Health Care Needs Among Participants With LRS or PTSD 5–6 Years after 9/11: World Trade Center Health Registry, New York City, 2006–2007**

Variable	None, No. (%)	LRS Only, No. (%)	PTSD Only, No. (%)	LRS and PTSD, No. (%)
<b>General health</b>				
Fair or poor	1052 (8.4)	472 (31.8)	413 (30.0)	556 (59.7)
Good, very good, or excellent	11 399 (91.6)	1013 (68.2)	964 (70.0)	376 (40.3)
Total	12 451	1485	1377	932
AOR <sup>a</sup>	1.0 (Ref)	3.6 (3.1, 4.2)	3.4 (2.9, 3.9)	8.6 (7.2, 10.2)
<b>Physical health not good, d</b>				
≥ 14	896 (7.2)	422 (28.7)	279 (20.3)	422 (45.6)
< 14	11 518 (92.8)	1047 (71.3)	1095 (79.7)	504 (54.4)
Total	12 414	1469	1374	926
AOR <sup>a</sup>	1.0 (Ref)	3.9 (3.3, 4.5)	2.4 (2.0, 2.8)	5.9 (4.9, 7.0)
<b>Mental health not good, d</b>				
≥ 14	1070 (8.6)	341 (23.8)	657 (47.8)	609 (65.6)
< 14	11 322 (91.4)	1131 (76.8)	718 (52.2)	320 (34.5)
Total	12 392	1472	1375	929
AOR <sup>a</sup>	1.0 (Ref)	2.7 (2.4, 3.2)	5.5 (4.8, 6.4)	10.0 (8.4, 11.9)
<b>Activity lost because of poor health, d</b>				
≥ 14	414 (3.5)	207 (14.2)	296 (21.6)	390 (42.0)
< 14	11 401 (96.5)	1250 (85.8)	1073 (78.4)	538 (58.0)
Total	11 815	1457	1369	928
AOR <sup>a</sup>	1.0 (Ref)	3.2 (2.6, 3.8)	4.4 (3.7, 5.3)	8.6 (7.1, 10.5)
<b>≥ 1 unmet health care need</b>				
Yes	1306 (10.5)	279 (18.8)	406 (29.3)	376 (40.0)
No	11 181 (89.5)	1208 (81.2)	979 (70.7)	564 (60.0)
Total	12 487	1487	1385	940
AOR <sup>a</sup>	1.0 (Ref)	1.9 (1.6, 2.2)	2.9 (2.6, 3.4)	4.5 (3.8, 5.3)
<b>Unmet outpatient needs</b>				
Yes	408 (31.2)	103 (37.1)	128 (31.5)	119 (31.7)
No	898 (68.8)	175 (63.0)	278 (68.5)	257 (68.4)
Total <sup>b</sup>	1306	278	406	376
AOR <sup>a</sup>	1.0 (Ref)	1.4 (1.1, 2.0)	1.1 (0.8, 1.4)	1.4 (1.0, 1.8)
<b>Unmet mental health counseling needs</b>				
Yes	236 (18.1)	49 (17.6)	196 (48.3)	193 (51.3)
No	1070 (81.9)	230 (82.4)	210 (51.7)	183 (48.7)
Total	1306	279	406	376
AOR <sup>a</sup>	1.0 (Ref)	1.0 (0.7, 1.4)	3.0 (2.3, 4.0)	3.2 (2.4, 4.4)

Note. AOR = adjusted odds ratio; LRS = lower respiratory symptoms; PCL = PTSD Checklist-Civilian Version; PTSD = posttraumatic stress disorder.

<sup>a</sup>Adjusted for age, education, race/ethnicity, smoking status, marital status, social support, recruitment, wave 2 mode, and the following medically diagnosed conditions: asthma, PTSD, depression, and anxiety.

<sup>b</sup>Total for LRS only excludes “don’t know” answers.

than do those with LRS or PTSD alone and thus constitute a uniquely vulnerable population. That more than half of participants with comorbidity report unmet health care needs likely puts them at significant risk for worsening

symptoms, greater morbidity, and, possibly, mortality. Proportionately similar numbers of participants with comorbidity and those with PTSD alone reported talking to a professional for a mental or emotional problem, but more

participants with comorbidity reported an unmet need for mental health counseling, perhaps indicating lack of access to mental health care sufficient to meet the severity of illness.

### Limitations

There are several limitations to this study. Seventy percent of participants were self-identified, and those with illness might have been more likely to enroll in the Registry. We lack objective measures on the severity and scope of respiratory symptoms and medical records to validate the reported diagnoses. However, in a nested case control study in this cohort, Friedman et al. found a strong association between reported LRS and lower airway dysfunction as measured objectively via impulse oscillometry.<sup>51</sup> The PCL has good psychometric properties but is not a substitute for a clinical diagnosis. Although we excluded pre-9/11 PTSD diagnoses, we cannot rule out unreported PTSD, particularly among those with pre-9/11 depression and anxiety.

We did not examine symptomatic individuals who did not meet full criteria for LRS or PTSD. Exposure assessment occurred several years after the event, and so symptomatic individuals might have recalled event-related exposures differently from asymptomatic individuals. We did not have good measures for the timing and frequency of treatment sought for symptoms. However, we used nationally validated questions, and conditions requiring diagnosis and regular treatment usually have the strongest correspondence between self-report and medical record.<sup>52</sup> Moreover, the overall pattern of reporting, particularly on respiratory symptoms and diagnoses, suggests participants did not indiscriminately overreport symptoms and conditions.

### Conclusions

These limitations notwithstanding, our results highlight the close association between physical and mental health problems among individuals exposed to 9/11. It is especially important to consider that for 9/11 survivors, respiratory symptoms not readily ascribed to an organic disease might in fact be linked to PTSD or another comorbid mental illness. Particularly for 9/11 survivors, these observations underscore the limitations of the single-disease

model<sup>15,53</sup> and highlight the importance of addressing mental illness when conducting public health outreach or treatment of respiratory illness and vice versa. The Registry has expanded outreach efforts to specifically provide health care referrals to individuals with comorbidity. Clinicians have also been encouraged to closely consider mental health status when diagnosing and treating respiratory illness among people exposed to 9/11 as practiced by the 9/11 Centers of Excellence.<sup>54</sup> ■

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This article was accepted January 11, 2012.

### Contributors

H. P. Nair, C. C. Ekenga, and S. D. Stellman designed the study. H. P. Nair analyzed the data. C. C. Ekenga contributed to the SAS coding of the data. R. M. Brackbill participated in establishing and designing the Registry. All authors assisted in interpreting the results and writing the article.

### Acknowledgments

This study was supported by the Agency for Toxic Substances and Disease Registry of the Centers for Disease Control and Prevention (cooperative agreement U50/ATU272750), the National Center for Environmental Health, and the New York City Department of Health and Mental Hygiene.

The authors would like to sincerely thank Laura DiGrande, DrPH, MPH, Lorna Thorpe, PhD, Thomas Matte, MD, MPH, Carey Maslow, DrPH, Alice Welch, DrPH, Hannah Jordan, MD, MPH, Carolyn Green, MD, James Hadler, MD, and Christina Norman, PhD, for their valuable comments on this article.

### Human Participant Protection

Registry protocols were approved by the institutional review boards of the Centers for Disease Control and Prevention and the New York City Department of Health and Mental Hygiene.

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