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The Relationship Between Post-Traumatic Stress Disorder and Self-Management Behaviors in World Trade Center Workers with Asthma

Juan P. Wisnivesky, MD, PhD[a,b], **Jacqueline H. Becker, PhD**[a], **Jyoti Ankam, MBBS, MPH**[a], **Steven B. Markowitz, MD, PhD**[c], **Molly Doernberg, MPH**[a], **Brittany Dickens, BA**[c], **Paula Busse, MD**[d], **Laura Crowley, MD**[e], **Alex Federman, MD, MPH**[a], **Craig Katz, MD**[f], **Jeffrey J. Weiss, PhD**[a,f], **Adam Gonzalez, PhD**[g], **New York, Queens, and Stony Brook, NY**

[a]Division of General Internal Medicine, Icahn School of Medicine at Mount Sinai, New York, NY

[b]Division of Pulmonary and Critical Care Medicine, Icahn School of Medicine at Mount Sinai, New York, NY

[c]Barry Commoner Center for Health and the Environment, Queens College, City University of New York, Queens, NY

[d]Division of Allergy and Immunology, Icahn School of Medicine at Mount Sinai, New York, NY

[e]Department of Environmental Medicine and Public Health, Icahn School of Medicine at Mount Sinai, New York, NY

[f]Department of Psychiatry, Icahn School of Medicine at Mount Sinai, New York, NY

[g]Department of Psychiatry and Behavioral Health, Renaissance School of Medicine, Stony Brook University, Stony Brook, NY

Abstract

BACKGROUND: Comorbid posttraumatic stress disorder (PTSD) is highly prevalent and associated with increased morbidity among World Trade Center (WTC) rescue and recovery workers with asthma. However, the potential behavioral pathways underlying this relationship remain unclear.

OBJECTIVE: To evaluate whether PTSD is associated with lower adherence to asthma self-management behaviors among WTC workers with asthma.

METHODS: We used data from a prospective cohort of WTC workers with a physician diagnosis of asthma who were prescribed controller medications. Presence of comorbid PTSD was determined based on structured clinical interviews. Asthma self-management behaviors included medication adherence, inhaler technique, use of action plans, and trigger avoidance. We conducted

Corresponding author: Juan P. Wisnivesky, MD, PhD, 1 Gustave Levy Pl., Box 1087, New York, NY 10029. juan.wisnivesky@mssm.edu. 2213-2198.

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unadjusted and multiple regression analyses to evaluate the association of PTSD with asthma self-management.

RESULTS: Overall, 30% of 276 WTC workers with asthma had comorbid PTSD. Posttraumatic stress disorder was associated with worse asthma control and poorer quality of life. However, PTSD was not significantly associated with medication adherence (odds ratio [OR] −0.15; 95% confidence interval [CI] −0.5 to 0.2), inhaler technique (OR −0.12; 95% CI −0.7 to 0.5), use of action plans (OR 0.8; 95% CI 0.4 to 1.8), or trigger avoidance (OR 0.9; 95% CI 0.4 to 1.8).

CONCLUSIONS: We did not find significant differences in key asthma self-management behaviors between WTC workers with and without PTSD. These results suggest that other mechanisms, such as differences in symptom perception or inflammatory pathways, may explain the association between PTSD and increased asthma morbidity.

Keywords

PTSD; WTC; 9/11; Asthma; Self-management

INTRODUCTION

Posttraumatic stress disorder (PTSD) has been consistently reported as a major determinant of asthma morbidity among rescue and recovery workers and other populations exposed to the debris generated by the collapse of the World Trade Center (WTC) towers.[1–3] Epidemiological studies have shown that up to one-third of WTC-exposed populations with asthma have comorbid PTSD.[4,5] Among WTC workers, PTSD has been associated with increased risk for airway hyperactivity, worse asthma control, worse quality of life, and increased risk of emergency room visits and hospitalizations.[6]

While the substantial negative impact of PTSD on asthma outcomes in WTC workers has been explored, the underlying mechanisms remain unclear. Several complex self-management behaviors such as medication adherence, inhaler technique, use of action plans, and trigger avoidance are key determinants of asthma control.[7,8] Unfortunately, the literature consistently shows that up to one-half of patients, including WTC workers with asthma, are nonadherent to their medication regimens.[9,10] Patients also frequently have difficulty performing all the tasks required for correct inhaler use, despite the critical nature of proper inhaler technique for adequate medication delivery.[11] Allergen avoidance is similarly only adhered to by a subset of patients, making environmental exposures that can trigger asthma symptoms and/or exacerbations more common, particularly in atopic patients.[9] Given the known association between lower rates of self-management behaviors and mental health conditions,[12–14] it is possible that lower adherence to asthma self-management may explain, in part, the relationship between PTSD and worse asthma control. Immunological mechanisms may also explain the relationship between PTSD and asthma control.

Posttraumatic stress disorder has been strongly associated with low treatment adherence in multiple chronic diseases.[15–18] However, there are limited data on the relationship between PTSD and asthma self-management behaviors in the general population or among WTC workers. It is possible that those with PTSD have different health beliefs about asthma or

emotional responses to the disease, factors that, according to the Self-Regulation Model (SRM), can be strong determinants of self-management behaviors.[19] The SRM provides a helpful framework to identify factors that may influence low treatment adherence in individuals with PTSD. According to the model, patients with chronic illness, like asthma, compare their somatic sensations (ie, symptoms) with their normal self, and interpret deviations from normal in relation to their mental model of their illness (based on cognitive representations of illness), which in turn guides their self-management behaviors. Emotional responses to asthma (ie, worry, upset, or anxious) also influence self-management according to the SRM. The framework of the SRM is highly useful for identifying the modifiable beliefs and emotional mechanisms, which underlie behaviors worth targeting for self-management support interventions. Accordingly, in this study, we used data from a well-characterized cohort of WTC workers to understand the potential mechanisms underlying worse asthma outcomes by evaluating the association of PTSD with asthma self-management.

METHODS

Study population and recruitment procedures

The study utilized data from a cohort of WTC rescue and recovery workers with a physician diagnosis of asthma, recruited from Mount Sinai Hospital or North Shore−Long Island Jewish Health System sites of the World Trade Center Health Programs (WTCHP) Clinical Centers of Excellence. To be eligible for the WTCHP, responders must have worked or volunteered at the WTC site for 4 or more hours from September 11 to 14, 2001, 24 or more hours during September 2001, or 80 or more hours from September to December 2001. Members of the Office of the Chief Medical Examiner who processed human remains and workers from the Port Authority Trans Hudson Corporation who were engaged in cleaning tunnels for 24 or more hours from September 11, 2001, to July 1, 2002, were also eligible. The WTCHP has been previously described in the literature.[1,5,6]

Eligibility for the current study included age 18 years or older, physician diagnosis of asthma, being prescribed at least 1 asthma controller medication, and English or Spanish speaking. We excluded WTC workers with preexisting history of chronic obstructive pulmonary disease (COPD), 15 or more pack-years of tobacco exposure (because of potential undiagnosed COPD), or other chronic respiratory illness.

We identified potentially eligible WTC workers from a list provided by the WTCHP of participants who had expressed willingness to be contacted for research. An invitation letter was mailed and workers were later contacted by research staff. Those interested in participating signed an informed consent, underwent screening to confirm eligibility, and were scheduled for an in-person interview. Surveys were in English or Spanish based on participant’s preference. The study was approved by the institutional review boards of the Icahn School of Medicine at Mount Sinai and Queens College, City University of New York.

Study variables

Data about participants' baseline sociodemographic characteristics (age; sex; race and ethnicity; education; income; and marital status) were collected using validated items from national surveys.[20] Information regarding smoking behaviors and comorbidities was obtained by self-report. Level of exposure at the WTC site was categorized using a published classification.[3] To characterize asthma in study participants, we collected age at diagnosis and relationship of onset with WTC exposure, history of intubation, allergies, medication regimen, use of oral steroids, and emergency room visits or hospitalizations due to asthma in the prior 12 months.

Asthma control and quality of life.—Asthma control was evaluated using the Asthma Control Questionnaire, which has been shown to be a valid and reliable measure, with strong psychometric properties for clinical and research use.[21] This 7-item tool captures symptoms and activity limitations over the prior week.[22] The total score is the mean of the 7 items and ranges from 0 (totally controlled) to 6 (severely uncontrolled), with a score of 1.5 or more points indicating not well-controlled asthma.[23] The Asthma Quality of Life Questionnaire has demonstrated reliability and construct validity for assessing quality of life in adults with asthma.[24] This 32item measure includes 4 domains: physical, emotional, social and occupational. Scores range from 1 to 7, with higher scores indicating better quality of life.[24,25] A score of less than 4.7 indicates poor quality of life.

Structured clinical interview for Diagnostic and Statistical Manual for Mental Disorders.—Presence or absence of PTSD was determined based on results of the Structured Clinical Interview for Diagnostic and Statistical Manual for Mental Disorders−Clinician Version Five (SCID-5-CV). We also administered the mood disorders module to determine the presence of major depressive disorder. The SCID-5-CV is the gold standard for psychiatric diagnosis obtained for research, is well validated, and was administered by research staff with prior background in psychology (ie, psychology graduate students who underwent standardized training by a clinical psychologist). Several studies have confirmed it has excellent reliability, high specificity, and clinical validity in identifying PTSD and major depressive disorder.[26,27]

Study outcomes

Primary study outcomes included adherence to asthma controller medications, inhaler technique, use of asthma action plans, trigger avoidance, and influenza vaccination. These are considered critical self-management behaviors, are recommended by current national asthma management guidelines, and have been associated with outcomes.

Medication adherence is one of the most important asthma self-management behaviors and, thus, was assessed using 2 validated tools, as described later.

Medication Adherence Reporting Scale.—The Medication Adherence Reporting Scale (MARS) is a 10-item self-reported medication adherence scale that has been adapted to inhaled medications and has been validated against objective measures on electronic

devices.[28] The scale was developed using neutral language to avoid social desirability reporting bias. A score greater than 4.5 is considered a marker of good adherence.[28]

Adherence Starts with Knowledge-12.—The Adherence Starts with Knowledge-12 (Ask-12) is a 12-item self-report questionnaire developed to identify patient-specific barriers to medication adherence within 3 domains: inconvenience/forgetfulness, treatment beliefs, and behavior. Items are scored on a 5-point scale, and total scores range from 12 to 60, with higher scores representing greater adherence barriers.[29]

Inhaler technique was assessed by a trained research coordinator using a validated scale.[30–32] Participants who correctly completed more than 75% of the steps were categorized as demonstrating good technique. Use of asthma action plans was evaluated with an item from prior studies that asks, “How often do you use your asthma action plan to help you decide what to do when your asthma gets worse?”[25] Trigger avoidance behaviors included use of pillow and mattress covers; washing sheets in hot water; keeping windows closed and using an air conditioner during the allergy season; smoking avoidance; avoiding house pets; removal of carpets, curtains, and drapes; and elimination of cockroaches. Adherence to these recommended behaviors (≥5) were evaluated using items from the National Asthma Survey.[33] Annual influenza vaccination is recommended for all patients with asthma[34]; thus, we collected self-reported data regarding vaccination during the prior influenza season.

Illness and medication beliefs are strong predictors of self-management behaviors in patients with asthma.[19,35] These beliefs are modifiable and can be influenced by the presence of mental health conditions such as PTSD.[9] We used the SRM as a framework to assess potential associations of PTSD with health beliefs. The Brief Illness Beliefs Questionnaire measures asthma-related beliefs among WTC workers.[36] This validated scale was expanded with WTC-specific items from a prior study.[3] Beliefs about asthma medications were assessed using the Asthma Beliefs About Medicines Questionnaire, a 10-item validated tool assessing medication necessity and concerns.[37]

Statistical analysis

Baseline characteristics of WTC workers with asthma and with and without PTSD were compared using a *t* test, Wilcoxon test, or chi-square test, as appropriate. We compared unadjusted MARS, Ask-12, and inhaler technique scores according to the presence or absence of PTSD using a *t* test. Rates of adherence to controller medication (based on the MARS cut-off of >4.5), good inhaler technique, use of asthma action plans, trigger avoidance, and influenza vaccination were compared among WTC workers with and without PTSD using a chi-square test.

Linear regression assessed the adjusted association between PTSD with medication adherence and inhaler technique scores, controlling for age, sex, race and ethnicity, education, socioeconomic status, asthma onset (pre- vs post-WTC exposure), and presence or absence of comorbid depression. Mean difference in scores (with 95% CI) between WTC workers with and without PTSD was calculated based on estimated beta coefficients. The adjusted association between PTSD and rates of medication adherence, good inhaler

technique, use of asthma action plans, trigger avoidance, and influenza vaccination in WTC workers was evaluated using logistic regression. We compared Brief Illness Beliefs Questionnaire and Asthma Beliefs About Medicines Questionnaire responses in WTC workers with and without PTSD using a *t* test and calculated Cohen effect sizes (0.2 small, 0.5 medium, 0.8 high effect). We used multiple imputation methods to address missing data. Sample size calculations showed that, with a sample size of 250 participants, the study had greater than 80% power to detect a difference of 0.5 or greater units in medication adherence (MARS) scores assuming an SD of 1 unit. Analyses were performed using SAS 9.4 (SAS, Inc., Cary, NC) statistical software, using 2-sided *P* values.

RESULTS

Between February 2017 and January 2020, we contacted potential participants; of these, 177 were found ineligible during screening (23% reported no history of asthma, 23% had a history of COPD, 14% were non−English or −Spanish speakers, and 39% due to other reasons) and 360 eligible WTC workers were enrolled into the study. Of these 360 WTC workers, 3 were found to be ineligible after enrollment, 13 withdrew after recruitment, 52 were excluded because they were not prescribed a controller medication, and 16 did not complete the SCID-5-CV assessment and were excluded. Our final cohort included 276 WTC workers with asthma who were prescribed at least 1 controller medication.

Overall, 84 (30%) WTC workers in the study had PTSD based on SCID-5-CV results (Table I). A greater percentage of WTC workers with PTSD had very poorly controlled asthma (69% vs 46%; $P = .001$) and poorer asthma-related quality of life (60% vs 30%; $P < .0001$), whereas a greater percentage of those without PTSD had well-controlled asthma (35% vs 17%; $P = .001$). Posttraumatic stress disorder was also associated with greater acute resource utilization (28% vs 11%; $P = .0006$), and greater prevalence of comorbid major depression (64% vs 10%; $P < .0001$).

Unadjusted analyses showed no significant differences in medication adherence based on MARS scores in WTC workers with or without PTSD (34% vs 41%; $P = .4$; Table II). However, Ask-12 scores showed lower rates of adherence among WTC workers with versus without PTSD (24.0 ± 5.9 vs 22.1 ± 5.5, respectively; $P = .01$). Inhaler technique scores (6.6 ± 1.7 vs 6.5 ± 1.6; $P = .6$) as well as the proportion of WTC workers who showed adequate technique (80% vs 75%; $P = .4$) were not significantly different among the 2 groups. Similarly, we found no significant differences in the proportion of WTC workers who used an asthma action plan (49% vs 42%; $P = .2$), avoided asthma triggers (55% vs 47%; $P = .2$) or received the influenza vaccine (62% vs 59%; $P = .7$) in those with or without PTSD.

Adjusted analyses showed that PTSD was not associated with MARS scores (mean difference −0.15; 95% CI −0.5 to 0.2), percentage adherence based on MARS scores of 4.5 or greater (odds ratio [OR] 2.5; 95% CI 0.9 to 6.8), or Ask-12 scores (mean difference 1.7; 95% CI −0.3 to 3.6; Table III) after controlling for age, sex, race and ethnicity, education, income, asthma onset pre-vs post-9/11, depression, and other comorbidities. Similarly, WTC workers with and without PTSD did not have significant differences in inhaler technique

scores (mean difference −0.11; 95% CI −0.7 to 0.5) or in odds of showing an adequate inhaler technique (OR 0.9; 95% CI 0.4 to 2.3). Use of asthma action plans (OR 0.8; 95% CI 0.4 to 1.8), trigger avoidance (OR 0.9; 95% CI 0.4 to 1.8), and influenza vaccination (OR 0.7; 95% CI 0.3 to 1.5) were not significantly different according to PTSD status after controlling for potential confounders.

Whereas self-management was similar in both groups, we evaluated potential differences in illness and medication beliefs known to be associated with adherence among WTC workers with and without PTSD (Table IV). The WTC workers with PTSD were significantly more likely to have emotional responses to their asthma, such as reporting that thinking about asthma makes them sad (4.5 vs 1.4; $P < .0001$), worried about their future (3.0 vs 2.3; $P < .0001$), feeling that nothing will ever improve their asthma (4.6 vs 2.6; $P < .0001$), and reporting that asthma affects them emotionally (5.6 vs 2.9; $P < .0001$). They also were more likely to report asthma consequences, such as that asthma affects their lives (6.3 vs 4.8; $P = .0001$) and they experience a lot of asthma symptoms (5.9 vs 5.2; $P = .04$). Beliefs about medication necessity (3.1 vs 2.9; $P = .1$) and concerns (3.0 vs 2.9; $P = .2$) were not significantly different in those with or without PTSD.

DISCUSSION

Posttraumatic stress disorder is a major risk factor for poor asthma control and increased resource utilization among WTC workers with asthma. In this study, we evaluated whether differences in adherence to guideline-recommended self-management behaviors may explain this association. Consistent with prior studies, we found that many participants reported low rates of asthma controller adherence and other self-management behaviors[38–42]; however, the rates of controller medication adherence, use of action plans, and trigger avoidance were not statistically different between WTC workers with and without PTSD. Inhaler technique was also not significantly different across groups. These results suggest that other mechanisms may lead to worse asthma morbidity in WTC workers with PTSD.

Accordingly, we also found that WTC workers with PTSD reported different illness beliefs. In particular, WTC workers with PTSD were significantly more likely to be emotionally affected by their asthma. They also were more likely to report feeling a lack of control over their health and worried about their future because of their asthma. According to the SRM and empirical data, disease beliefs are strong modifiable predictors of self-management adherence.[19] Thus, these data can help physicians identify and address potential barriers to medication adherence in WTC workers with asthma. In addition, these beliefs could be the target of behavioral interventions to improve asthma self-management, given that almost half of participants reported low adherence to self-management.

Long-term follow-up studies show that approximately one-third of workers exposed to WTC contaminants developed asthma, and thus, achieving good control of symptoms and decreasing exacerbations are important goals for improving the health of this population. Many WTC workers with asthma have comorbid PTSD, which remains a major risk factor for increased asthma morbidity.[4,6,43] Self-management behaviors are a frequent focus of behavioral and/or educational interventions to improve outcomes of patients with chronic

diseases such as asthma.[44] In addition, PTSD has been linked to lower self-management adherence in several chronic diseases,[45,46] raising concern about its potential role in WTC workers with asthma. A study by the WTC Health Registry Cohort evaluated the relationship between mental health conditions (including depression, PTSD, or anxiety), adherence to asthma medications, and asthma control.[47] The presence of any mental health condition was associated with lower adherence scores, which is consistent with prior studies showing a strong association between depression and asthma controller medication adherence.[47] Conversely, we did not find a relationship between PTSD and medication adherence; however, we controlled for depression in our study, which may explain the differences in findings from prior studies.[5,12] Regardless, both studies showed that self-management is unlikely to explain the association between PTSD and asthma control, suggesting that other mechanisms should be considered in future research.

There is a growing literature about the important role played by symptom perception among patients with asthma.[48–50] Delays in seeking care for worsening asthma due to symptom under-perception has been proposed as a potential risk factor for emergency room visits or hospitalizations. Asthma symptom under-perception has also been linked to decreased adherence to chronic controller medications.[50–52] Conversely, overperception of asthma symptoms can lead patients to interpret and report that their disease is poorly controlled.[53] Prior studies have found that PTSD is more strongly associated with self-reported (eg, Asthma Control Questionnaire scores) compared with objective (eg, lung function) measures of asthma control.[54,55] Thus, it is possible that overperception may partially mediate the relationship between PTSD and asthma morbidity.

Posttraumatic stress disorder has a multisystem impact, leading to changes in the hypothalamic-pituitary axis, the immunological system, and the autonomic nervous system.[56] Indeed, prior studies have shown persistent, systemic low-grade inflammation in patients with PTSD.[57] Increased airway inflammation is the hallmark of asthma, with levels of sputum eosinophilia correlating with asthma symptoms, level of control, and exacerbations. Posttraumatic stress disorder may modulate the airway inflammatory response, suggesting a potential mechanism for the association between these conditions. Thus, a better understanding of potential differences in airway inflammatory markers in asthma patients with and without PTSD may unveil new therapeutic targets for these patients. The autonomic nervous system imbalance typically described in patients with PTSD is characterized by decreased parasympathetic activation coupled with a hyperactive sympathetic nervous system.[58,59] Given that these changes should induce bronchodilation, it is unlikely that autonomic nervous system dysregulation explains the association between PTSD and decreased asthma control.

Our study has a number of strengths and limitations. We used detailed data from a cohort of WTC workers with asthma who underwent extensive in-person interviews. Posttraumatic stress disorder was diagnosed using the SCID-5-CV, the gold standard for psychiatric interviews in research. We used validated instruments to evaluate a broad range of self-management behaviors that are recommended by current guidelines and have been linked to asthma outcomes. However, these measures were based on self-report and, thus, may be subject to reporting and social desirability biases. Participant bias is also possible because

there may have been systematic differences among WTC workers who were willing to participate in our study compared with those who declined enrollment. We limited our study to WTC workers who are part of the general WTC responder cohort. Consequently, our finding may not be representative to other populations exposed at the WTC site, including local residents, firefighters, and other service members.

The lack of pulmonary function assessments and biomarkers are additional limitations to our study. Whereas we had a relatively robust sample of participants, we may have lacked power to detect small differences in adherence among WTC workers with and without PTSD.

In summary, our study showed that PTSD was not associated with adherence rates to key self-management behaviors in WTC workers with asthma. These findings suggest that behavioral pathways are unlikely to explain the relationship between PTSD and increased asthma morbidity. Nevertheless, we found that many WTC workers were not adherent to asthma self-management, suggesting a potential target for future interventions to improve asthma control.

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Abbreviations used

ASK-12	Adherence Starts with Knowledge-12
COPD	Chronic obstructive pulmonary disease
MARS	Medication Adherence Rating Scale
PTSD	Posttraumatic stress disorder
SCID-5-CV	Structured Clinical Interview for Diagnostic and Statistical-5—Clinician Version
SRM	Self-Regulation Model
WTC	World Trade Center
WTCHP	World Trade Center Health Program

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What is already known about this topic?

Posttraumatic stress disorder (PTSD) is associated with increased asthma morbidity in World Trade Center (WTC) workers, but the underlying pathways are unknown.

What does this article add to our knowledge?

We found that self-management behaviors are not different in WTC workers with and without PTSD, suggesting that other factors, such as symptom perception or immunological pathways, may explain this relationship.

How does this study impact current management guidelines?

This study points to the need for additional research evaluating biological differences in WTC workers with asthma and PTSD.

TABLE I.

Characteristics of WTC workers with asthma with and without PTSD

Characteristic	No PTSD (n = 192)	PTSD (n = 84)	*P* value
Age, y, mean (SD)	56.4 (7.9)	53.7 (8.2)	.009
Female, n (%)	47 (25)	26 (31)	.2
Race and ethnicity, n (%)			.1
White	63 (33)	23 (27)	
Black	50 (26)	15 (18)	
Hispanic	57 (30)	31 (37)	
Other	22 (11)	15 (18)	
Married, n (%)	118 (62)	41 (52)	.1
Education, (%)			.7
High school or less	54 (29)	21 (27)	
Some college or college graduate	135 (71)	58 (73)	
Income, n (%)			.002
≤$3,000/mo	46 (27)	32 (46)	
>$3,000/mo	127 (73)	37 (54)	
WTC exposure, n (%)			.2
Low	17 (12)	4 (7)	
Intermediate	93 (67)	35 (60)	
High	18 (13)	10 (17)	
Very high	11 (8)	9 (16)	
Smoking history, n (%)			.9
Never	137 (76)	63 (77)	
Former	42 (23)	18 (22)	
Current	2 (1)	1 (1)	
Post 9/11 asthma, n (%)	144 (84)	70 (88)	.4
Sensitized to aeroallergens (at least 1), n (%)	88 (84)	38 (88)	.4
History of intubation, n (%)	2 (1)	4 (5)	.07
Hospitalized for asthma in the past year, n (%)	4 (2)	9 (11)	.001
Emergency room visit for asthma in the past year, n (%)	21 (11)	23 (28)	.0006

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Characteristic	No PTSD (n = 192)	PTSD (n = 84)	*P* value
Oral steroids use in the past year, n (%)	58 (30)	34 (42)	.06
Asthma control, n (%)			.001
Well controlled	68 (35)	14 (17)	
Uncontrolled	36 (19)	12 (14)	
Very poorly controlled	88 (46)	57 (69)	
Poor asthma-related quality of life, n (%)	57 (30)	50 (60)	<.0001
Comorbidities, n (%)			
Gastric esophageal reflux disorder	131 (68)	55 (66)	.6
Chronic sinusitis	113 (59)	50 (60)	.9
Diabetes	38 (20)	13 (16)	.3
Hypertension	102 (53)	32 (38)	.02
Major depression	19 (10)	46 (64)	<.0001

TABLE II.

Unadjusted associations between PTSD and self-management behaviors among WTC workers with asthma

Self-management behavior	No PTSD (n = 192)	PTSD (n = 84)	*P* value
Medication adherence			
MARS score, mean (SD)	4.0 (0.8)	4.1 (0.7)	.7
MARS percent adherent, n (%)	54 (41)	18 (34)	.4
ASK-12 score, mean (SD)	22.0 (5.5)	24.0 (5.9)	.01
Inhaler technique			
Inhaler technique, mean (SD)	6.5 (1.6)	6.6 (1.7)	.6
Adequate inhaler technique, n (%)	132 (75)	62 (80)	.4
Use action plan, n (%)	76 (42)	35 (49)	.2
Trigger avoidance, n (%)	89 (47)	44 (55)	.2
Influenza vaccination, n (%)	110 (59)	49 (62)	.5

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TABLE III.

Adjusted associations between PTSD and self-management behaviors among WTC workers with asthma *

Self-management behavior	Adjusted mean difference (95% CI) or adjusted OR (95% CI)
Medication adherence	
MARS score, mean difference (95% CI)	−0.15 (−0.5 to 0.2)
MARS percent adherent, OR (95% CI)	2.5 (0.9 to 6.8)
ASK-12 score, mean difference (95% CI)	1.70 (−0.3 to 3.6)
Inhaler technique	
Inhaler technique, mean difference (95% CI)	−0.12 (−0.7 to 0.5)
Adequate inhaler technique, OR (95% CI)	0.9 (0.4 to 2.3)
Use action plan, OR (95% CI)	0.8 (0.4 to 1.8)
Trigger avoidance, OR (95% CI)	0.9 (0.4 to 1.8)
Influenza vaccination, OR (95% CI)	0.7 (0.3 to 1.5)

* Adjusted for age, sex, race and ethnicity, education, income, asthma onset post 9/11, and comorbidities.

TABLE IV.

Disease and medication beliefs among WTC workers with asthma with and without PTSD

Belief	No PTSD Mean (SD)	PTSD Mean (SD)	*P* value	Effect size
Illness beliefs				
Timeline				
Asthma will continue for a very long time/forever	7.7 (3.4)	8.1 (3.1)	.4	0.1
Have asthma all the time, not only with symptoms	2.6 (1.4)	2.7 (1.4)	.4	0.1
Cause				
Asthma is due to WTC exposure	3.43 (0.9)	3.35 (0.9)	.5	−0.1
Asthma is due to inadequate protection at WTC site	3.40 (0.9)	3.32 (1.0)	.5	−0.1
Control				
Lack personal control over asthma	3.4 (2.7)	4.3 (3.0)	.02	0.3
Treatment does not help control asthma	1.6 (2.0)	2.4 (2.5)	.01	0.3
Hard to know when asthma is starting to get worse	1.9 (0.9)	2.2 (0.9)	.05	0.2
Managing asthma is difficult	3.4 (2.7)	4.1 (3.0)	.1	0.3
WTC-related asthma is more severe	2.9 (0.8)	3.0 (0.8)	.2	0.2
Consequences				
Asthma affects my life	4.8 (2.8)	6.3 (2.5)	.0001	0.6
Experience a lot of asthma symptoms	5.2 (2.6)	5.9 (2.5)	.04	0.3
Emotional responses				
Concerned about asthma	6.6 (3.4)	7.5 (2.8)	.05	0.3
Asthma affects emotionally	2.9 (2.9)	5.6 (3.3)	<.0001	0.9
Always not feeling well	2.4 (2.9)	4.8 (3.4)	<.0001	0.8
Nothing will ever improve the asthma	2.6 (3.2)	4.6 (3.6)	<.0001	0.6
Thinking about asthma makes me sad	1.4 (2.3)	4.5 (3.8)	<.0001	1.1
Worry when asthma is starting to get worse	2.7 (1.2)	3.3 (1.1)	.0005	0.5
Worry about future because of asthma	2.3 (1.4)	3.0 (1.5)	<.0001	0.5
Coherence				
Don’t understand asthma well	2.3 (2.6)	2.9 (3.0)	.09	0.2
Medication beliefs				
Necessity	2.9 (0.9)	3.1 (0.8)	.1	0.2

Belief	No PTSD Mean (SD)	PTSD Mean (SD)	*P* value	Effect size
Concerns	2.9 (0.8)	3.0 (0.8)	.2	0.2
Self-efficacy				
Confident in ability to control asthma	16.7 (4.4)	18.3 (3.8)	.004	0.4
Confident in ability to use controller medicines	14.0 (3.8)	16.1 (3.8)	.0003	0.5
Feel control over future health	1.8 (0.9)	1.6 (0.8)	.07	−0.2