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MENTAL HEALTH

Associations between asthma trigger reports, mental health conditions, and asthma morbidity among world trade center rescue and recovery workers

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ABSTRACT

Aim: There is limited information regarding asthma triggers in World Trade Center (WTC) rescue and recovery workers (RRW) or how mental health conditions affect the perception of triggers. *Methods*: We included 372 WTC workers with asthma. The Asthma Trigger Inventory (ATI) assessed triggers along five domains: psychological, allergens, physical activity, infection, and pollution. We administered the Structured Clinical Interview to diagnose post-traumatic stress disorder (PTSD), major depression and panic disorder (PD). The Asthma Control Questionnaire (ACQ) and Mini Asthma Quality of Life Questionnaire (AQLQ) measured asthma control and quality of life, respectively. Linear regression models were fitted to examine the association of ATI total and subdomain scores with mental health conditions as well as the percent of ACQ and AQLQ variance explained by ATI subscales. *Results*: The most common triggers were air pollution (75%) and general allergens (68%). PTSD was significantly associated with psychological triggers (partial r^2=0.05, $p < 0.01$), physical activity (partial r^2=0.03, $p < 0.01$) and air pollution (partial r^2=0.02, $p = 0.04$) subscales while PD was significantly associated with air pollution (partial r^2=0.03, $p = 0.03$) and general allergens (partial r^2=0.02, $p = 0.03$). ATI subscales explained a large percentage of variance in asthma control (r^2=0.37, $p < 0.01$) and quality of life scores (r^2=0.40, $p < 0.01$). Psychological subscale scores explained the largest portion of the total variability in ACQ (partial r^2= 0.11, $p = 0.72$) and AQLQ (partial r^2=0.14, $p = 0.64$) scores. *Conclusion*: RRW with mental health conditions reported more asthma triggers and these triggers were associated with asthma morbidity. These data can help support interventions in RRW with asthma.

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Asthma trigger; asthma; World Trade Center; mental health; psychological; asthma outcomes; asthma management

Introduction

Asthma is one of the main chronic pulmonary conditions that developed as a result of exposures during and after the World Trade Center (WTC) attacks. Several studies report prevalence rates of asthma ranging from 12% to 28% in this population [1,2]. Similarly, research has shown that several mental health diagnoses developed in people exposed to the events of 9/11, including major depressive disorder (MDD) [3,4] panic disorder (PD) [1], and post-traumatic stress disorder (PTSD) [1,2,5–7].

Proper identification and avoidance of asthma triggers are critical for effective self-management of asthma [8]. Lack of recognition and exposure to asthma triggers can lead to worse control and increase the risk of exacerbations. Conversely, over reporting of asthma triggers may be associated with unnecessary avoidance of exposures (e.g. unnecessarily staying indoors) and poorer quality of life. Previous studies identified respiratory infections, cigarette smoke, air pollution, and physical activity as common asthma triggers [9,10]. More recent research has focused on the role of emotions as triggers of asthma [11–15]. One study conducted in the general adult asthma population found that psychological triggers explained a considerable portion of variance in disease control and asthma quality of life [14]. A more recent study

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conducted by Vazquez et al. found that psychological asthma triggers were significantly reported at a higher frequency among Latino adults with PD [15]. These recent findings suggest that the presence of mental health disorders can influence the perception of asthma triggers.

There are limited data regarding the role of psychological and other triggers in WTC workers with asthma and the relationship with mental conditions. Several studies have shown that PTSD is linked to worse asthma control and poorer quality of life in WTC workers [8–10]. Furthermore, there is evidence that mental health disorders can influence what patients with asthma perceive as their triggers [12,14,15], suggesting the need for further analysis of these relationships. In this study, we examined the most common types of triggers in a cohort of WTC workers with asthma and assessed whether presence of mental health conditions is associated with specific trigger domains. We hypothesized that those with a mental health disorder will also report higher psychological asthma triggers and be significantly associated with asthma control and asthma-related quality of life.

Methods

Study population

Data were collected as part of a multi-site cohort study examining determinants of asthma morbidity in WTC rescue and recovery workers [16]. The study consisted of WTC workers with asthma who were enrolled in the Mount Sinai Hospital, Northwell Health Queens, or New York University Langone Medical Center WTC Health Programs. Inclusion criteria were: ≥18 years of age, physician diagnosed asthma, and ability to complete interviews in English or Spanish. WTC workers with chronic obstructive pulmonary disease (COPD), other chronic respiratory illness, or lack of asthma diagnosis were excluded. Additionally, individuals with a history of heavy smoking (≥ 15 pack-years) were excluded because of the possibility of undiagnosed COPD. Written consent was obtained in accordance with Institutional Review Board guidelines for all sites.

Study variables

Sociodemographic data included age, sex, race/ethnicity, education, marital status, and language based on items adapted from the National Health Interview Survey [17]. Asthma status included date of diagnosis, family history, and asthma medication regimen. Categorical levels of WTC exposure were based on contact with the 9/11 cloud of debris, work on the pile of debris and total time spent working at the WTC site [1].

Asthma triggers

Study participants completed the Asthma Trigger Inventory (ATI) questionnaire, which is a validated 32-item tool to assess asthma triggers [10]. Participants indicated the frequency and importance of each trigger as a cause of asthma symptoms on a 5-point scale (0 = never to 4 = always). The questionnaire yielded scores on six trigger subscales, including psychological/emotional (10 items), air pollution/irritants (6 items), physical activity (5 items), animal allergens (3 items), pollen allergens (3 items), and infections (4 items). Psychological triggers included questions related to being angry, excited, feeling lonely, tense, unhappy, weak, stress at home, depressed mood, arguments with people, and intense worries. We combined animal and pollen allergens to a single category labeled as general allergens, providing us with a total of five domains. Subscale scores were calculated by averaging trigger items relevant to that subscale.

Mental health conditions

Diagnoses of current major depression (MDD), PD and PTSD were determined using the Structured Clinical Interview for (SCID) for the Diagnostic and Statistical Manual, Version Four, Revised (DSM-IV-TR) at the time of enrollment [18]. The SCID is considered the gold standard for psychology assessments and has excellent reliability [19–21].

Asthma control and quality of life

Asthma control was measured by the Asthma Control Questionnaire (ACQ) [22], a validated tool recommended by the National Asthma Education and Prevention Program [8]. The 7-item questionnaire instructs participants to recall their experience with asthma in the past week and rate on a 7-point scale from 0 (no impairment) to 6 (maximum impairment). ACQ score is calculated as the mean score of all items; lower scores indicate better asthma control [22–24]. Poor asthma control was defined as a score ≥1.5 [25,26]. The Mini Asthma Quality of Life Questionnaire (AQLQ) is a validated tool that asks about participant's experience in the past 2 weeks regarding their physical, emotional, social and

occupational well-being [22]. Items were rated on a Likert-type scale, ranging from 1 (all of the time; totally limited) to 7 (none of the time; not at all limited). Higher scores are aligned with better quality of life and a change in 0.5 units is considered clinically significant [22]. Mean scores range from 1 to 7 and poor quality of life was defined as a score $\geq$4.7 [26,27].

Statistical analysis

Means and standard deviations were examined for continuous variables or percentages for categorical variables. The frequency of WTC workers who endorse each trigger is presented with 95% confidence intervals (CI) based on the binomial distribution.

Linear regression analysis was used to assess the association between MDD, PD, and PTSD with total and subscale ATI scores. Although some participants were diagnosed with more than one mental health condition, our analyses examined each disorder separately. We calculated total and partial R-squared statistics to assess the percent variability in ATI scores explained by these mental health conditions. All models were adjusted for age, sex, race/ethnicity, and asthma history of post 9/11 diagnosis. We used Type 3 sums of squares analyses, as it does not depend on the order in which the terms are entered into the model. We also fitted regression models assessing the association of ATI subdomain scores and mental health conditions with ACQ and AQLQ scores. All statistical analyses were conducted with SAS version 9.4 (SAS Institute Inc., Cary, NC, USA) and used two-sided p values with a statistical significance of $p < 0.05$.

Results

Between December 2012 and July 2016, a total of 2,101 potentially eligible WTC workers were contacted, of which 1,037 refused participation. Of those who were screened, 694 were ineligible due to COPD ($n = 198$) or because they had a smoking history $\geq$15 pack-years ($n = 63$), due to language exclusion ($n = 76$), or other reasons ($n = 357$). This analysis included 372 study participants with complete data on asthma triggers and psychological diagnoses.

Study participants had a mean (SD) age of 52 (9) years, 71% were male, 41% identified as Latino and 14% as Black (Table 1). Overall, 74% of participants had a post 9/11 asthma diagnosis, with an average of 1.89 (0.43) emergency room visits and 2 (0.29) hospitalizations reported in the previous year. Based on the psychological assessment, 15% were diagnosed with MDD, 14% with PD, and 28% met clinical criteria for PTSD, with some participants presenting with multiple mental health conditions. About 47% of the participants reported their asthma as very poorly controlled and 50% of the participants had mean scores corresponding to low asthma quality of life.

Table 1. Characteristics of world trade center rescue and recovery workers.

Characteristics	Value
Age, years, mean (SD)	52 (9)
Male, no. (%)	261 (71)
Race/ethnicity, no. (%)	
Latino	156 (41)
White	130 (35)
Black	51 (14)
Other	30 (8)
Marital status, no. (%)	
Married	228 (61)
Asthma status, no. (%)	
Post 9/11 diagnosis	276 (74)
Psychological conditions, no. (%)	
Major depressive disorder	54 (15)
Panic disorder	53 (14)
Post-traumatic stress disorder	103 (28)
Asthma control, no. (%)	
Very poorly controlled asthma (ACQ Score $\geq$1.5)	177 (47)
Asthma-related quality of life, no. (%)	
Low (AQLQ score >4.7)	187 (50)
WTC exposure, no. (%)	
Very high	30 (9)
Smoker status, no. (%)	
Current or former smoker	108 (29)
Allergy sensitization, no. (%)	
Indoor allergens	187 (55)
Outdoor allergens	103 (30)
Healthcare utilization, mean, (SD)	
Asthma-related emergency room visits, past 12 months	1.89 (0.43)
Asthma-related hospitalizations, past 12 months	2 (0.29)
Asthma treatment site, no. (%)	
WTC treatment program	271 (73)
Healthcare provider in charge of asthma care, no. (%)	
Yes	276 (74)
Asthma controller medication, no. (%)	
Yes	245 (66)
Received asthma action plan, no. (%)	
Yes	121 (32)
Received peak flow meter, no (%)	
Yes	83 (22)

Figure 1 shows the frequency of asthma triggers reported by WTC workers. The most common triggers were air pollution and general allergens reported by 75% (95% CI: 70%–79%) and 68% (95% CI: 63%–73%) of participants, respectively. Other triggers included psychological (21%, 95% CI: 17%–25%), physical activity (53%, 95% CI: 48%–58%), and infections (52%, 95% CI: 47%–57%).

Figure 2 illustrates the percentage of participants who reported asthma triggers stratified according to mental health conditions. Overall, WTC workers with mental health conditions reported higher prevalence of asthma triggers in some subdomains. Psychological triggers were reported more often among those with

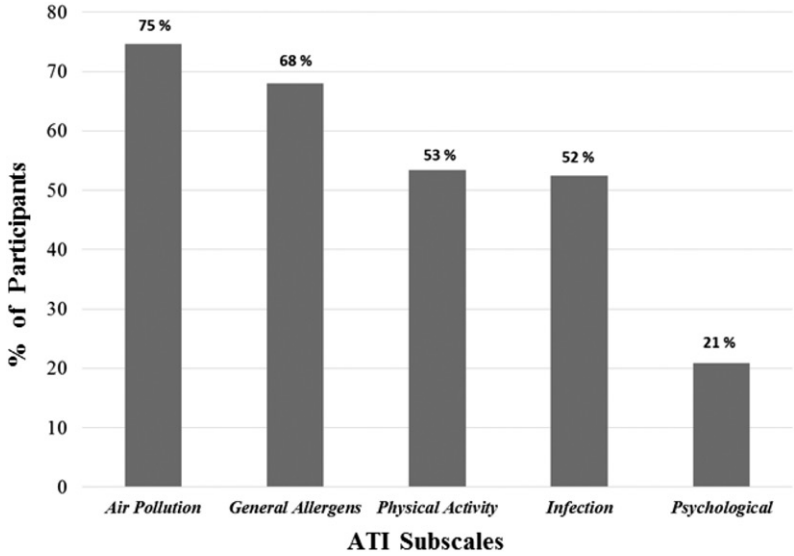

Figure 1. Percentage of Participants Perceiving Asthma Triggers.

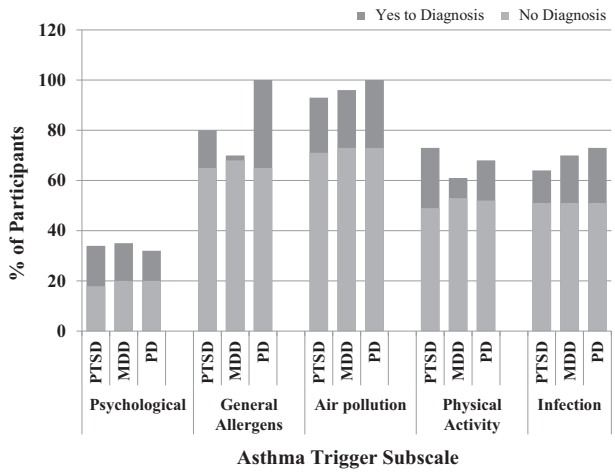

Figure 2. Participants Reporting Asthma Triggers by Mental Health Conditions.

PTSD (34% vs. 17%, OR: 2.85, $p = 0.03$), than those without PTSD. There were no significant differences in reports of psychological triggers among those with PD (32% vs. 20%, $p = 0.26$) or MDD (35% vs. 20%, $p = 0.10$) than those without these conditions. General allergen triggers were most common among WTC workers with PD than those without PD (100% vs. 65%, $p < 0.01$). There was no significant difference in reports of general allergen triggers in participants with PTSD (80% vs. 65%, $p = 0.09$) or MDD (70% vs. 68%, $p = 0.99$). Air pollution as a trigger was more commonly reported by WTC workers with PD (100% vs. 73%, $p < 0.01$), MDD (96% vs. 73%, $p = 0.02$) and PTSD (93% vs. 71%, $p < 0.01$). Similar patterns were observed for physical activity and infectious triggers.

Results of linear regression analyses (Table 2) showed that after controlling for covariates, 13% of the variability in the ATI total scores ($p < 0.01$) was explained by PTSD, PD and MDD. Furthermore, PTSD was significantly associated with psychological triggers (partial $r^2=0.05$, $p < 0.01$), physical activity (partial $r^2=0.03$, $p < 0.01$) and air pollution (partial $r^2=0.02$, $p = 0.04$) subscales. PD was significantly associated with air pollution (partial $r^2=0.03$, $p = 0.03$) and general allergens (partial $r^2=0.02$, $p = 0.03$). Conversely, MDD was not significantly associated with any asthma trigger subscales.

Figure 3 indicate that ATI subscales explained a large percentage of variance in asthma control (ACQ scores, $r^2=0.37$, $p < 0.01$) and quality of life scores ($r^2=0.40$, $p < 0.01$). Psychological subscale scores explained the largest portion of the total variability in ACQ scores (partial $r^2=0.11$, $p = 0.72$), followed by physical activity subscale scores (partial $r^2=0.11$, $p < 0.01$), infection (partial $r^2=0.06$, $p < 0.01$), air pollution (partial $r^2=0.03$, $p < 0.01$), and general allergens (partial $r^2=0.006$, $p = 0.12$). Similarly, psychological subscale scores explained a greater portion of the total variability in AQLQ scores (partial $r^2=0.14$, $p = 0.64$), followed by air pollution (partial $r^2=0.06$, $p < 0.01$), physical activity (partial $r^2=0.06$, $p = 0.01$), infection (partial $r^2=0.04$, $p < 0.01$), and general allergens (partial $r^2=0.005$, $p = 0.16$).

Discussion

Asthma and mental health conditions are highly prevalent among WTC rescue and recovery workers. This study is the first to examine the relationship between WTC workers' report of asthma triggers, mental health conditions and asthma morbidity.

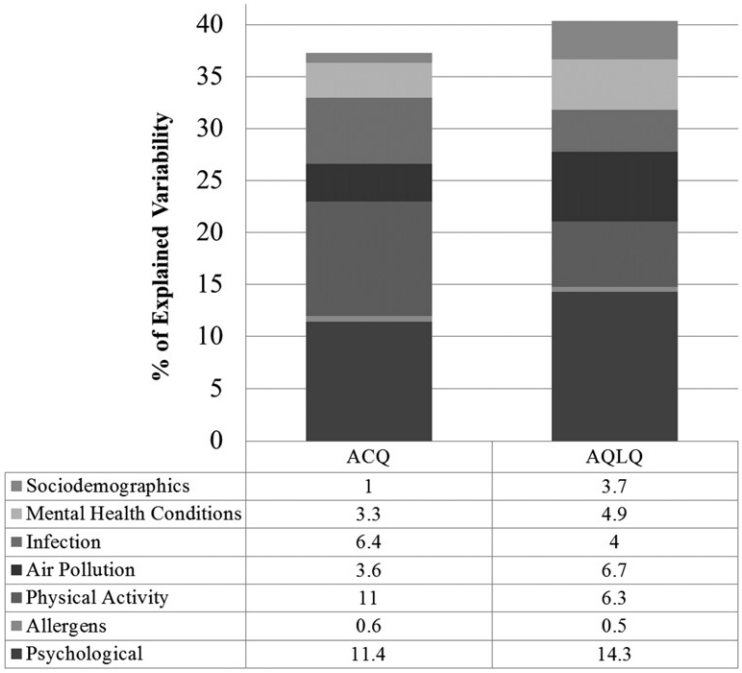

Figure 3. Percent Variance Explained in Asthma Control and Quality of Life Scores.

Table 2. Association between asthma trigger subscales scores and mental health conditions.

			Major depression		Panic disorder		Post-traumatic stress disorder	
ATI subscale	Total r^2	*p*-value	*r*	*p*-value	*r*	*p*-value	*r*	*p*-value
Total	0.13	<0.01	0.01	0.90	0.03	0.07	0.02	0.04
Psychological	0.16	<0.01	0.01	0.89	0.01	0.49	0.05	0.01
General allergens	0.10	0.01	<0.01	0.21	0.02	0.03	<0.01	0.66
Physical activity	0.08	0.04	0.01	0.97	0.01	0.45	0.03	0.01
Air pollution	0.15	<0.01	0.01	0.81	0.03	0.03	0.02	0.04
Infection	0.11	<0.01	0.01	0.35	<0.01	0.48	0.01	0.31

ATI: Asthma Trigger Inventory.

Overall, specific asthma triggers were associated with PTSD and PD. Psychological and air pollution triggers were more likely to be present among people with mental health disorders. Furthermore, we found that psychological triggers explained the largest proportion of variability in asthma control and quality of life scores. These results suggest that efforts to educate WTC workers on the relationship between psychological and asthma triggers and provide behavioral interventions addressing asthma exacerbated by mental health conditions may improve the outcomes of WTC workers with asthma.

There is substantial evidence showing an association between mental health conditions and asthma [2,28–34]. WTC workers, in particular, have very high prevalence of asthma and mental health conditions and a high degree of comorbidity [1]. Several studies have shown that PTSD and other mental health conditions are associated with increased asthma morbidity in the WTC population [35–37]. While multiple mechanisms have been implicated in this association, including potential inflammatory and cognitive pathways, emotional triggers, likely play an important role. Studies in the general population show that psychiatric disorders are associated with psychological triggers in patients with asthma in the general populations [11,12]. In this study, we found that psychological triggers were more related to PTSD compared to PD and MDD and non-psychological triggers were related to both PTSD and PD.

Reducing exposure and avoiding asthma triggers are important components of asthma self-management [38]. We found that psychological triggers account for a large proportion of the variability in asthma control and asthma-related quality of life. Although a lack of control group did not allow us to make side-by-side comparisons, our findings are consistent with prior research showing that psychological triggers are associated with asthma control and quality of life measures [14,39]. In a German adult population with

asthma recruited from respiratory specialty clinics, Ritz et al. found that psychological trigger were strongly related to mental health disorders. In particular, psychological and air pollution triggers were associated with anxiety. After adjusting for covariates, the presence of a mental health condition, including depression and anxiety, explained 21% of the variance in ATI psychological trigger reports. About one-third of the variance in asthma quality of life scores was explained by asthma trigger factors, with the majority being non-allergen triggers including psychological triggers [14]. Furthermore, there is evidence to indicate that the presence of mental health conditions including anxiety and depression can affect asthma control through biological mechanisms. Studies have found that stress and anxiety are linked to changes in the hypothalamic-pituitary adrenal (HPA) axis, leading to a pro-inflammatory state [40–43]. Changes in the HPA axis can also lead to low levels of cortisol (which helps with reducing inflammation) [42]. These biological mechanisms can explain how emotional triggers may worsen asthma control, particularly in patients with current mental health conditions associated with heightened emotional responses.

Interestingly, we also found that PTSD was associated with psychological trigger reports, asthma control and asthma-related quality of life. It is possible that WTC workers with PTSD have heightened sensitivity to stimuli related to trauma and asthma, therefore, may be more likely to report psychological triggers as causes of their asthma. For instance, persistent avoidance as a dimension of PTSD includes avoidance of people, places and activities that remind them of the WTC attacks along with feelings of detachment from others and restricted range of affect [18,21]. These PTSD features can be comparable to psychological triggers of "feeling alone," "feeling tense," and "feeling unhappy," and possibly, exacerbate asthma symptoms. Furthermore, persistent hyper-arousal in PTSD, including irritability and outbursts of anger, can promote identification of "feeling tense," "argument with people," and "being angry" as psychological triggers of asthma [10,21]. Likewise, WTC workers with comorbid PTSD and asthma may confuse features of PTSD such as sleep disturbances, physiological reactivity to trauma cues, and avoidance of activities with components of asthma control such as nighttime symptoms, activity limitation and respiratory symptoms.

We found that reports of allergen and air pollution triggers were most common among WTC workers with PD. This finding is aligned with past research that found allergic patients reports a significant higher number of panic attacks than non-allergic patients [44]. However, WTC workers' report on the types of triggers that affect their asthma may be limited to their general perception. There is research to indicate that asthma trigger identification requires perception of a causal relationship between asthma triggers and symptoms, but the presence of emotional states such as fear or anxiety can encourage inaccurate perceptions in those relationships [13]. Individuals with elevated levels of panic-fear often misidentify certain sensations such as panic and worry as symptoms of asthma [45,46]. For instance, those with panic symptoms may attribute hyperventilation to asthma or asthma symptoms to PD, as there is substantial overlap in symptoms of these conditions [47]. Furthermore, PD can produce an overgeneralized fear response when in contact with cues that are similar to the feared cue [13,48].

Our study has several strengths and limitations. Our sample was limited to WTC workers participating in the WTC Health Program. Participation in the WTC Health Program is entirely voluntary; thus, WTC workers who had been more affected by WTC exposures may be overrepresented. Additionally, the program does not include local residents or pedestrians exposed during and in the aftermath of the WTC disaster. Our cross-sectional design did not allow us to make causal interpretations on any observed associations between asthma triggers and asthma outcomes. We evaluated perception of asthma triggers, which sometimes can be inaccurate. However, perceptions and subsequent beliefs guide important self-management behaviors such as trigger avoidance. Thus, understanding these perceptions is important for both patients and providers in order to develop effective self-management plans. We also did not adjust for asthma control which was another major limitation of our study. Lack of asthma control may result in underestimation of the impact of asthma triggers. Finally, our study relied on self-reported data of asthma outcomes, which can be subject to recall bias. It should be considered as it can overestimate a true association. For instance, those with more severe psychological disorder(s) may result in overestimating the impact of asthma triggers, and in turn, the odds ratio would also increase.

Conclusion

In summary, we found that WTC rescue and recovery workers with mental health conditions reported more asthma triggers and those asthma trigger reports were

associated with asthma morbidity. Results from this study suggest that greater attention is needed to the perception of asthma triggers among WTC rescue and recovery workers with co-morbid asthma and psychological conditions. Implementing educational or behavioral interventions with the goal of asthma education and reducing emotional stress may help reduce decrease asthma morbidity among this population.

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