Published in final edited form as:

Ann Allergy Asthma Immunol. 2016 November ; 117(5): 568–570. doi:10.1016/j.anai.2016.08.033.

Determinants of Asthma Morbidity in World Trade Center Rescue and Recovery Workers

Kevin Y Xu, BA[1,2], **Emily Goodman, MS**[3], **Ruchir Goswami, MD**[2], **Michael Crane, MD**[4], **Laura Crowley, MD**[4], **Paula Busse, MD**[5], **Craig L Katz, MD**[1,6], **Steven Markowitz, MD**[7], **Rafael E de la Hoz, MD, MPH**[3,4], **Hannah T Jordan, MD, MPH**[8], **Gwen Skloot, MD**[9], and **Juan P Wisnivesky, MD, DrPH**[3,9]

[1]Department of Medical Education, Icahn School of Medicine at Mount Sinai, New York, NY

[2]Graduate Program in Public Health, Icahn School of Medicine at Mount Sinai, New York, NY

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

[4]Department of Preventive Medicine, Icahn School of Medicine at Mount Sinai, New York, NY

[5]Division of Clinical Immunology, Department of Medicine, Icahn School of Medicine at Mount Sinai, New York, NY

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

[7]Center for the Biology of Natural Systems, Queens College-City University of New York, Queens, NY

[8]World Trade Center Health Registry, New York City Department of Health and Mental Hygiene, Queens, NY

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

Keywords

Asthma; 9/11; asthma control; PTSD; GERD

Asthma is one the most common chronic conditions affecting World Trade Center (WTC) rescue and recovery workers in the aftermath of the terrorist attacks on September 11, 2001. While exposure-response gradients between asthma risk and duration of work at the WTC

Corresponding Author Information: Juan Wisnivesky, MD, DrPH, Divisions of General Internal Medicine and Pulmonary, Critical Care, and Sleep Medicine, Icahn School of Medicine at Mount Sinai, 17 East 102 Street, 6th Floor West Tower, New York, 10029, Tel: 212-824-7567, Fax: 212-824-2317, juan.wisnivesky@mssm.edu.

Trial Registration: Not applicable

Conflict of Interest: Dr. Wisnivesky is a member of the research board of EHE International, has received consulting honorarium from Quintiles and Merck, and research grants from Aventis and Quorum. All other authors have nothing to report.

site, exposure to the dust cloud, and work in the Ground Zero pit, compounded by inadequate protection have been described, [1–3] there is limited knowledge about how exposure and other factors affect long-term asthma outcomes among WTC rescue and recovery workers. In this study, we used data from a cohort of WTC workers with a physician diagnosis of asthma to study factors associated with worse asthma control, acute asthma-related outpatient and inpatient resource utilization, and poor quality of life.

We collected data on asthma history, levels of WTC exposures (categorized based on established criteria),[4] and comorbidities from a prospective cohort of 218 WTC workers with physician-diagnosed asthma who were enrolled in the WTC Health Program (WTCHP). Structured clinical interviews assessed for post-traumatic stress disorder (PTSD) and major depression. A validated questionnaire was used to measure gastroesophageal reflux disease (GERD) symptoms.[5] Outcomes included asthma control,[6] self-report resource utilization, and quality of life.[6] We performed multiple regression analyses to identify factors associated with increased morbidity.

Asthma was well controlled in 63 (29%) WTC workers, not well controlled in 60 (28%) and very poorly controlled in 95 (44%). More than one-third had an unscheduled asthma-related physician visit (67%), while 37 participants (17%) had inpatient asthma-related visits in the twelve months prior to study enrollment. More than half of patients (53%) had poor asthma-related quality of life.

Table 1 shows that after adjustment for socio-demographic and health status variables, very poor asthma control was associated with increased age (odds ratio [OR]: 1.89 per 10 years, 95% confidence interval [CI]: 1.05–3.41), lower income (OR: 7.52, 95% CI: 2.56–22.08), high WTC exposure levels (OR: 5.19, 95% CI: 1.14–23.73), higher GERD scores (OR: 1.13, 95% CI: 1.06–1.20), and PTSD (OR: 3.44, 95% CI: 1.08–10.95).

Outpatient resource utilization was associated with intermediate WTC exposures (OR: 0.23, 95% CI: 0.08–0.71) and major depression (OR: 2.70, 95% CI: 1.01–7.21), while inpatient resource utilization was associated with higher GERD scores (OR: 1.06, 95% CI: 1.01–1.10) and PTSD (OR: 3.52, 95% CI: 1.30–9.48). Poor asthma quality of life was associated with lower income (OR: 3.58, 95% CI: 1.68–7.60), post 9/11 asthma (OR: 2.73, 95% CI: 1.09–6.86), and higher GERD scores (OR: 1.05, 95% CI: 1.01–1.09).

Our study revealed that WTC-related asthma is frequently poorly controlled and results in substantial impairment in quality of life. Furthermore, we found that lower income and physical and mental health comorbidities were independently associated with increased asthma morbidity in the WTC rescue and recovery worker populations. Our results highlight the medical needs of WTC workers with asthma and suggest potential targets for future interventions.

Our findings are consistent with a study conducted among members of the WTC Health Registry, encompassing both local residents and rescue and recovery workers, which found participants to have low levels of asthma control.[7] A potential reason for the high levels of asthma morbidity in WTC rescue and recovery workers is the high prevalence of comorbid GERD, estimated to affect almost 40% of WTC workers and identified as an important

exacerbating factor in patients with poorly controlled asthma.[4] In addition, our finding of a strong association between PTSD and worse asthma morbidity in adjusted analysis is consistent with some community-based studies that reported associations between mental health comorbidities and poor asthma control.[8]

Post 9/11 asthma onset was associated with worse morbidity suggesting more severe disease. While it is possible that workers with pre 9/11 asthma were more likely to utilize respiratory protection and avoid high exposure areas, our findings are consistent with research reporting that late-onset asthma is associated with a poorer response to standard asthma treatments and increased morbidity.[9] There is evidence of a distinct pathophysiological signature associated with irritant-induced WTC-related asthma that is marked by increased sputum eosinophils and neutrophils,[10] elevated blood eosinophils and persistent lower respiratory tract symptoms of cough, wheeze, dyspnea on exertion, and chest tightness.[11]

Another potential explanation for the relatively higher morbidity rates observed in our study is low adherence to asthma self-management behaviors. It is possible that some WTC workers with asthma are not adhering to inhaled corticosteroids or to other self-management behaviors such as allergen avoidance, use of peak flow meters, and action plans, which are important for adequate asthma control.[12] Future studies are needed to examine whether these factors are important, and potentially modifiable, contributors to asthma morbidity in this population.

Our study was limited by reliance on self-report measures of several risk factors and; however, we used validated scales to measure all study variables. In addition, while our three-level measure of WTC exposure was based on established criteria based on self-report data,[4] no objective assessments have been developed to date. Moreover, our sample was limited to WTC rescue and recovery workers enrolled in the WTCHP. Thus, our results may not be generalizable to other WTC workers or other populations affected by the WTC disaster. Nonetheless, this study has a number of strengths including its use of clinically-validated mental health measures.

In summary, we found high levels of asthma morbidity among WTC rescue and recovery workers over 15 years after exposure. Our finding that GERD symptom and PTSD are associated with worse asthma outcomes can help identify high-risk WTC workers and guide development of highly needed interventions.

Acknowledgments

Funding: This study was funded by the National Institute for Occupational Safety and Health (U01OH010405). Dr. de la Hoz's contribution was supported in part by grant U01-OH040701 from the CDC/NIOSH.

Study design: Xu, Wisnivesky, Crane, Crowley, Busse, Katz, Markowitz, de la Hoz, Skloot

Data acquisition: Xu, Wisnivesky, Goodman, Goswami

Data analysis: Xu, Wisnivesky, Goodman

Data Interpretation: Xu, Wisnivesky, Goodman, Goswami

Drafting of manuscript: Xu, Wisnivesky, Goswami

Critical revision of intellectual content: Crane, Busse, Katz, de la Hoz, Skloot, Jordan

Final manuscript approval: All authors (Xu, Goodman, Goswami, Crane, Crowley, Busse, Katz, Markowitz, de la Hoz, Jordan, Skloot, Wisnivesky)

We acknowledge the research support staff at the Division of General Internal Medicine and at the Icahn School of Medicine at Mount Sinai and the World Trade Center Health Program.

Abbreviations

ACQ	Asthma Control
AQLQ	Asthma Quality of Life
CI	Confidence Interval
COPD	Chronic Obstructive Pulmonary Disease
DSM	Diagnostic and Statistical Manual
GERD	Gastro-Esophageal Reflux Disease
OR	Odds Ratio
PTSD	Post-Traumatic Stress Disorder
SCID	Structured Clinical Interview for DSM Disorders
WTC	World Trade Center
WTCHP	Health Program

References

1. Antao VC, Pallos LL, Shim YK, et al. Respiratory protective equipment, mask use, and respiratory outcomes among world trade center rescue and recovery workers. Am J Ind Med. 2011; 54:897–905. [PubMed: 21932428]
2. Lippmann M, Cohen MD, Chen LC. Health effects of world trade center (wtc) dust: An unprecedented disaster's inadequate risk management. Crit Rev Toxicol. 2015; 45:492–530. [PubMed: 26058443]
3. Wheeler K, McKelvey W, Thorpe L, et al. Asthma diagnosed after 11 september 2001 among rescue and recovery workers: Findings from the world trade center health registry. Environ Health Perspect. 2007; 115:1584–1590. [PubMed: 18007989]
4. Wisnivesky JP, Teitelbaum SL, Todd AC, et al. Persistence of multiple illnesses in world trade center rescue and recovery workers: A cohort study. Lancet. 2011; 378:888–897. [PubMed: 21890053]
5. Fass R. Symptom assessment tools for gastroesophageal reflux disease (gerd) treatment. J Clin Gastroenterol. 2007; 41:437–444. [PubMed: 17450022]
6. Juniper EF, Guyatt GH, Cox FM, Ferrie PJ, King DR. Development and validation of the mini asthma quality of life questionnaire. Eur Respir J. 1999; 14:32–38. [PubMed: 10489826]
7. Jordan HT, Stellman SD, Reibman J, et al. Factors associated with poor control of 9/11-related asthma 10–11 years after the 2001 world trade center terrorist attacks. J Asthma. 2015; 52:630–637. [PubMed: 25539137]
8. Goodwin RD, Jacobi F, Thefeld W. Mental disorders and asthma in the community. Arch Gen Psychiatry. 2003; 60:1125–1130. [PubMed: 14609888]
9. de Nijs SB, Venekamp LN, Bel EH. Adult-onset asthma: Is it really different? Eur Respir Rev. 2013; 22:44–52. [PubMed: 23457164]

10. Fireman EM, Lerman Y, Ganor E, et al. Induced sputum assessment in new york city firefighters exposed to world trade center dust. Environ Health Perspect. 2004; 112:1564–1569. [PubMed: 15531443]

11. Kazeros A, Maa MT, Patrawalla P, et al. Elevated peripheral eosinophils are associated with new-onset and persistent wheeze and airflow obstruction in world trade center-exposed individuals. J Asthma. 2013; 50:25–32. [PubMed: 23227974]

12. Halm EA, Mora P, Leventhal H. No symptoms, no asthma: The acute episodic disease belief is associated with poor self-management among inner-city adults with persistent asthma. Chest. 2006; 129:573–580. [PubMed: 16537854]

Ann Allergy Asthma Immunol. Author manuscript; available in PMC 2017 November 01.

Table 1

Adjusted Analysis – Asthma Control, Outpatient / Inpatient Resource Utilization, and Quality of Life

Variable	All Participants N = 218	Very Poor vs. Good Asthma Control	Poor vs. Good Asthma Control	Outpatient Resource Utilization	Inpatient Resource Utilization	Poor vs. Good Asthma Quality of Life
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age, Years (SD) [1]	52.9 (8.0)	1.89 (1.05–3.41)	1.10 (0.62–1.92)	1.04 (0.67–1.62)	0.77 (0.43–1.38)	1.23 (0.79–1.93)
Female Sex, N (%)	62 (28.4)	0.88 (0.33–2.38)	0.93 (0.35–2.48)	1.45 (0.67–3.17)	1.44 (0.56–3.68)	1.09 (0.50–2.36)
Race, N (%)						
Non-Hispanic White	29 (13.4)	Reference	Reference	Reference	Reference	Reference
Non-Hispanic Black	77 (35.7)	1.64 (0.43–6.24)	0.75 (0.20–2.85)	0.81 (0.28–2.32)	1.87 (0.50–6.98)	1.71 (0.59–4.97)
Hispanic	95 (44.0)	0.99 (0.35–2.77)	0.90 (0.34–2.40)	0.44 (0.19–1.02)	1.03 (0.34–3.10)	1.16 (0.52–2.59)
Other	15 (6.9)	1.61 (0.33–7.94)	0.84 (0.17–4.14)	0.52 (0.13–2.20)	0.69 (0.09–5.33)	1.49 (0.40–5.48)
Monthly Income, N (%)						
Over $3,000	117 (53.4)	Reference	Reference	Reference	Reference	Reference
Under >$3,000	81 (37.0)	7.52 (2.56–22.08)	3.69 (1.26–10.80)	0.68 (0.30–1.52)	1.46 (0.54–3.93)	3.58 (1.68–7.60)
Unknown	21 (9.6)	1.64 (0.24–11.28)	1.77 (0.24–13.10)	0.98 (0.20–4.74)	0.95 (0.18–5.04)	1.97 (0.49–7.94)
Post 9/11 Asthma, N (%)	169 (81.6)	1.72 (0.55–5.39)	1.01 (0.36–2.84)	0.58 (0.23–1.41)	0.43 (0.14–1.35)	2.73 (1.09–6.86)
Atopy [2]**, N (%)**	119 (54.3)	0.87 (0.36–2.13)	0.57 (0.24–1.36)	1.25 (0.61–2.55)	0.33 (0.13–0.84)	0.81 (0.41–1.60)
WTC Exposure, N (%)						
Low	27 (12.4)	Reference	Reference	Reference	Reference	Reference
Intermediate	98 (45.0)	4.04 (0.91–17.91)	3.62 (0.84–15.62)	0.23 (0.08–0.71)	0.38 (0.09–1.59)	2.26 (0.71–7.22)
High	93 (42.7)	5.19 (1.14–23.73)	2.42 (0.54–10.87)	1.05 (0.36–3.09)	1.31 (0.33–5.22)	2.09 (0.64–6.82)
Comorbidities, N (%)						
GERD Score [3]	9.4 (10.5)	1.13 (1.06–1.20)	1.07 (1.01–1.14)	1.04 (1.00–1.08)	1.06 (1.01–1.10)	1.05 (1.01–1.09)
Sinusitis [4]	135 (64.0)	0.81 (0.31–2.13)	0.65 (0.26–1.62)	1.06 (0.48–2.32)	1.19 (0.43–3.29)	0.70 (0.33–1.50)
Major Depression [5]	35 (16.0)	1.33 (0.34–5.20)	0.60 (0.13–2.66)	2.70 (1.01–7.21)	0.82 (0.25–2.73)	2.05 (0.71–5.95)
PTSD [6]	61 (27.9)	3.44 (1.08–10.95)	1.86 (0.56–6.19)	1.50 (0.65–3.43)	3.52 (1.30–9.48)	1.99 (0.85–4.67)

GERD: Gastro-esophageal reflux disease; PTSD: Post-traumatic stress disorder;

[1] = Per 10 years in adjusted analysis,

[2] = IgE-validated Indoor Allergies,

[3] = Validated GERD Score,

[4] = Self-reported,

[5] = SCID-diagnosed major depression,

[6] = SCID-diagnosed PTSD