

RESEARCH ARTICLE

New onset of asthma and job status change among world trade center responders and workers

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Background: Despite the high rates, the consequences of new onset asthma among the World Trade Center (WTC) responders in terms of the change in job status have not been studied.

Methods: This study consists of a cohort of 8132 WTC responders out of the total 25 787 responders who held a full-time job at the baseline visit, and participated in at least one follow-up visit.

Results: Overall, 34% of the study cohort changed their job status from full-time at a follow-up visit. Multivariable models showed that asthmatics were respectively 27% and 47% more likely to have any job status change and get retired, and twice as likely to become disabled as compared to non-asthmatics.

Conclusions: With asthma incidence from WTC exposure, negative job status change should be considered as a potential long-term consequence of WTC exposure.

KEYWORDS

asthma, job status change, socioeconomic status, WTC responders, world trade center

1 | INTRODUCTION

Asthma is a chronic lung disease which affects approximately 26 million children and adults in the United States each year. Along with the burdens on the healthcare system, uncontrolled asthma poses severe economic and social consequences as well, including missed work-days, and lost productivity and earnings. A recent national study observed that for individuals with uncontrolled asthma, medical expenditures were up to \$4,423 greater; and they were more likely to be unemployed, be absent from work, and have more activity limitations as compared to those who did not have asthma.¹ Asthma has also been reported to adversely affect the employee's career by disabling them from pursuing their desired career,

affecting promotion aspects due to absenteeism, changing to a worse job, and being perceived as incapable of more responsible work assignments.²

A study found that occupationally associated asthma is related with professional and financial consequences and 42-78% of those with occupationally associated asthma reported a substantial loss of income.³ Another study has reported that among the general working population, blue collar workers having asthma were two to six times less likely to return to work quickly compared with office.⁴ Research has also shown that reduction income is more frequently reported by employees with occupationally associated asthma than those without. Additionally, work-aggravated asthma is also reportedly associated with similar outcomes.³

The collapse of the World Trade Center (WTC) towers on September 11, 2001 exposed a large number of first responders and nearby residents to the potential toxic effects of multiple airborne pollutants, and dust. Multiple health problems related to WTC exposures have been documented in the literature; in particular the increased prevalence of respiratory symptoms and diagnoses such as asthma and reactive airways dysfunction syndrome.^{5–8} Recent studies have also observed an increased rate of asthma and other pulmonary disorders among certain groups of WTC responders, such as firefighters.⁹

Although higher rates of asthma symptoms among WTC responders have been reported, the present study aims to further assess the impact of asthma induced by exposure to dust and other pollutants at the WTC destruction site on work-related outcomes specifically in terms of the change in job status among WTC responders which has not been investigated. This study also compares the outcome among those with new onset asthma reported after the WTC disaster with those without asthma.

To accomplish its aims, the present study uses data from a prospective cohort of responders participating in the WTC Medical Monitoring and Treatment Program between 2002 and 2010 to assess whether responders diagnosed with asthma after exposure to the WTC disaster experienced a more negative change in job status in terms of hours being able to work compared with responders not diagnosed with asthma.

2 | METHODS

2.1 | Study population

The study population consisted of 25 787 responders who participated in the WTC Health Program by enrolling in one of the five WTC clinical centers (NY/NJ WTC consortium) at least once between July 16th, 2002 and December 31st, 2010. Active firefighters and emergency medical services (EMS) workers of the Fire Department of the City of New York (FDNY) were served by a separate but similar health surveillance system—the FDNY WTC Health Program and are not included in this analysis. The WTC Health Program initially started as a medical screening program of workers and volunteers who worked at the WTC sites (lower Manhattan, the Staten Island landfill, barges and loading piers) for at least 4 h from 9/11 to 9/14, 2001, at least 24 h in the month of September, or at least 80 h from 9/11 to the end of December 2001. Additional workers who were eligible included morgue workers and employees of the Office of the Chief Medical Examiner (OCME) and the Port Authority Trans-Hudson Corporation workers.¹⁰ Complete details on the original cohort enrolled in the WTC Health Program have previously been published.¹¹ The section ahead provides details about the selection criteria for cohort for the present study.

The study cohort consisted of responders who participated in the WTC Health Program before December 31, 2010, who held a full-time job at the baseline visit, and participated in at least one follow-up visit. Participants underwent a comprehensive baseline interview and were subsequently followed every 12–18 months for periodic exams and data collection regarding current job status. The comprehensive

baseline interview and examination could have occurred anytime between July 16, 2002 and December 31, 2010; the majority of participants conducted their baseline visit and examination between 2002 and 2004. Follow up rates in the WTC Health Program were 71% and 42% for the first and second follow-up visits, respectively. Among the total 25 787 responders who participated in the WTC Health Program before December 31, 2010, 32% ($n = 8132$) were included in this analysis.

2.2 | Asthma and job status information

To ascertain asthma diagnosis, participants were asked if they were ever diagnosed by a doctor as having asthma or history of reactive airways dysfunction syndrome. WTC responders were also asked to report the date of their asthma diagnosis, as well as whether they had an asthma attack during the prior 12 months. Importantly, to distinguish lifetime prevalence of asthma from new onset asthma that occurred post the WTC disaster, participants who reported history of an asthma diagnosis prior to January 2002, were not included as new onset asthma cases. During baseline and follow-up interviews, participants were also asked several questions related to job status and occupation. Job status was categorized as the following: (1) full-time; (2) part-time; (3) disabled (due to WTC or non-WTC exposure); (4) laid-off or unemployed; (5) retired, student, or other.

2.3 | Information on WTC dust/fumes exposures

WTC exposures were also assessed using an interviewer administered questionnaire. Among the various exposure variables collected, four major WTC exposures were selected that potentially indicate the level of WTC dust/fumes. First, arrival time to WTC site was categorized as; (1) arrived on 9/11 in the dust cloud; (2) arrived on 9/11 but not in the dust cloud; and (3) arrived on 9/12 or later. Second, number of hours worked at WTC site in September as a continuous variable was enquired about. Third, location of work performed in September was categorized as (1) on the pile or in the pit; (2) adjacent to the pile or the pit; (3) landfill; (4) barges or loading piers; and (5) elsewhere, south of Canal St or the Office of the Chief Medical Examiner at 520 First Ave in Manhattan. The stated three WTC exposures have been described in detail elsewhere Woskie et al., 2011. Lastly, information about the type of respiratory protection equipment used in 9/11–9/18 as three categories was sought which included; (1) did not wear one; (2) nuisance dust/surgical/disposal masks, with a N95 to P100 rating at most; and (3) half-face or full-face respirator with replaceable filters/chemical cartridges/clean air supply (SCBA)/powered air purification (PAPR).¹²

2.4 | Additional covariates

Additional covariates include age at baseline visit, sex, race, and ethnicity (categorized based on the Office of Management and Budget classification), income, marital status, and cigarette smoking. Age at baseline visit was grouped into the following categories: 18–29, 30–39, 40–49, 50–59, and >60 years of age. Highest level of education

received was categorized into less than high school, high school or equivalent, more than high school, and missing.

Pre-9/11 occupations were identified by asking "what was your trade/profession on 9/10/01?" Narrative text of this occupation has been cleaned and re-categorized using the Standard Occupational Classification (SOC) 2000 developed by the Bureau of Labor Statistics (Bureau of Labor Statistics [BLS]).¹³ Five major categories were used: (1) construction workers (SOC code: 47-000); (2) protective service workers (33-000); (3) electrical, telecommunications, & other installation & repair workers (49-000, abbreviated to "utility" from here); (4) Transportation and material movers (53-000, abbreviated to "transportation" from here); and (5) business, engineering, & administration (11-000, 13-000, 17-000, abbreviated to "business" from here). Additional details of pre-9/11 occupation have been previously reported.¹⁴

2.5 | Statistical analyses

The chi-squared (χ^2) test was used to compare the distribution of baseline characteristics by employment status among WTC participants. To examine the effect of new onset asthma diagnosis on change in job status classified as: (1) from full-time to part-time; (2) full-time to disabled; (3) full-time to retired, and (4) full-time to laid-off, generalized estimating equations (GEE) were used and 95% confidence interval (CI) based on the Poisson distribution were estimated. To handle mild violations of the equidispersion assumption (underdispersion) of the Poisson distribution when the outcome variable is a binary or count response, the robust variance option in Stata was used.¹⁵ Unadjusted and adjusted models examining the association between asthma diagnosis and any change in job status (yes/no) was first modeled, with subsequent models examining the effects of asthma diagnosis on the type of change in job status as described earlier. To determine whether the distribution of demographic and WTC dust exposures differed based on asthma diagnosis, stratified models examining risk factors associated with job status change were conducted among asthmatic and non-asthmatic WTC responders.

All analyses were performed in Stata Version 12.0.¹⁶

The study was approved by the Institutional Review Board of the Feinstein Institute for Medical Research at the North Shore-LIJ Health System and only participants who provided signed consent to use their data were included in this study.

3 | RESULTS

3.1 | Descriptive characteristics

Overall 8132 WTC responders were included in the study cohort. Mean age of WTC responders was 42 (± 8 years). Among the study cohort, 87% were males, 62% were White, 11% Black, and 23% were of Hispanic ethnicity. The most common occupation at baseline was protective services (61%). Among our study cohort, 34% responders ($n = 2748$) maintained full-time status through the last visit, and 66% changed job status ($n = 5384$) at a follow-up visit. Within the 2002-2010 follow-up period, 405 (5%) WTC responders were diagnosed with asthma. Asthmatics as compared to non-asthmatics were less likely to work full-time, and more likely to retire and become disabled (Figure 1). Table 1 presents demographic, and WTC exposure-related characteristics by job status change and total cohort ($n = 25\ 787$).

3.2 | Multivariable analysis

Table 2 displays the results from the multivariable models examining the associations between asthma diagnosis, WTC-related exposures, and change in job status among participants. Asthmatics as compared to non-asthmatics were twice as likely to become disabled. In fully adjusted models, responders who reported having an asthma diagnosis had a 27% increased risk of experiencing a negative change in job status from full-time to the other categories compared to non-asthmatics (Incidence Rate Ratio [IRR] 1.27, 95%CI: 1.14-1.40). In particular, asthmatics were over two times more likely to experience a negative change in job status as a result of disability or retirement, when compared to non-asthmatic responders (IRR 2.41, 95%CI: 1.54-3.78).

Female as opposed to male were more likely to experience a job status change. Female were also significantly more likely to become retired as compared to male (IRR 1.48, 95%CI: 1.23-1.78). Being of races including Blacks, Asians, and Other races as compared to Whites were in general protective against job status change (Table 2). Table 2 also shows that those with income of \$30 000 and above were at a significantly lower risk for any job status change, job status change to part-time, being disabled, and laid-off as compared to those with income less than that. Hispanics responders were at an elevated risk for being laid-off from jobs at the follow-up visit (IRR 2.27, 95%CI:

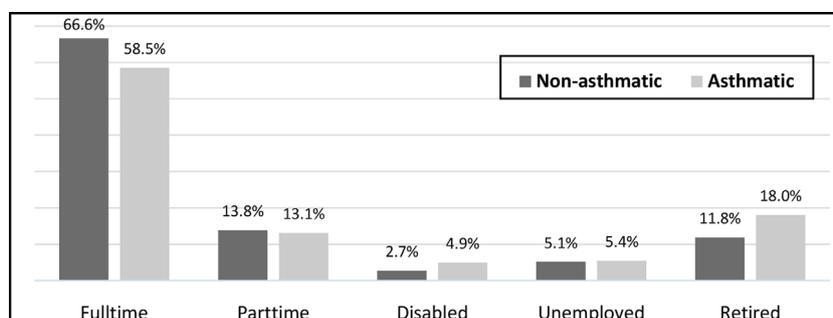


FIGURE 1 Job status change at the follow-up visit by asthma status

TABLE 1 Asthma incidence, demographics, and WTC dust exposures, by job status change within WTC Health Program participants (n = 8132)

Variables	No job status change (n = 5384)		Any job status change (n = 2748)		Total (N = 25 747)	
	n	%	n	%	n	%
Asthma diagnosis*						
Asthmatic	237	4.4	168	6.1	1039	4.0
Non-asthmatic	5147	95.6	2580	93.9	24748	96.0
Sex						
Male	4735	87.9	2378	86.5	22088	85.7
Female	649	12.1	370	13.5	3699	14.3
Race*						
White	3369	62.6	1767	64.3	15272	59.2
Black	649	12.1	270	9.8	2889	11.2
Asian	102	1.9	38	1.4	360	1.4
Other	157	2.9	57	2.1	723	2.8
Unknown	1107	20.6	616	22.4	6543	25.4
Hispanic						
Yes	1092	20.3	605	22	6091	23.6
No	3087	57.3	1516	55.2	14354	55.7
Unknown	1205	22.4	627	22.8	5342	20.7
Education*						
High school or less	3434	63.8	1950	71	17942	69.6
College or more	1825	33.9	703	25.6	7002	27.2
Unknown	125	2.3	95	3.5	843	3.3
Income*						
<\$30 000	207	3.8	228	8.3	2270	8.8
\$30-60 000	1354	25.1	567	20.6	5952	23.1
\$60-80 000	1418	26.3	686	25	5921	23.0
>\$80 000	1485	27.6	752	27.4	6606	25.6
Unknown	920	17.1	515	18.7	5038	19.5
Age at the baseline visit*						
18-29	199	3.7	93	3.4	1234	4.8
30-39	2028	37.7	758	27.6	8326	32.3
40-49	2346	43.6	1169	42.5	10536	40.9
50-59	728	13.5	578	21	4536	17.6
>60	83	1.5	150	5.5	1155	4.5
Occupation*						
Protective service	3283	61	1374	50	10590	41.1
Construction	495	9.2	402	14.6	3350	13.0
Utility	386	7.2	172	6.3	1447	5.6
Transportation	175	3.3	122	4.4	849	3.3
Business	195	3.6	92	3.3	870	3.4
Other	677	12.6	490	17.8	4571	17.7
Arrival time at the WTC site*						
On 9/11 in dust cloud	1101	20.4	546	19.9	4911	19.0
On 9/11 not in dust cloud	1411	26.2	634	23.1	5889	22.8

(Continues)

TABLE 1 (Continued)

Variables	No job status change (n = 5384)		Any job status change (n = 2748)		Total (N = 25 747)	
	n	%	n	%	n	%
Arrived 9/12 or later	2748	51	1506	54.8	14346	55.6
Respiratory protection equipment used during 9/11-9/18*						
Did not wear one	1032	19.2	495	18	4371	17.0
Dust/surgical/disposal mask	2836	52.7	1253	45.6	11739	45.5
Half-face or full respirator	749	13.9	459	16.7	4547	17.6
Other/unknown	407	7.6	231	8.4	5129	19.9
Location of worked in Sept 2001*						
On the pile	1904	35.4	978	35.6	8860	34.4
Adjacent to pile	2464	45.8	1186	43.2	11901	46.2
Landfill	140	2.6	87	3.2	687	2.7
Barges/loading piers	51	0.9	36	1.3	255	1.0
OCME	88	1.6	31	1.1	340	1.3
Elsewhere south of Canal St	400	7.4	182	6.6	1509	5.9
Unknown	337	6.3	248	9	2234	8.7
Mean total hours worked in Sept 2001 (95%CI)*	148	(145-150)	143.8	(138-145)	144	(143-145)

*Represents significant differences ($P < 0.05$) between "No job status change" and "Any job status change." Chi-square test for categorical and *t*-test for continuous variables were used.

1.24-4.17). Those with college education and above were also at a significantly lower risk for any job status change, so were older responders. With protection services as reference, all other occupation groups were at a higher risk of getting disabled and laid-off. Of note, those in construction industry were at a 21 times higher risk of getting laid-off (IRR 21.3, 95%CI: 13.77-32.85). Arriving at the disaster site on 9/11 but not in dust cloud and arriving on 9/12 and later were slightly protective against job status change, but this was not significant.

3.3 | Stratified analysis

Table 3 displays the results of the multivariable models examining the associations between participant demographics, WTC dust exposures, and job status change among asthmatic and non-asthmatic responders. Females in both asthma and non-asthma group were at an elevated risk for any job status change. Among non-asthmatics, those with college education and above were at a significantly lower risk for any job status change (IRR 0.76, 95%CI: 0.70-0.83). Non-asthmatics who earned \$30 000 and above were also at a significantly lower risk for any job status change. Risk of any job status change was higher among older age groups in both asthmatic and non-asthmatic group; however, this was not significant among asthmatics. Non-asthmatic construction workers were at higher risk for job status change but not asthmatic construction workers. In general, both asthmatics and non-asthmatics who reported wearing any type of protective personal equipment were at an elevated risk for any job status change. Responders with new-onset asthma, who worked at the landfill site, were almost twice as likely to have any job status change (IRR 1.75, 95%CI: 1.17-2.62).

4 | DISCUSSION

This study investigated the pattern of job status changes from full-time employment to less than full-time among WTC responders and compared the risk between asthmatic and non-asthmatic groups. This topic has not been previously studied among WTC responders, even though lowered socioeconomic status that could result from no longer being able to work full-time, has been shown to have a strong negative impact on quality of life and has been adversely associated with both physical and mental health.¹⁷⁻²⁰

In this study, asthma was found to be an independent predictor of job status change after controlling for demographics and WTC exposures. Responders diagnosed with asthma had a 27% greater risk of losing their full-time job, 47% higher risk of getting retired as compared to those without asthma. Our study suggests that WTC responders who developed a new onset of asthma were at increased risk of having a negative change in job status from being able to maintain full-time employment. Several prior studies have documented the complex and multidirectional association between asthma and work. In the years immediately following 9/11, new-onset asthma rates were elevated among both rescue/recovery workers and exposed community members. Similarly, studies of firefighters that were among WTC responders observed large declines in FEV1²¹ and a high prevalence of obstructive disease.²²

While our study did not focus on identifying mechanisms through which asthma could impact job status, there are several potential such explanations that have been documented in the literature. A recent study examining factors associated with poor symptom control of

TABLE 2 Adjusted associations of asthma incidence, demographics, WTC related dust exposures and change in job status among WTC Health Program Participants (n = 8132)

Variables	Any job status change (n = 2748)		Full-time to part-time (n = 1119)		Full-time to disabled (n = 225)		Full-time to retired (n = 987)		Full-time to laid-off (n = 417)	
	IRR	95%CI	IRR	95%CI	IRR	95%CI	IRR	95%CI	IRR	95%CI
Asthma diagnosis										
Non-asthmatic	1		1		1		1		1	
Asthmatic	1.27	1.14-1.40	1.06	0.86-1.30	2.41	1.54-3.78	1.47	1.22-1.78	1.00	0.65-1.55
Sex										
Male	1		1		1		1		1	
Female	1.17	1.05-1.29	0.97	0.79-1.18	1.15	0.71-1.88	1.48	1.23-1.78	0.99	0.58-1.67
Race/ethnicity										
White	1		1		1		1		1	
Black	0.79	0.70-0.89	0.69	0.55-0.87	0.70	0.42-1.15	0.75	0.60-0.94	1.31	0.84-2.06
Asian	0.78	0.57-1.07	0.48	0.24-0.95	0.88	0.21-3.74	1.05	0.63-1.76	1.42	0.66-3.06
Other	0.74	0.57-0.95	0.86	0.57-1.28	0.31	0.09-1.14	0.63	0.37-1.06	0.88	0.38-2.00
Hispanic										
No	1		1		1		1		1	
Yes	1.07	0.93-1.23	1.12	0.88-1.42	0.86	0.45-1.55	0.97	0.72-1.31	2.27	1.24-4.17
Education										
High school or less	1		1		1		1		1	
College or more	0.77	0.71-0.84	1.09	0.77-1.56	0.88	0.45-1.75	0.71	0.61-0.82	0.71	0.50-1.00
Income										
<\$30 000	1		1		1		1		1	
\$30-60 000	0.63	0.55-0.73	0.69	0.53-0.91	0.61	0.34-1.09	2.38	0.98-5.76	0.35	0.23-0.55
\$60-80 000	0.74	0.64-0.86	0.74	0.56-0.97	0.41	0.22-0.76	4.23	1.77-10.11	0.29	0.17-0.50
>\$80 000	0.76	0.65-0.88	0.81	0.61-1.06	0.32	0.17-0.61	3.88	1.61-9.34	0.31	0.19-0.50
Age at the baseline visit										
18-29	1		1		1		1		1	
30-39	0.96	0.78-1.19	0.99	0.71-1.38	0.89	0.38-2.11	1.35	0.45-3.99	0.86	0.51-1.44
40-49	1.17	0.95-1.44	0.82	0.59-1.34	1.09	0.47-2.49	2.75	0.92-8.16	1.06	0.65-1.74
50-59	1.59	1.28-1.96	0.83	0.58-1.18	1.75	0.75-4.09	7.17	2.36-21.79	1.25	0.70-2.25
60 and above	2.18	1.74-2.75	0.76	0.45-1.26	0.76	0.20-2.89	22.49	7.18-70.48	0.45	0.19-1.05
Occupation										
Protective service	1		1		1		1		1	

(Continues)

TABLE 2 (Continued)

Variables	Any job status change (n = 2748)		Full-time to part-time (n = 1119)		Full-time to disabled (n = 225)		Full-time to retired (n = 987)		Full-time to laid-off (n = 417)	
	IRR	95%CI	IRR	95%CI	IRR	95%CI	IRR	95%CI	IRR	95%CI
Construction	1.26	1.14-1.40	1.07	0.88-1.31	3.63	2.40-5.49	0.38	0.29-0.49	21.3	13.77-32.85
Utility	0.67	0.74-1.01	0.97	0.75-1.27	1.58	0.89-2.80	0.42	0.31-0.56	6.01	3.29-10.97
Transportation	1.15	0.98-1.34	1.23	0.91-1.68	2.88	1.56-5.30	0.54	0.38-0.76	8.83	4.5-17.3
Business	0.88	0.72-1.07	1.19	0.85-1.67	1.59	0.72-3.51	0.36	0.23-0.54	6.45	3.22-12.89
Other	1.15	1.03-1.28	1.36	1.14-1.63	1.74	1.09-2.77	0.31	0.23-0.40	12.61	8.08-19.68
Arrival time at the WTC site										
On 9/11 in dust cloud	1		1		1		1		1	
On 9/11 not in dust cloud	0.96	0.88-1.06	0.98	0.31-1.16	0.77	0.48-1.21	1.05	0.88-1.24	0.97	0.59-1.61
Arrived 9/12 or later	0.94	0.86-1.03	0.98	0.84-1.15	0.79	0.55-1.15	0.87	0.74-1.02	1.07	0.69-1.65
Respiratory protection equipment used during 9/11-9/18										
Did not wear one	1		1		1		1		1	
Dust/surgical/disposal mask	0.99	0.91-1.08	1.05	0.90-1.23	0.86	0.58-1.25	1.00	0.85-1.18	0.77	0.53-1.13
Half or full face respirator	1.10	0.99-1.22	1.24	1.02-1.50	0.98	0.62-1.56	0.88	0.70-1.10	1.16	0.76-1.78
Location of worked in Sept 2001										
On the pile	1		1		1		1		1	
Adjacent to pile	0.94	0.87-1.01	0.92	0.80-1.04	0.90	0.62-1.28	0.98	0.84-1.13	0.87	0.65-1.18
Landfill	1.16	0.95-1.41	0.99	0.67-1.45	0.15	0.02-1.16	1.68	1.20-2.34	2.10	0.63-7.00
Barges/loading piers	1.31	1.02-1.68	1.64	1.06-2.54	1.56	0.41-6.00	1.29	0.73-2.31	0.70	0.27-1.81
OCME	0.84	0.61-1.67	0.93	0.55-1.58	0.31	0.03-2.78	0.85	0.48-1.51	0.51	0.11-2.42
Elsewhere South of Canal St	0.97	0.85-1.11	0.96	0.75-1.23	0.72	0.36-1.47	1.03	0.80-1.32	1.51	0.79-2.88
Mean total hours worked in Sept 2001 (in 100 h)	1.02	0.99-1.06	1.00	0.96-1.09	0.91	0.75-1.07	1.00	0.96-1.10	1.03	0.87-1.19

All the variables listed in the Table 2 are used for estimating adjusted Incidence Rate Ratios from multivariable regression modelling.

TABLE 3 Adjusted associations of demographics, WTC dust exposures and job status change among asthmatics and non-asthmatics within WTC Health Program participants

Variables	Any job status change			
	Asthmatics (N = 405)		Non-asthmatics (N = 7727)	
	IRR	95%CI	IRR	95%CI
Sex				
Male	1		1	
Female	1.15	0.91-1.45	1.16	1.04-1.31
Race/ethnicity				
White	1		1	
Black	0.85	0.59-1.22	0.79	0.70-0.89
Asian	0.19	0.03-1.15	0.84	0.61-1.15
Other	1.09	0.65-1.82	0.72	0.55-0.94
Hispanic				
No	1		1	
Yes	1.18	0.80-1.72	1.08	0.93-1.25
Education				
High school or less	1		1	
College or more	0.92	0.74-1.15	0.76	0.70-0.83
Income				
<\$30 000	1		1	
\$30-60 000	0.96	0.59-1.56	0.60	0.52-0.70
\$60-80 000	0.97	0.59-1.61	0.71	0.61-0.83
>\$80 000	1.07	0.64-1.77	0.73	0.62-0.85
Age at the baseline visit				
18-29	1		1	
30-39	0.64	0.40-1.04	0.98	0.79-1.23
40-49	0.98	0.62-1.54	1.18	0.94-1.47
50-59	1.10	0.69-1.75	1.62	1.29-2.03
60 and above	1.25	0.68-2.27	2.27	1.78-2.90
Occupation				
Protective service	1		1	
Construction	0.86	0.58-1.27	1.28	1.15-1.42
Utility	0.76	0.49-1.18	0.88	0.75-1.04
Transportation	1.19	0.73-1.94	1.15	0.97-1.35
Business	1.01	0.61-1.66	0.87	0.71-1.07
Other	1.06	0.80-1.41	1.16	1.04-1.30
Arrival time at the WTC site				
On 9/11 in dust cloud	1		1	
On 9/11 not in dust cloud	1.00	0.78-1.28	0.96	0.87-1.06
Arrived 9/12 or later	0.91	0.72-1.16	0.94	0.86-1.03
Respiratory protection equipment used during 9/11-9/18				
Did not wear one	1		1	
Dust/surgical/disposal mask	1.12	0.87-1.45	0.98	0.89-1.07
Half or full face respirator	1.38	1.01-1.88	1.08	0.97-1.21
Other/Unknown	1.33	0.95-1.87	1.12	0.98-1.28

(Continues)

TABLE 3 (Continued)

Variables	Any job status change			
	Asthmatics (N = 405)		Non-asthmatics (N = 7727)	
	IRR	95%CI	IRR	95%CI
Location of worked in Sept 2001				
On the pile	1		1	
Adjacent to pile	0.96	0.77-1.18	0.93	0.86-1.01
Landfill	1.75	1.17-2.62	1.14	0.93-1.40
Barges/loading piers	1.29	0.64-2.62	1.31	1.01-1.70
OCME	0.56	0.18-1.73	0.86	0.61-1.20
Elsewhere South of Canal St	0.97	0.65-1.45	0.98	0.85-1.13
Mean total hours worked in Sept 2001 (in 100 h)	1.04	1.00-1.14	1.02	0.98-1.06

All the variables listed in the Table 3 are used for estimating adjusted Incidence Rate Ratios from multivariable regression modeling.

9/11-related asthma observed that more than a decade after WTC exposure, more than two thirds of asthmatics had either poorly controlled or very poorly controlled asthma symptoms. Notably, the presence and number of mental health conditions including probable post-traumatic stress disorder, depression, and generalized anxiety disorder were associated with poorer asthma control.²³

The stratified analyses showed that in general, responder demographic characteristics influenced job status change among both asthmatics and non-asthmatics. However, when looking at occupational categories, with protective service as reference, only non-asthmatic construction workers had a significantly higher risk of any job status change. Transportation workers among both asthma groups also had an elevated risk for job status change, although this was not significant. The findings of this study are consistent with prior studies showing the impacts of asthma, job loss, and productivity among blue collar workers, but significantly contribute to the literature by including in the analyses, workers employed in business, protective service, and other occupational categories in a work group that had not been investigated earlier for this relation.

This study has limitations, which should be considered when interpreting the findings. While it is estimated that there could have been around 90 000 WTC responders,¹¹ this study only covers 25 787 responders. There is no information available on the remaining responders and any conclusions drawn from this study only imply to the study cohort. There could be differences between our cohort and the remaining responder population.

Next, additional information on asthma symptoms, medication use, or spirometer evaluations among the study participants was not used in this analysis; as such, there may be potential for misclassification of asthma diagnosis among participants. Also latency of asthma diagnosis since 9/11 was not considered in the analysis. It is possible that the time distance from WTC exposure to asthma diagnosis can differently affect to job status change. As questions regarding change in job status were asked at each follow up visit, recall bias cannot be excluded, as asthmatics may differentially report changes to their employment status when compared to non-asthmatics. While many of findings of this study are consistent with other literature examining

asthma and job loss, since the study sample is limited to responders who were exposed to the WTC disaster, the findings may not be generalizable to other populations or geographic contexts.

To the extent of our knowledge, the present study is the first study to examine the association between new onset asthma resulting from exposures due to working at the WTC disaster site and changes in job status. Findings from this study contribute to a growing body of literature demonstrating the negative impacts of asthma in terms of change in job status from full-time which may have potential negative socioeconomic consequences. The reduction in socioeconomic status should be considered an important adverse consequence of WTC exposure as lowered socioeconomic status may lead to increased risk of new health problems or worsening of existing health conditions. Additional programs and outreach efforts are recommended to assist responders who have experienced job loss or negative changes to their employment responsibilities, particularly among those who have also experienced health problems.

AUTHORS' CONTRIBUTIONS

HK lead entire process. SB collaborated on the conceptualization of paper; interpreted results, edited the manuscript. MC collaborated on the conceptualization of paper; interpreted results, edited the manuscript. JM collaborated on the conceptualization of paper; interpreted results, edited the manuscript. NB interpreted results, edited the manuscript. AS interpreted results, edited the manuscript.

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ETHICS APPROVAL AND INFORMED CONSENT

The study was approved by the Institutional Review Board of the Feinstein Institute for Medical Research at the North Shore-LIJ Health System and University of Minnesota and only participants who provided signed consent to use their data were included in this study.

DISCLOSURE (AUTHORS)

The authors report no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

Paul Landsbergis declares that he has no conflict of interest in the review and publication decision regarding this article.

DISCLAIMER

None.

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