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The World Trade Center Disaster and the Health of Workers: Five-Year Assessment of a Unique Medical Screening Program

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Abbreviations:

AOEC	Association of Occupational and Environmental Clinics
ATS	American Thoracic Society
BD	bronchodilator
COEM	Irving J. Selikoff Center for Occupational and Environmental Medicine
EPA	United States Environmental Protection Agency
ESC	Executive Steering Committee
FDNY	New York City Fire Department
FEV_1	Forced Expiratory Volume
FVC	Forced Vital Capacity
GERD	Gastro-esophageal reflux disorder
HIPAA	Health Insurance Portability and Accountability Act
IRB	Institutional Review Board
L	Liters
LLN	Lower Limit of Normal
$\mu g/m^3$	Micrograms per cubic meter
MSP	World Trade Center Worker and Volunteer Medical Screening Program
NHANES	National Health and Nutrition Examination Survey
NIOSH	National Institute for Occupational Safety
PAH	Polycyclic aromatic hydrocarbons
PATH	Port Authority Trans- Hudson
PFT	Pulmonary function test
pH	power of hydrogen
OCME	Office of the Chief Medical Examiner
RADS	Reactive Airway Dysfunction Syndrome
VOC	Volatile organic compound
WTC	World Trade Center

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Abstract

Background. An estimated 40,000 rescue and recovery workers were exposed to caustic dust and airborne toxins following the September 11, 2001 World Trade Center (WTC) attacks. These workers included traditional first responders such as firefighters and police as well as a diverse population of construction workers, utility workers, and public servants.

Methods. The WTC Worker and Volunteer Medical Screening Program (MSP) was established to identify and characterize possible WTC-related health effects in responders. The MSP is a multi-center clinical screening program that provided free standardized examinations to responders between July 2002 and April 2004. Examinations included medical, mental health, and exposure assessment questionnaires, physical examination, spirometry both pre- and post-bronchodilator, and chest X-ray.

Results. Sixty-nine percent of 9,442 responders reported new or worsened respiratory symptoms while performing WTC work. Symptoms persisted to the time of examination in 59%. Among the 85% who were asymptomatic before 9/11, 61% developed respiratory symptoms while working at the WTC. Twenty-nine percent had abnormal spirometry, with low FVC in 21% and obstruction in 6%. In non-smokers, 28% had abnormal spirometry compared to 13% in the general US population. Respiratory symptoms and PFT abnormalities were significantly associated with early arrival at the site.

Conclusion. WTC responders had exposure-related increases in respiratory symptoms and PFT abnormalities that were persistent up to 2.5 years after the attacks. Continuing medical monitoring will be required to track persistence of these abnormalities and to identify late effects, including possible malignancies. Lessons learned have the potential to guide future responses to civil disasters.

INTRODUCTION

An estimated 40,000 men and women worked at Ground Zero, the former site of the World Trade Center (WTC) in New York City, and at the Staten Island landfill, the principal wreckage depository in the days, weeks, and months after September 11, 2001 (Levin et al., 2004). Firefighters, law enforcement officers, paramedics, construction workers, utility workers, volunteers, and others carried out rescue-and-recovery operations, restored essential services, cleaned up massive amounts of debris and, in a time period far shorter than anticipated, deconstructed and removed remains of buildings. The diverse worker and volunteer group included operating engineers, laborers, ironworkers, railway tunnel cleaners, telecommunications workers, and workers at the landfill and the Office of the Chief Medical Examiner. Many had no training in response to civil disaster. The highly diverse nature of this workforce posed unprecedented challenges for worker protection and medical follow-up.

Workers were exposed to a complex mix of toxic chemicals and extreme psychological trauma that varied over time and by location (Landrigan et al., 2002; Lioy et al., 2002). Combustion of 90,000 L of jet fuel created a dense plume of black smoke containing volatile organic compounds (VOCs, including benzene), metals, and polycyclic aromatic hydrocarbons (PAHs). The collapse of the "twin towers" (WTC 1 and WTC 2) and then of a third building (WTC 7) produced an enormous dust cloud containing thousands of tons of coarse and fine particulate matter (PM), cement dust, glass fibers, asbestos, lead, hydrochloric acid, polychlorinated biphenyls (PCBs), organochlorine pesticides, and polychlorinated dioxins and furans (Clark et al., 2003; Landrigan et al., 2004; Lioy et al., 2002; McGee et al. 2003). EPA estimates of airborne dust ranged from 1,000 $\mu g/m^3$ to

over 100,000 μg/m^3 (U.S. EPA 2002). The high content of pulverized cement made the dust highly caustic (pH 10-11) (Lioy et al., 2002; Landrigan et al., 2004).

Dust and debris gradually settled, and rains on 9/14 diminished the intensity of outdoor ambient dust exposure somewhat. However, rubble removal processes repeatedly re-aerosolized the dust, leading to continuing intermittent exposure for many months. Fires burned both above and under ground until December 2001 (Banauch et al. 2003; Chen and Thurston 2002; US EPA 2003). Levels of certain contaminants remained high well into 2002, with spikes in both benzene and asbestos levels, for example, as late as March and May 2002 respectively (US EPA 2003).

Workers began noting symptoms soon after September 11th, most commonly involving the aero-digestive tract (upper and lower respiratory tract and GERD) (Szeinuk et al., 2003; Banauch et al., 2006). FDNY firefighters experienced persistent cough, termed the "World Trade Center cough," accompanied by respiratory distress and bronchial hyperreactivity (Prezant et al., 2002). A sample of FDNY firefighters who had sustained extreme exposures on September 11th was nearly 8 times more likely to manifest bronchial hyperreactivity than firefighters with lower exposures when examined after six months (Banauch et al., 2003). Laborers and ironworkers manifested new-onset cough, wheeze, and sputum production (Geyh et al., 2005; Skloot et al., 2004), likely attributable to respiratory inflammation caused by the highly alkaline dust (Chen and Thurston 2002).

Other reported pulmonary effects included cough, asthma, and RADS (Banauch et al., 2006; Balmes et al., 2006). Chronic rhinosinusitis, vocal cord inflammation, and laryngitis (de la Hoz et al., 2004) and case reports of eosinophilic pneumonia (Rom et al.

2002), granulomatous pneumonia, and bronchiolitis obliterans (Safirstein et al., 2003; Mann et al., 2005) were also reported.

Although New York has an extensive hospital network and strong public health system, no preexisting infrastructure was sufficient for providing unified and appropriate occupational health screening and treatment in the aftermath of 9/11. Local labor unions, whose members made up the majority of responders, became increasingly aware that their members were developing respiratory and psychological problems and developed an active campaign to educate local elected officials about the importance of establishing an occupational health screening program. In early 2002, Congress directed the Centers for Disease Control (CDC) to fund most of the MSP, an action attributable in large part to the collaborative efforts of organized labor and elected officials. The goals of the program were:

- To rapidly develop a clinical program by building a regional and national consortium of occupational medicine clinics to conduct geographically convenient standardized WTC responder medical evaluations.
- To develop a proactive outreach program to identify WTC responders, notify them about this clinical program, and encourage participation.
- To provide clinical examinations for eligible individuals to identify WTC-related physical and/or mental health conditions.
- To coordinate referral for follow-up clinical care for affected individuals.

- To educate workers and volunteers about exposures and associated risks to their health.

- To advise affected individuals about available benefit and entitlement programs.

- To establish "baseline" clinical status for individuals exposed at or near Ground Zero for comparison with future clinical assessments for diseases with longer latency and to provide a basis for long-term follow-up.

In April 2002, the Irving J. Selikoff Center for Occupational and Environmental Medicine (COEM) at Mount Sinai was awarded a contract by NIOSH to establish and coordinate the MSP. The Bellevue/New York University Occupational and Environmental Medicine Clinic, the State University of New York Stony Brook/Long Island Occupational and Environmental Health Center, the Center for the Biology of Natural Systems at Queens College in New York, and the Clinical Center of the Environmental & Occupational Health Sciences Institute at UMDNJ-Robert Wood Johnson Medical School in New Jersey were designated as the other members of the regional consortium. The Association of Occupational and Environmental Clinics (AOEC) was designated to coordinate a national examination program for responders who did not live in the New York/New Jersey area.

This paper describes design and implementation of the MSP and prevalence of selected clinical findings from screening examinations conducted between July 2002 and April 2004 in those from whom informed consent and HIPAA authorization were obtained. Mental health service provision and findings will be presented in a separate paper.

MATERIALS AND METHODS

Establishing the Cohort: Identification and Outreach

The target population was approximately 18,000 WTC responders not eligible to participate in other federally-funded programs (e.g., the FDNY program). No systematic roster of names and contact information was available. An MSP Outreach Unit was therefore established and staffed by people experienced in occupational health and familiar with key organizations, primarily labor unions representing responders. Staff worked to customize outreach to usual modes of communication. Many unions requested speakers at meetings while others sent mailings to members. One union recorded a telephone message for members waiting on hold and another sent a "blast" telephone message recorded by the union president to thousands of their members urging enrollment in the MSP.

The MSP Executive Steering Committee

To ensure key stakeholder input into all aspects of program development and oversight, a program Executive Steering Committee (ESC) was established. Twenty-five Executive Steering Committee members were appointed by NIOSH, with significant input from relevant stakeholders. ESC members included representatives from each of the consortium clinics, representatives from labor unions, employers, and technical experts from relevant fields.

The ESC advised the program directors on all program decisions and basic components of the medical examination, eligibility criteria, and the outreach plan. An Advisory

Council of more than 100 people was created several months after the start of the program in order to broaden stakeholder involvement in the program. Size limitations of the ESC had precluded dozens of organizations from ESC membership. The Advisory Council tapped into the enthusiasm and creativity of responder organizations. Generally 40-50 responder representatives attended quarterly Advisory Council meetings. The ESC and Advisory Council helped maintain open lines of communication with representatives of the program's diverse responder population.

Examination Eligibility

The MSP established a multi-lingual phone bank (English, Spanish, and Polish) to determine eligibility of prospective participants, schedule appointments, and make referrals for those noting meeting eligibility criteria. To be eligible to receive an examination, a responder must have been either:

A rescue, recovery, debris cleanup and related support services worker or volunteer in (a) lower Manhattan, south of Canal St, and/or (b) the Staten Island Landfill, and/or (c) barge loading piers, and have worked and/or volunteered on-site for 4 hours from September 11-14, 2001, or at least 24 hours during the month of September, or for at least 80 hours during the months of September, October, November, and December combined.

or

To have been an employee of the Office of the Chief Medical Examiner (OCME) involved in the examination and processing of human remains or other morgue worker who performed similar post-9/11 functions to OCME staff; a worker in the Port Authority Trans-Hudson Corporation (PATH) tunnel from 9/11/02-7/1/02 for a minimum of 24

hours; a vehicle maintenance worker with post-9/11 functions within the requisite timeframes and exposure to WTC debris while retrieving, driving, cleaning, repairing, and maintaining contaminated vehicles.

Eligible responders were invited for clinical examinations irrespective of their willingness to provide consent to have data aggregated. Only data from responders providing IRB consent and HIPAA authorization (on or after April 14, 2003) are included in data analyses.

Development of the examination protocol

The clinical consortium partners, supplemented by experts in psychiatry, pulmonary medicine, otolaryngology, industrial hygiene, and epidemiology, collaborated in protocol development to provide high quality standardized occupational health screening examinations and gather information for a research database to enable scientific assessment of the full health impact of the disaster. A decision was made early in protocol planning that direct clinical services had priority where clinical protocols conflicted with collection of research data.

Standardized Medical Examination

Responders received a clinical screening evaluation consisting of medical, mental health and exposure-assessment questionnaires, a standardized physical examination, pre- and post-bronchodilator (BD) spirometry, complete blood count, blood chemistries, urinalysis, and chest radiograph. Participants received both immediate and final letters with examination results and a face-to-face physician consultation at the end of the

examination day. Participants were provided referrals for evaluation and treatment for physical or mental health conditions identified in the screening examination.

A trained healthcare practitioner administered a medical questionnaire on selected diagnoses and on prior upper and lower respiratory conditions (e.g., chronic sinusitis and asthma); occurrence of symptoms in the year before 9/11/01, while working at the WTC site, for the month before the screening examination and whether pre-existing symptoms and diagnoses worsened during their WTC work; smoking history. Where possible questions were adapted from standardized instruments (e.g. Miller et al., 2005; Burney et al., 1989; ECRHS 1994; NCHS 1996; NIOSH 2006; Piccirillo et al., 2002).

Pulmonary Function Examination

Spirometric examination employed the EasyOne spirometer (ndd Medical Technologies, Chelmsford, MA) using standard techniques (Miller et al., 2005). We compared spirometry results to age-, gender-, and ethnic-specific reference values derived from the NHANES III national population survey (Hankinson et al., 1999). Interpretation followed American Thoracic Society guidelines (Pellegrino et al., 2005). Airway obstruction was defined as FEV_1/FVC below the lower limit of normal (LLN) (i.e., below the 5^{th} percentile of predicted) with a normal FVC. Spirometry with FVC < LLN but $FEV_1/FVC \geq$ LLN was categorized as "low FVC." Obstruction and low FVC was defined as FEV_1/FVC and FVC below the LLN. A significant bronchodilator response was defined as an increase in FEV_1 or FVC of greater than 12% and 200 ml. Comprehensive spirometry quality assurance was an integral aspect of this program. Only spirometry of acceptable quality (Miller et al., 2005) was included in the analysis (n=8,384).

Exposure Assessment Questionnaire

We used an interviewer-administered survey instrument to obtain pre- and post-9/11 occupational and environmental exposure histories, including dates that responders reported for first working or volunteering for 9/11-related duties and, for those present on 9/11, whether they were exposed to the cloud of dust from the building collapses. We constructed the ordinal date-related categories shown in the tables as a rough measure of relative dust exposures, and also categorized workers by location where they spent the majority of their time when first working at Ground Zero. We also obtained data on respirator type and use during the first week of the WTC recovery and will report those data in subsequent analyses.

Data analysis

We used SAS 9.1 (SAS Institute, Inc., Cary, NC) for all analyses. Categorization of occupational sector was based on the union and/or organization to which the responder reported belonging during work on the WTC effort. We categorized prevalence of specific health outcomes by date of arrival and exposure to the dust cloud and used the Cochrane-Armitage trend test to assess significance of trends in prevalence across exposure categories.

RESULTS

The MSP began examining responders in July 2002, three months after receipt of federal funding. Of the 16,528 responders meeting eligibility criteria, we examined 11,095 responders in the New York / New Jersey regional clinical consortium (85% at Mount

Sinai), and 645 elsewhere between July 16, 2002 and April 16, 2004. In the NY/NJ Consortium, 9,442 responders provided appropriate IRB consent and HIPAA authorization to be included in this report.

Demographics: The responders screened in this program were predominantly male (87%) and white (66%), with a median age of 42 years (range: 18-82 years) (Table 1), with more than 90% living in the tristate (New York, New Jersey, Connecticut) area: 54% from New York City and 15% on Long Island. Eighty-six percent were union members. Thirty-four percent were construction workers and 29% law enforcement. We conducted more than 14% of the examinations in languages other than English.

Time of arrival and location: As shown in Table 1, more than 40% of the screenees first arrived for work at the site on September 11th, with 49% reporting being engulfed in the building-collapse dust cloud. Thirty percent first arrived on 9/12 or 9/13. About one-third (35%) reported initially working on the pile or in the pit at Ground Zero for the majority of their shift. Another 55% worked adjacent to the pile. The remaining 10% worked at other sites, including the Staten Island landfill, on the barges or loading piers, or at the OCME. The reported average duration of exposure (the time between the first and last days of work on the WTC effort) was 171 days (range, 1 day to 2.5 yrs). The average time between first work day and the MSP examination was 20 months.

Symptoms: Most of the 9,442 responders examined reported being asymptomatic in the year prior to 9/11 for lower respiratory tract symptoms (85%) and a large majority (66%) were asymptomatic for upper respiratory tract symptoms (Table 2). In the previously asymptomatic group, 44% reported developing lower respiratory symptoms and 55%

developed upper respiratory symptoms while engaged in WTC-related work. These newly incident symptoms were persistent in many; at the time of exam, 32% reported still experiencing lower respiratory symptoms and 44% reported still experiencing upper respiratory symptoms (Table 2). Fully 69% of all responders reported having had at least one WTC-worsened or newly incident respiratory symptom while performing WTC response work (63%, upper airway and 47% lower airway symptoms, with overlap between the groups) (Table 3).

Early arrival at the WTC site was significantly associated with an increased prevalence of both the newly incident and worsened respiratory symptoms reported (Table 3). We observed the highest prevalence among those who arrived on September 11th and were exposed to the dust cloud (54% lower, and 66% upper respiratory symptoms). Those who began work on September 11th without reporting dust cloud exposure had the next highest prevalence (47% lower, and 62% upper respiratory symptoms). We found a statistically significant downward trend (although the prevalence remained high) in the incidence of reported symptoms for later arrival dates. Even those who arrived at the site on or after October 1st had a 41% prevalence of lower respiratory and 59% prevalence of upper respiratory symptoms, which is nearly three times the percentage who had reported lower respiratory symptoms in the year prior to 9/11 and nearly twice that of those with upper respiratory symptoms before 9/11.

Twenty-nine percent of the 8,384 participants with acceptable quality pulmonary function exams had abnormal pre-bronchodilator spirometry results (Table 4). A low FVC was the most common abnormality (21%), while obstruction occurred in 6% and a mixed pattern (obstruction and low FVC) in 2%. We also documented a significant response to

bronchodilator in 1,039 (11%) of all participants including 33% of those with obstruction, 56% with a mixed pattern, and 19% of those with a low FVC.

Compared with a US general population sample of employed, adult, white males (Mannino et al., 2003), the 4641 participants who had never smoked had a higher prevalence of abnormalities on spirometry (28% vs. 13%). The difference was mainly attributable to a higher prevalence of tests with a low FVC (21% vs. 4%).

A statistically significant association was observed between time of arrival and low FVC, with a higher prevalence of abnormality in those who arrived earlier (Table 5). There was no significant difference in the prevalence of obstruction based on onset of exposure.

Thirty-one percent of the sample reported having received medical care for WTC-related respiratory conditions. A total of 17 % of examinees reported missing work because of WTC-related health problems. Of the 1973 workers with a self-reported history of sinusitis, 40% were diagnosed with sinusitis during the six months after 9/11, compared to only 12% in the six months prior to 9/11. Similar increases were reported in the numbers of responders who sought medical help for acute bronchitis (45% vs. 12%) and pneumonia (10% vs. 1%).

DISCUSSION

Two principal lessons emerge from our experiences with the World Trade Center Worker and Volunteer Medical Screening Program. First, the prevalence rates of respiratory and other symptoms, and the prevalence of pulmonary function abnormalities in the nearly 10,000 WTC workers and volunteers whom we examined clinically between 2002 and

2004 were very high. Not surprisingly, health effects were most frequent and severe in responders who sustained the most intense exposures. In the aftermath of future civil disasters, health care providers will need to anticipate and prepare for the inevitable health consequences from the extreme exposures sustained by workers in these situations. Second, in the event of future disasters, it is likely that large, multi-center medical follow-up programs will again be needed and the experience we have gained through this program can provide unique lessons, both positive and negative.

Abnormal spirometry was still evident in almost one third of all WTC workers and volunteers one to two and a half years after September 11, 2001. The most common spirometric abnormality seen was a low FVC, as reported in the first 1,138 participants (Levin et al., 2004). This pattern was about 5 times more prevalent than expected in the general US population, based on NHANES III data (Mannino et al., 2003). Possible explanations for a low FVC include obesity, submaximal inspiratory and/or expiratory effort, parenchymal lung disease (e.g., pneumoconiosis), and air trapping. Air trapping can cause a "pseudorestrictive" pattern with a low FVC but a normal total lung capacity (as seen on a chest radiograph taken at full inspiration). A low FVC due to air trapping often partially reverses following inhaled bronchodilator, a finding seen in 19% of WTC workers and volunteers with this pattern. A significant increase in the low FVC pattern was seen in participants who arrived at the disaster site closer to the time of the collapse of the towers than in those who arrived on or after October 1st. Further analyses that include lung volume testing, gas exchange measurement and review of radiographic studies are warranted to clarify the implications of these results. Given the high frequency of asthma–like respiratory symptoms in this cohort, the relatively low prevalence of

airway obstruction when compared to a national population survey was surprising. One possible explanation is that the irritant-induced airway obstruction had resolved by the time of this examination but that air trapping was slower to resolve. This cannot be the sole mechanism since Feldman and colleagues (Feldman et al., 2004) found a nearly equal reduction in FVC and FEV_1 (not an obstructive pattern) 3 weeks after the disaster on a sample of firefighters. We will examine this issue further during follow up evaluations of this cohort.

The frequency of respiratory symptoms in these workers is consistent with that seen in other medical evaluations of 9/11 responders (Balmes et al., 2006; Salzman et al., 2004; Prezant et al., 2002; Rom et al., 2002) as well as with reports of new or worsening respiratory symptoms by adult survivors of collapsed and damaged buildings who were exposed to the dust and debris cloud (73% vs. 67%) (Brackbill et al., 2006). The severe respiratory effects that we observed reflect the toxic nature of the dust, with its intense alkalinity and billions of microscopic shards of glass (Chen and Thurston 2002; Landrigan et al., 2004; Lioy et al., 2002).

The MSP faced many challenges which are likely to arise in other major civil disasters. We faced organizational challenges in coordinating work at five clinical sites in the New York New Jersey metropolitan area, as well as in the national program. There was no systematic roster of responders. The population was large, diverse, and with little formal training in disaster preparedness. We found that a broad and vigorous outreach program to systematically identify responders and persuade them of the importance of undergoing examination was urgently needed. Most of these workers, many of whom had volunteered their services after September 11th, were unable to take paid time off to be

screened, and many were not in the position to forfeit a day's wages. We needed to schedule the examinations at times and in locations that respected those difficulties. The examination content needed to be relevant and acceptable to the responders and at the same time sufficiently standardized to permit interpretation of aggregated clinical data. Translation was one of the more challenging aspects of program coordination. More than 14% of responders required non-English examinations and written materials.

The need for follow-up medical treatment and social benefits in the event of future civil disasters must be anticipated and federal funds must be provided early on to support such programs. There was substantial social and economic disruption to the lives of many of the responders and benefits counseling became an urgent need and an integrated component of the MSP. Many responders need follow-up treatment for physical or mental health illnesses, and many lacked health insurance. We felt obliged to secure private funding from philanthropic organizations to develop and implement treatment programs for responders. Federal funding for treatment of these workers is anticipated to begin in Fall 2006.

Several limitations to the data should be noted. By necessity we do not have uniform pre-9/11 clinical information. The time urgency for establishing the MSP and practical and financial constraints precluded our designing a control population into the project. It may be that those responders who were sicker were more likely to participate leading to an overestimation of risk. Conversely, we may be underestimating risk because most responders were likely to have been fit workers (healthy worker effect). This paper does not consider the psychological consequences, which we already know to be serious (Smith et al., 2004). Subsequent papers will address responder mental health.

CONCLUSIONS

The workers and volunteers who served New York City and the Nation through their heroic service in the aftermath of September 11, 2001 need continuing medical surveillance and follow-up, especially since some diseases, like cancer, are of long latency. Malignant mesothelioma resulting from exposure to asbestos, for example, may not become evident for 30 to 50 years. These biological facts and the unprecedented magnitude and complexity of the exposures mean that WTC responders should be monitored for at least twenty to thirty years, so that long-term effects are detected early, when treatment would be most beneficial.

The most important lesson we have learned is preparedness. Federal leadership is needed to bring together a wide range of both civilian and military experts to consider in advance and prepare for the complex physical and mental health issues and the environmental issues certain to arise in future disasters. Future programs of disaster response must include both diagnosis and treatment and must make a firm commitment for the long-term follow up of exposed workers to ensure that chronic health effects which may not become apparent until years after the event are identified and treated in a timely fashion. Finally, there is a need to ensure strong and active participation by worker representatives and other stakeholders. A lesson taught by both 9/11 and Hurricane Katrina is that the affected population has deep and intimate knowledge of problems on the ground. This unique local knowledge will not become available to state and federal planners unless stakeholders are invited to take an active role in the planning and implementation of responses to future disasters.

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Table 1. Demographic and exposure characteristics of the WTC Medical Screening Program study population (n=9442)

	N	%
Gender		
Male	8186	86.7
Female	1256	13.3
Race		
White	6203	65.7
Black	1060	11.2
Asian	121	1.3
Other	253	2.7
Unknown	1805	19.1
Hispanic Ethnicity		
Yes	2249	23.8
Language of exam		
English	8114	85.9
Spanish	984	10.4
Polish	311	3.3
Other	33	0.3
Union member		
Yes	8075	86.0
Union/organization affiliation		
Construction	3207	34.0
Law Enforcement	2775	29.4
Public Sector -- Blue Collar	739	7.8
Technical and Utilities	683	7.2
Transportation	516	5.5
Cleaning/Maintenance	258	2.7
Volunteers	245	2.6
Firefighters*	138	1.5
Health Care	83	0.9
News Agencies	81	0.9
Office/Administration/Professional	50	0.5
Other	664	7.0
Time first began WTC-related work		
On 9/11	3812	40.5
On 9/11 and in dust cloud	1878	20.0
On 9/11 and not in dust cloud	1934	20.5
9/12-9/13	2801	29.8
9/14-9/30	2133	22.7
On or after 10/1	666	7.1
Location of majority of work		
On the pile/in the pit	3215	34.8
Adjacent to pile/pit	5074	54.8
Landfill	313	3.4
Barges/loading pier	106	1.1
OCME	77	0.8
Elsewhere south of Canal St.	466	5.0

*Does not include active-duty New York City firefighters

Table 2. Prevalence of lower and upper respiratory symptoms among the WTC Medical Screening Program study population (n=9442)

	Responders who reported symptoms in year prior to 9/11		Responders who did not report symptoms in year prior to 9/11: New symptoms while working at WTC site		Responders who did not report symptoms in year prior to 9/11: Symptoms still present in month prior to exam	
	N	%	N	%	N	%
Lower Respiratory Symptoms						
Dry cough	362	3.9	2541	28.3	1534	17.1
Cough with phlegm	325	3.5	1183	13.1	742	8.2
Shortness of breath	344	3.7	1477	16.5	1266	14.1
Wheeze	557	6.0	1232	14.1	749	8.6
Chest tightness	464	5.1	1258	14.6	933	10.8
Any lower respiratory symptom	1451	15.4	3486	43.8	2535	31.9
Upper Respiratory Symptoms						
Sinus-related[1]	2169	23.1	2219	30.7	1863	25.8
Nasal-related[2]	1967	20.9	3254	43.8	2536	34.1
Throat-related[3]	887	9.4	3579	42.0	2450	28.8
Any upper respiratory symptom	3148	33.5	3453	55.2	2772	44.3
Any respiratory symptom	3767	40.0	3443	61.0	2846	50.4

[1] Facial pain or pressure, head of sinus congestion, or post-nasal discharge
[2] Blowing your nose more than usual, stuffy nose, sneezing, runny nose, or irritation in nose
[3] Throat irritation, hoarseness, sore throat, or losing your voice (laryngitis).

Table 3. Prevalence of **new or worsened** lower and upper respiratory symptoms while working at the WTC site by date of arrival for work at WTC site and exposure to the dust cloud among the WTC Medical Screening Program study population (n=9442)

	All responders (N=9442)		Arrived on 9/11 and in dust cloud (N=1878)		Arrived on 9/11 and not in dust cloud (N=1934)		Arrived 9/12-9/13 (N=2801)		Arrived 9/14-9/30 (N=2133)		Arrived on or after 10/1 (N=666)		Trend Test p-value[1]
	N	%	N	%	N	%	N	%	N	%	N	%	
Lower Respiratory Symptoms													
Dry cough	2688	28.7	640	34.2	587	30.6	777	28	538	25.5	140	21.3	<0.001
Cough with phlegm	1320	14.1	328	17.6	256	13.4	373	13.5	275	13	84	12.7	<0.001
Shortness of breath	1613	17.3	390	20.9	298	15.6	471	17.1	339	16.1	109	16.6	0.001
Wheeze	1408	15.1	339	18.3	296	15.5	403	14.6	281	13.4	85	13	<0.001
Chest tightness	1393	15.4	334	18.5	268	14.4	384	14.3	311	15.2	91	14.1	0.003
Any lower respiratory symptom	4371	46.5	1017	54.2	912	47.2	1232	44.2	930	43.8	271	40.8	<0.001
Upper Respiratory Symptoms													
Sinus-related[2]	3510	37.3	785	41.9	712	36.9	1020	36.6	783	37	200	30.1	<0.001
Nasal-related[3]	4552	48.4	982	52.4	939	48.6	1334	47.9	981	46.3	300	45.1	<0.001
Throat-related[4]	4128	43.9	885	47.2	847	43.9	1199	43.1	923	43.6	264	39.7	0.001
Any upper respiratory symptom	5883	62.5	1233	65.8	1205	62.4	1719	61.7	1316	62.1	394	59.2	0.001
Any respiratory symptom	6479	68.8	1376	73.4	1345	69.7	1878	67.3	1435	67.7	429	64.5	<0.001

[1] One sided p-values using the Cochran-Armitage trend test

[2] Facial pain or pressure, head of sinus congestion, or post-nasal discharge

[3] Blowing your nose more than usual, stuffy nose, sneezing, runny nose, or irritation in nose

[4] Throat irritation, hoarseness, sore throat, or losing your voice (laryngitis).

Table 4. Prevalence of abnormal spirometry results (pre-bronchodilator) among the WTC Medical Screening Program study population (n=8384)[1]

	National Population[2]	WTC Medical Screening Program Population							
	Never smoker	Never smoker		Former smoker		Current smoker		All	
	%	N	%	N	%	N	%	N	%
Normal	87.1	3348	72.1	1520	71.8	1029	66.0	5942	70.9
Obstruction[3]	8.0	245	5.3	104	4.9	118	7.6	471	5.6
Low FVC[4]	4.4	972	20.9	447	21.1	349	22.4	1783	21.3
Obstruction and low FVC[5]	0.5	76	1.6	47	2.2	64	4.1	188	2.2
Total	--	4641	55.8	2118	25.5	1560	18.8	8384	100.0

[1] Only acceptable quality spirometric examinations are included in this table (Miller et al 2005).

[2] General U.S. population sample of employed, adult, white males ages 17-69 who never smoked from the National Health and Nutrition Examination Surveys (NHANES III)

[3] Airway obstruction was defined as FEV1/FVC below the lower limit of normal (LLN) (i.e., below the 5th percentile of predicted) with a normal FVC.

[4] Low FVC was defined as FVC < LLN but FEV1/FVC ≥ LLN.

[5] Obstruction and low FVC was defined as FEV1/FVC and FVC below the LLN.

Table 5. Prevalence of abnormal spirometry results (pre-bronchodilator) by date of arrival for work at WTC site and exposure to the dust cloud among the WTC Medical Screening Program study population (n=8384)[1]

	Arrived on 9/11 and in dust cloud		Arrived on 9/11 and not in dust cloud		Arrived 9/12-9/13		Arrived 9/14-9/30		Arrived on or after 10/1		Trend Test p-value[2]
	N	%	N	%	N	%	N	%	N	%	
Normal	1140	67.3	1211	69.3	1748	70.3	1375	74.1	449	78.0	--
Obstructive[3]	85	5.0	98	5.6	145	5.8	112	6.0	29	5.0	0.48
Low FVC[4]	422	24.9	407	23.3	532	21.4	329	17.7	88	15.3	<0.0001
Obstruction and low FVC[5]	46	2.7	33	1.8	62	2.5	39	2.1	10	1.7	0.07

[1] Only acceptable quality spirometric examinations are included in this table (Miller et al 2005).

[2] One sided p-values using the Cochran-Armitage trend test

[3] Airway obstruction was defined as FEV1/FVC below the lower limit of normal (LLN) (i.e., below the 5th percentile of predicted) with a normal FVC.

[4] Low FVC was defined as FVC < LLN but FEV1/FVC ≥ LLN.

[5] Obstruction and low FVC was defined as FEV1/FVC and FVC below the LLN.