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The World Trade Center health surveillance program: results of the first 10 years and implications for prevention

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ABSTRACT. BACKGROUND: *The terrorist attacks on the World Trade Center (WTC) of September 11, 2001 resulted in the deaths of 2,823 persons. They also generated a long-lasting burden of multiple physical and mental health illnesses among the cohort of 50,000 rescue workers who responded to the attacks and in the 400,000 residents and workers in nearby areas of New York City.*

A comprehensive health surveillance program was developed from the first months after the accidents and was further developed in the subsequent ears. Individual exposure and health data were stored in ad hoc databases and produced epidemiological outcomes on the various exposure-related illnesses.

METHODS: *About 10 years of longitudinal assessment of this large cohort of WTC rescue and recovery workers, yielded data from participants in the WTC Screening, Monitoring, and Treatment Program. Police officers, firefighters, construction workers, and municipal workers were included in the cohort. Cumulative and annual incidence were estimated for various physical disorders including asthma, sinusitis, and gastro-esophageal reflux disease, mental health disorders including depression, post-traumatic stress disorder [PTSD], and panic disorder. Respiratory functionality was also assessed. Exposure was characterized with qualitative parameter including working on the pile and being engulfed in the dust cloud, and quantitative parameters including the time of arrival on site and the exposure duration*

RESULTS: *Upper and lower respiratory conditions such as rhinosinusitis and asthma have been found in a significant number of people in WTC-exposed populations. A lack of appropriate respiratory protection may have contributed to these effects. Other commonly observed physical health conditions include gastro-esophageal reflux disease, obstructive sleep apnea and musculo- skeletal injuries. Many WTC-exposed individuals also suffer from mental health conditions, primarily post-traumatic stress disorder, depression, panic disorder, and substantial stress reaction. Recent studies suggest that WTC exposure may increase the risk of cancer and of mortality from cardiac disease.*

CONCLUSION: *Ten years of systematic health surveillance after the 9/11 WTC attacks, show long lasting burden of physical and mental health problems. Continued monitoring and treatment of this population is needed for early diagnoses of initial clinical conditions that can be treated more effectively. The experience of September 11 offers also indications on how to approach the acute and delayed health effects of civilian catastrophes. Critical lessons are derived about the importance of having trained responders - medical and non-medical - in place in advance of disasters, and about the need to proceed with adequate exposure assessment in a timely manner.*

Key words: *World trade center, health surveillance, prevention*

Introduction

The September 11, 2001 attacks on the World Trade Center (WTC) exposed thousands of emergency responders, area construction workers, policeman, firefighters and community residents to a massive array of airborne pollutants. Components of the dust included pulverized cement, glass fibers, asbestos, metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), organochlorine pesticides, polychlorinated furans and dioxins (Landrigan 2004). The wreckage of the towers, referred to as The Pile, burned for more than 3 months.

Few measurement of airborne particulate matter (PM) taken early in the event demonstrated an elevation of PM2.5 for weeks following the collapse, with ongoing intermittent releases of dust and smoke at the site during debris removal. Evaluation of the settled particulate material showed coarse cement and fibrous particles with an alkaline pH (9.0-11.0), 95% of which were ten microns or greater in diameter (McGee2003). Laboratory evaluation of mice exposed to this WTC PM2.5 dust demonstrated bronchial hyperreactivity and pulmonary inflammation (Gavett 2003). It is likely that the alkaline pH of the dust, coupled with the glass fibers present, was responsible for its observed inflammatory properties (Landrigan 2004).

Programs funded by the National Institute of Occupational Safety and Health (NIOSH) are the source of most of the information on WTC exposure-related medical conditions. These include: (1) the WTC Medical Monitoring and Treatment Program (MMTP), headquartered at the Mount Sinai School of Medicine in New York City, provided intensive medical evaluations to over 35,000 of the 60,000 to 80000 responders; (2) the New York City Fire Department (FDNY) WTC Program enrolled over 15,000 New York City firefighters and emergency medical service personnel; (3) the WTC Environmental Health Center (WTCEC) enrolled approximately 5,000 community residents, local area workers, and students; and (4) the WTC Health Registry did not provide health services to those exposed, but enrolled over 70,000 responders, area residents and workers.

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Respiratory Illness

Respiratory conditions are prevalent at significant rates in both the responder and community populations. Initial clinical and epidemiologic assessments documented a high prevalence of persistent cough, nasal congestion and chest tightness in New York City firefighters and rescue workers exposed to WTC dust (Levin 2004). Reibman (2005) studied 2812 local residents (WTCEC) in an exposed versus a control area 12 months after the collapse. New-onset respiratory symptoms were described by 55.8% of residents in the exposed area, compared with 20.1% in the control area after the event. Herbert (2006) reported that 69% of 9,442 responders (MMTP) examined between July 2002 and April 2004 developed new or worsened respiratory symptoms while performing WTC work. 20% of the nonsmokers in the population demonstrated low FVC, four times the normal rate in adults. Respiratory symptoms and spirometric abnormalities were significantly associated with early arrival at the site (Herbert 2006).

Banauch (2006) compared workers' adjusted average FEV1 during the first year after 9/11 with FEV1 values in the 5 years before 9/11. World Trade Center-exposed workers experienced a reduction in adjusted average FEV1 of 372 ml during the year after 09/11/2001, equal to twelve years of aging-related FEV1 decline. The decrease in function was related to arrival time at the site and to intensity of exposure. Clinical evaluation of 1,720 FDNY personnel by Weiden (2010) demonstrated that airways obstruction was the predominant physiologic finding underlying this reduction in lung function.

Wisnivesky (2011) recently summarized the health experiences of the responders followed in the MMTP. The nine-year cumulative incidence rate of asthma in the responder population was 27.6%, sinusitis 42.3%, and GERD 39%. Further, the annual incidence rates of asthma were 4-5 times the typical rates in adults. Aldrich (2010) showed reductions in FEV1 lasting more than six years in the FDNY population. Weakley (2011) found that WTC-exposed FDNY firefighters demonstrated a higher prevalence of self-reported diagnosed respiratory conditions over the nine years following the WTC disaster compared to US males interviewed by the National Health Interview Survey. The WTC Health Registry (Brackbill 2009) reported that, of participants with no asthma history, 10.2% reported new asthma diagnoses by five to six years post-9/11, with annualized rates of asthma diagnoses 2-6 times the average annual rate for adults. Intense dust cloud exposure on September 11 was a major contributor to new asthma diagnoses for all eligibility groups. Asthma risk was highest among responders who worked on the WTC pile on September 11. Researchers have found evidence of lung disease other than RADS and irritant asthma in relatively small numbers of patients among the WTC-exposed populations. Mann (2005) reported bronchiolitis obliterans in a previously healthy police officer exposed to the WTC on 9/11. Caplan-Shaw (2011) and Wu (2010) then reported pathologic findings in community residents and responders including interstitial fibrosis, small airways abnormalities and emphysema.

Elevated rates of sarcoidosis, or "sarcoid-like" granulomatous pulmonary disease, have also been found in WTC-exposed firefighters, responders and community residents (Crowley 2010). Using Registry data Jordan (2011) conducted a case control study of 28 biopsy-proven post-9/11cases of sarcoidosis and 109 controls. Working on the WTC debris pile was associated with sarcoidosis, but WTC dust cloud exposure was not.

Aerodigestive Illness

Rescue and recovery workers and others exposed to the WTC disaster site developed not only asthma and other respiratory conditions but were commonly diagnosed with multiple comorbid conditions. Common among this population was a new onset of an aerodigestive complex consisting of asthma, rhinosinusitis and gastroesophageal reflux disease (GERD), often along with obstructive sleep apnea. GERD symptoms were originally identified by by Prezant (2002) in the FDNY population and subsequently identified in other WTC responders and residents. Li (2011) reviewed WTC Registry data on 37,000 responders and area residents who had no pre-9/11 GERD symptoms. The cumulative incidence of post-9/11 GERD symptoms was 20%. Persistent GERD symptoms were associated with asthma and PTSD symptoms. Work on the Pile on 9/11, intense dust cloud exposure, and failure to evacuate from a nearby home raised the risk of persistent GERD symptoms.

Direct and indirect effects of the caustic and noxious environmental exposure of the WTC have been postulated as an etiology of higher rates of GERD reported among WTC survivors and volunteers via mechanisms as noted by Sayuk and Drossman (2011). They also considered as contributing to this increased rate of GERD, the effect of stress and psychological trauma associated with the WTC experience. Webber (2011) identified FDNY firefighters whose responses on a periodic questionnaire indicated new development of high risk for OSA. Early WTC arrival time, GERD, chronic rhinosinusitis, PTSD symptoms, self-assessed fair/poor health, low or elevated body mass index, and weight gain of ten or more pounds were independent predictors of new-onset high risk for OSA. Individuals reporting GERD, chronic rhinosinusitis, and PTSD symptoms were 6.5 times as likely to meet the high risk criterion for OSA.

What is apparent is that a complex relationship exists between toxic exposure to the aerodigestive system and the physical and mental health responses to the event. An important lesson learned from clinical experience with the WTC patient population is that the same clinical complex can be recognized in other airborne occupational exposures apart from the WTC, and clini-

cians should be alerted to this observation, even under non-disaster conditions.

Respiratory Protection

Lioy and Gochfeld (2002) observed that during their visit to Ground Zero on Day 6 "virtually no one" was using a respirator, although half of the field personnel had them "draped around their neck(s)". An FDNY report for Feldman (2004) supports these observations: 19% of firefighters did not use a respirator in the first two weeks after 9/11 and 50% used one only rarely. Antao (2011) found that in the general responder population, half of the workers wore no respiratory protection at all during the first day of response; however, this rate improved over time, as 50% of responders wore respirators most of the time by January 2002.

The low utilization rates of RPE may have been detrimental for responder health. Although Feldman's analysis of FDNY data did not show a protective effect of respirator use firefighters' lung function, Antao (2011) found that WTC workers who wore full-face respirators were significantly less likely to report new or chronic cough or other upper respiratory symptoms than those who did not utilize RPE (Antao 2011). The deficiency in utilization was partly due to lack of training; Antao (2011) analyzed the relationship between RPE utilization, fit-testing and training, and respiratory outcomes among 9,296 World Trade Center responders. Training on respirator use and being affiliated with construction, utilities, or remediation organizations were there strongest predictors of respirator use. Further, RPE use was decreased by the design of the respirators themselves. For instance, although the full-face mask that the firefighters used provided the highest level of respiratory and eye protection, this mask could only be worn for short time periods (Feldman 2004).

Mental Health Conditions

Elevated rates of mental health conditions have been repeatedly observed in WTC-exposed populations. Using WTC Health Registry data collected 2-3 years after the attacks, DiGrande (2011) evaluated probable posttraumatic stress disorder (PTSD) in 3,271 civilians who evacuated the WTC towers 1 and 2. More than 95% of these survivors reported PTSD symptoms; 15% had probable PTSD. 9/11 experiences significantly associated with PTSD included: witnessing horror; sustaining an injury; having been exposed to the dust cloud; being above the impact zones rather than below; and having evacuated. during or after the second plane's impact into the WTC. In the overall WTC Health Registry population, 16% endorsed probable PTSD and 8% serious psychological distress in the 2-3 years post-9/11 (Farfel 2008). In the MMTP population, 11.1% met criteria for probable PTSD, 8.8% for probable depression, 5% for probable panic disorder, and 62% for substantial stress reaction. PTSD was significantly associated with loss of family members and friends, disruption of family, work and social life, and higher rates of behavioral symptoms in children of workers (Stellman 2008). In a survey of over 11,006 WTC exposed FDNY personnel nine years after the exposure, the prevalence of probable PTSD was 7.4%. Probable PTSD was associated with early arrival at the WTC disaster site. Recovery was influenced by respiratory and aerodigestive symptoms, as well as patterns of exercise (Soo 2011).

In the longitudinal study of 27,449 participants in the MMTP, Wisnivesky (2011) found nine-year cumulative incidence rates of probable PTSD, depression and panic disorder of 9.3%, 7.0% and 8.4% respectively in NYC police officers. In other rescue and recovery workers, the rates were significantly higher with 31.9% of workers endorsing PTSD symptoms, 27.5% depression, and 21.2% panic disorder.

Cancer and Mortality

It is too early to definitively answer the complex question of whether or not WTC exposure will prove to be a significant risk for cancer. Nonetheless, new data concerning the association between WTC exposure and cancer risk are emerging. Zeig-Owens (2011) analyzed cancer incidence among almost 10,000 firefighters within the first seven years of the attacks. Firefighters exposed to WTC debris had approximately 10% greater cancer incidence than the general USA male population of a similar demographic, and up to 32% greater incidence than among firefighters not exposed to the WTC debris. Analysis of specific cancers diagnosed in the firefighter cohort suggested possible increased risk of the following malignancies: melanoma, prostate cancer, thyroid cancer, Non Hodgkin's Lymphoma, colon cancer, and stomach cancer (Zeig-Owen 2011). Moline (2009) described 8 cases of multiple myeloma (MM) among WTC responders in 2009. The investigators found that "four of the eight cases of MM seen here occurred in responders younger than 45 years", when 1.2 were expected for a comparable population. Jordan (2011) analyzed mortality rates among WTC Health Registry participants between 2003 and 2009. The authors identified 156 deaths in 13,337 responders and 634 deaths in 28,593 non-responders. All cause mortality was lower than expected in both responders and non-responders. There was no significant increase in standardized mortality rates for cancer. However, when the relationship between mortality and exposure level was examined, with low exposure used as the reference category, high and intermediate levels of exposure in non-responders (lower Manhattan area residents, workers, school staff and students, commuters and passers-by on 9/11) were significantly associated with mortality. Specifically, cardiac mortality was associated with high exposure level in non-responders compared to low-level exposure (Jordan 2011).

Conclusion

These reports emphasize the critical need for ongoing surveillance and medical treatment of the 9/11 WTC community and responder populations. The 9/11 experience clearly demonstrates the vital role of both worker safety training, particularly with appropriate respiratory protection, and accessible physical and mental health care to address the overwhelming impact of such disasters on community members and responders alike.

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