Responder Safety and Health: Preparing for Future Disasters

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ABSTRACT

This article reviews lessons learned about managing the safety and health of workers who were involved in disaster response, recovery, and cleanup after the 2001 World Trade Center (WTC) disaster. The first two sections review ongoing responder health burdens and the tragic toll of this disaster from a worker safety and health perspective. The remaining sections address changes in federal infrastructure, response planning, and resources for protection of response and recovery personnel.

Proper preparation includes pre-event and “just-in-time” disaster-worker training on likely hazards, organizational assets for hazard monitoring, and hands-on instruction in the use of assigned protective equipment. Good planning includes predeployment medical review to ensure “fitness for duty” and considers the following: (1) personal risk factors, (2) hazards likely to be associated with particular field locations, and (3) risks involved with assigned tasks (e.g., workload and pace, work/rest cycles, available resources, and team/supervisory dynamics). Planning also should address worker health surveillance, medical monitoring, and availability of medical care (including mental health services). Disaster safety managers should anticipate likely hazards within planning scenarios and prepare asset inventories to facilitate making timely safety decisions.

Disaster safety management begins immediately and provides ongoing real-time guidance to incident leadership at all levels of government. Robust standards must be met to reliably protect workers/responders. An integrated and measurable multiagency safety management function must be built into the incident command system before an incident occurs. This function delineates roles and responsibilities for rapid exposure assessments, ensuring cross-agency consistency in data interpretation, and timely, effective communication of information and control strategies. The ability to perform this safety management function should be tested and evaluated in exercise simulations and drills at multiple levels.

Joint planning and exercising of the safety management plan and its function are effective ways to build interagency relationships and to be more systemic in managing logistics for safety equipment and converging personnel. Planning must include mechanisms to enable safety decisions to be implemented—such as effective and rapid scene control (site access), personnel tracking, and safety enforcement. Worker safety and health preparedness and leadership are essential for protecting workers and promoting resiliency among personnel involved in disaster response, recovery, and cleanup. Mt Sinai J Med 75:135–141, 2008. © 2008 Mount Sinai School of Medicine

Key Words: worker safety, disaster-worker health, responder health, responder safety, disaster-safety management.

BACKGROUND ON THE WORLD TRADE CENTER DISASTER

Terrorists hijacked 4 commercial jet airliners that were carrying passengers and full complements of jet fuel on September 11, 2001. Each hijacked aircraft was used as an unconventional weapon, was filled with jet fuel, was moving at more than 300 mph, and was targeting major US symbols of power (Pentagon) and financial prowess (World Trade Center [WTC]). The first Boeing 767 crashed into the WTC North Tower in lower Manhattan, followed by a second airplane that crashed into the South Tower 14 minutes later. Initially, the command center for rescue operations was set up on the ground floor of the towers and on nearby streets, according to protocol for
a high-rise fire in this vicinity. Unfortunately, the multitude of rescuers quickly ascending the burning WTC towers to assist with evacuation/rescue and fire suppression were not aware of the imminent loss of structural integrity in either building. About 90,000 L of jet fuel was burning at high temperatures and weakening the steel framework of the towers. Within 2 hours, both towers dramatically collapsed, with fires subsequently destroying 7 WTC (housing the Emergency Operations Center for New York City) and 6 WTC (housing the Manhattan area office of the Occupational Safety and Health Administration [OSHA]). The death toll was 2801 people—including 343 firefighters from the Fire Department of New York City (FDNY), 23 officers from the New York City Police Department (NYPD), 37 officers from the Port Authority of New York and New Jersey, 2251 building occupants, and 127 aircraft passengers and 20 crew members.3

Thousands of responders and volunteers quickly converged to assist with rescue operations, with a continual influx of many thousands trained and spontaneous (unaffiliated) volunteers arriving over the ensuing days and months to help with the sustained response campaign. The WTC site continued to burn intensely until early October 2001, forming a 6-story pile of rubble called “Ground Zero.” Demolition and removal of thousands of tons of debris then began while fires continued to smolder and release toxic combustion products.4 The last debris fire was extinguished on December 20, 2001. More is known about the content of settled dust than about suspended particulates and gases, especially during the first 24 hours (most intense plume) when testing was not conducted.5 Much of the settled dust was composed of construction materials such as pulverized cement, wallboard, office furnishings, and glass fibers. However, the coarse and fine particulates were found to be very alkaline in nature (pH ranging from 8 to >11) and, thus, likely to be corrosive to the respiratory tract lining.6 Numerous hazardous substances were identified within both settled and airborne dust, including asbestos, silica, and polyaromatic hydrocarbons (PAH)—agents that may cause cancer or pneumoconiosis over the long term.

Attempts to set up screening and medical monitoring programs for WTC responders have been administratively challenging for a number of reasons—including the lack of adequate systems for personnel tracking (knowing who was there, when, and for how long), contractual and financing issues, and the intricacies of standardizing clinical and data collection and analysis procedures.7 There were acute medical problems among early responders—such as reactive airway symptoms from inhaling smoke and toxic dust, injuries from a multitude of physical hazards associated with the rubble pile, and acute stress reactions from the traumatic nature of these events, and the loss of responder comrades.8 Given the significant increase in persistent respiratory complaints detected early among FDNY responders, medical screening programs for other responders were initiated.9 Philanthropic organizations were the first to provide funding for medical screening of WTC responders. In 2002, congress provided $12 million to enable other responders to receive medical screening and to allow researchers to standardize data collection for epidemiological study. The WTC Worker and Volunteer Medical Screening Program (MSP) was created as a multicenter clinical program that provided a once-only free standardized screening examination, including assessment of exposure, medical, and psychiatric complaints, and provided occupational health education and service referral.10 Testing included a physical examination, pre- and postbronchodilator spirometry, blood cell counts and chemistry, urinalysis, and chest radiography. Eligibility was determined by timing (when responders arrived) and exposure duration (how many hours they worked). FDNY and State of New York employees were not eligible, as they had access to other programs. Early findings of adverse health effects among responders prompted the appropriation of an additional $90 million in 2003 to extend the MSP and to add a 5-year medical monitoring component, with repeat examinations every 18 months. A cross-sectional study of firefighters in New York City conducted in early October 2001 found that 19% of participating firefighters did not use a respirator, and 50% reported using a respirator only rarely.9 Banauch and colleagues examined changes in firefighter lung function by using a retrospective longitudinal study of 12,079 rescue personnel from FDNY, 11,766 of whom had some sort of exposure to the WTC site.11 By using mixed linear random-effect modeling, Banauch analyzed the difference in average spirometric measurements from the 5 years before September 11, 2001 to the first year after September 11, 2001 and whether WTC exposure intensity influenced spirometric changes. Exposure intensity was determined by the time of arrival, with the referent group arriving at the WTC site on or after September 13, 2001. The demographics of FDNY personnel reporting no exposure to the WTC site were too disparate to use for comparison. The analysis revealed an average-adjusted decline equivalent to 12 years of normal age-related decreases in lung function (average adjusted-FEV1 loss of 372 mL, 95% confidence interval [CI] 364–381, P < .001). The decrement in lung function correlated linearly

DOI:10.1002/MSJ
In 2006, the MSP reported that 69% of 9442 study responders experienced new or worsened respiratory symptoms, with persistence in 59% of these workers. The most prevalent industrial sectors in the cohort were technical and public utility, law enforcement, and construction, with at least 80% belonging to a labor union. Among one-third of all responders in the MSP had persistently abnormal spirometry—most commonly low-forced vital capacity (FVC)—with a higher likelihood of such problems noticed among responders who arrived closer to the time when the twin towers collapsed. In a recent analysis of WTC Health Registry data, 926 workers (3.6% of study sample) reported newly diagnosed asthma, which, again, appeared associated with early arrival (dust-cloud exposure), longer duration of work, and longer delays in initial use of masks or respirators (P < .001). Various studies have reported considerably different rates of psychopathology among rescue and response personnel, at least in part because of the use of various assessment methods and study eligibility criteria. In analyzing rescue/recovery worker data from the voluntary WTC Health Registry, Perrin and colleagues noted that the overall prevalence of post-traumatic stress disorder (PTSD) among 28,962 worker participants was 12.4%, ranging from 6.2% for police to 21.2% for unaffiliated volunteers. After adjusting for demographics, direct traumatic exposure (ie, evacuated the WTC, witnessed trauma), exposed to the dust cloud, and/or injured), and type of work at Ground Zero (ie, operated heavy equipment, performed light construction, welded, firefought, hand dug, and/or searched and rescued), unaffiliated volunteers (adjusted odds ratio ORadj = 3.7; 95% CI: 3.1–4.4) and construction/engineering workers (ORadj = 3.8; 95% CI: 3.2–4.6) had the highest prevalence of PTSD. Sanitation workers (ORadj = 2.7; 95% CI: 2.1–3.4) and individuals affiliated with volunteer organizations (ORadj = 2.0; 95% CI: 1.6–2.5) had the next highest PTSD prevalence. The MSP found that 6.4% of the 10,133 participating WTC workers examined between 10 and 61 months after the collapse of the WTC reported symptoms meeting the criteria for probable PTSD. Other psychiatric morbidities were present including probable depression reported in 8.8%, probable panic disorder in 5.0%, and probable generalized anxiety disorder in 0.9%. Odds ratios for a WTC-responder with probable PTSD also to be diagnosed with probable depression (OR = 17, 95% CI: 1.9–2.9) or panic disorder (OR = 6.9, 95% CI: 5.5–8.5) were significant and high.

Given the magnitude of health burdens emerging in this group, $75 million was appropriated in 2006 to provide services to meet the healthcare needs of MSP-participating responders who developed chronic conditions related to their WTC response work—now termed the WTC Medical Monitoring and Treatment Program. Numerous legal battles over financial and legal accountability have ensued because of shortfalls in coverage arising from inadequate or absent personal insurance and workman’s or victim’s compensation policies—which have been especially difficult for volunteers, immigrant day laborers, or responders who were working outside their normal jurisdictions. Projected long-term costs for ongoing medical monitoring and treatment in New York have ranged from $238 million to $392 million per year.

Unfortunately, our understanding of responder safety and health from the WTC disaster is severely constrained by insufficient strategies during and immediately after the event to 1) assess and characterize environmental contamination, 2) quantify individual occupational exposures, and 3) control and manage the disaster site to ensure safe-work practices and prudent use of personal protective equipment (PPE). In December 2001, the National Institute for Occupational Safety and Health (NIOSH) convened a conference in New York City, organized and led by the RAND Science and Technology Policy Institute, to explore lessons on protecting the safety and health of emergency responders in the context of terrorist attacks. Worker-safety and health lessons from this and other large-scale and complex domestic disasters were reviewed, with key findings and recommendations published in a 4-volume series. These published findings reveal that on-scene professional responders and managers noted that Ground Zero site management and perimeter control were initially chaotic because of the emotionally charged atmosphere and confusion over boundaries of authority, especially as key leaders were lost in the building collapses.

Emotions ran high as responders worked frantically under dire circumstances to try and find missing comrades in the rubble. There were more than 30 entry points to the WTC site initially (external perimeter), which made scene control very difficult and personnel tracking impossible. Safety and health officials reported that erratic credentialing procedures, multiple logistical challenges (supply shortages, disrupted telecommunication systems, and faulty instrument readings due to intense smoke), and the lack of unified authority thwarted efforts to enforce appropriate PPE use and safe-work practices.

DOI:10.1002/MSJ
Conference participants reported that safety and health personnel were not permitted early access to the disaster site, and it took a week before coordinated daily hazard information briefings were instituted at Ground Zero. At this point, the initial intensity (first phase) of the exposure had dissipated (rainfall occurred on September 14), and, subsequently, efforts to reconstruct exposure or estimate dose during this critical period were hampered. Despite implementation of daily briefings, hazard and risk information did not flow effectively to the frontline responders across all involved organizations. Situations existed where different contractors working next to each other on the same task were wearing different levels of protection. Lack of coordination among multiple entities conducting hazard assessments led to confusion about responsibilities for monitoring, appropriate contaminants to assess, and clearance thresholds; some of these issues remain unresolved (ie, thresholds for community clearance; appropriate contaminants). Inconsistencies in reporting and interpreting findings and safe thresholds from different federal, state, and local sources created dilemmas, distress, and mistrust in managing risk and uncertainties. Shortcomings in site information, training, and enforcement made it difficult to control internal perimeters or hazard zones set up to indicate different needs for training, PPE, and special work practices. Subgroups of workers were not familiar with the PPE being dispensed or were unfamiliar with basic safe-work practices such as not consuming food and beverages in contaminated areas. PPE was sometimes selected on the basis of appearance or comfort rather than on knowledge of the hazards or the intended design of the technology.

The scale of this disaster, the prolonged rescue and recovery campaigns, the complexity of hazards encountered, and the need to preserve evidence (crime scene) required many responders to take on tasks (new roles) for which they were insufficiently prepared (informed, equipped, and trained).

LESSONS LEARNED: FEDERAL PLANS FOR RESPONDER SAFETY AND HEALTH

The U.S. Department of Homeland Security (DHS) was created in March 2003 in the aftermath of the 2001 multiple acts of terrorism—including anthrax spores found within the U.S. Postal Service system in October 2001. Problems with sampling methodologies and data interpretation for the anthrax contamination arose from different philosophical approaches (eg, environmental microbiology) and disconnected efforts among multiple entities charged with measuring exposure. Even as the new DHS was being assembled, the United States was facing the threat of an emerging and deadly virus causing what came to be known as severe acute respiratory syndrome (SARS). SARS was substantively an occupational disease (healthcare sector); with the heavy burden of disease occurring among hospital workers and healthcare providers in affected countries.

In an effort to address lessons learned, the Worker Safety and Health Support Annex (WSH-A) was added to the National Response Plan (NRP) to help focus on and systematize protection of response and recovery personnel. Occupational Safety and Health Administration (OSHA) personnel, in the U.S. Department of Labor, were given lead responsibility to coordinate federal assets for worker safety and health and to provide technical support when activated under the NRP. These plans were approved only months before the devastation of Hurricane Katrina ravaged nearly 93,000 m² in several states along the Gulf Coast in August 2005. The widespread nature of multiple simultaneous catastrophes in this unprecedented storm season overwhelmed response capabilities and provided challenges outside the then current disaster operational plan. Despite the magnitude and breadth of activities that resulted in the removal of 20,000 workers from serious hazards, an extensive hazard assessment effort, and interventions covering more than 50,000 workers, numerous problems were uncovered in this initial activation of the WSH-A. There were conflicts over authority (who’s in charge); general lack of awareness on the role of OSHA personnel plays in a disaster; and insufficient logistics to meet the needs for on-scene worker training, personal protective equipment, worker health, and injury surveillance (federal responders), and mental health service delivery.

In further efforts to address lessons learned, DHS worked with numerous stakeholders to produce a list of essential capabilities to assist planning for communities and all levels of government in support of the National Preparedness Goal. In 2006, responder safety and health became 1 of these essential (targeted) capabilities and incorporated incident safety management within the National Incident Management System (NIMS) framework and key elements of the WSH-A of the NRP. However, specific safety and health operational challenges and performance measures still need to be incorporated into exercise simulations and drills at federal, state, and local levels.
LESSONS LEARNED: PREPARING FOR THE FUTURE

Since Katrina, the NRP no longer requires event-related activation but is considered to be operational at all times. However, the implementation of the Support Annexes (such as the WSH-A) still requires specific activation based on situational analysis. As such, delays in activating essential federal activities for worker safety and health could compromise early decisions for safety management. Currently, federal efforts for disaster preparedness and response are being reconfigured into a National Response Framework, but this is still under development (http://www.fema.gov/emergency/nrf/mainindex.htm). These elements only apply to federal responders and their contractors; there is no coordinated system for general industry responders (such as those responding to Katrina). Disaster safety management needs to provide ongoing real-time guidance to incident leadership at all levels of government to ensure robust standards are met to reliably protect responders. Interagency coordination and unified functional command are essential for comprehensive incident-wide safety management during complex, large-scale operations. An integrated and scalable multiagency safety management function must be built into the incident command system before an incident occurs. This safety management function needs direct access to advise the incident commander/manager or unified command about overall workforce protection needs.

Priority and authority for incident safety management need to be determined early to facilitate disaster site access, to implement strategic planning and oversight, and to rapidly engage in hazard assessments. Information management is critical, especially when multiple entities collect and interpret data on hazards. Scalable planning considers mechanisms to rapidly coordinate, vet, and disseminate hazard data and real-time control measures. Interpretation can be aided by geographic information systems, which give visual dimensions to emerging hazardous zones. Joint planning and execution of the safety management plan and functions are effective ways to build interagency relationships. Although each response organization manages its own personnel, a larger scale and multiagency operation will need a more systemic solution to manage the logistics for safety equipment and converging personnel, disaster volunteers, and others who may flock to the scene (eg, important persons or media).

Planning for effective incident-safety management must include mechanisms to enable safety decisions to be implemented—such as effective and rapid scene control (site access) and safety enforcement. Safety and health training requirements often differ across response organizations. Proper preparation includes pre-event training on likely hazards, organizational assets for hazard monitoring, and hands-on instruction in the use of assigned protective equipment. Preparedness plans and exercises should delineate roles and responsibilities for rapid assessment of exposure, ensure cross-agency consistency in data interpretation, and effectively communicate results. Event management plans need to include mechanisms to provide on-scene training on likely hazards and accessible PPE (logistics and proper use), with real-time updates as more information and PPE become available. The on-scene training (just-in-time-training) must consider the environment where training will take place as well as target audiences (education, language, skills, predicted tasks, or responsibilities). Anticipating likely hazards within planning scenarios will help identify monitoring equipment needs and technical expertise that may reside in different response organizations. Having an inventory of such assets and a strategic plan that defines priorities for assessment will facilitate safety decisions. Prior events have highlighted the need for front-line dissemination of risk and safety information and standardization of safe-work practices and interoperable safety equipment (eg, donated equipment caches). The prolonged duration of complex, large-scale response operations raises the need for PPE ensembles that are more comfortable, flexible, allow for better temperature regulation, improve job-related communication, and remain effective against a spectrum of likely hazards.

Medical, emotional, and cognitive readiness are important dimensions of workforce health protection planning. Good planning includes predeployment medical review to ensure fitness for duty and considers the following: 1) personal risk factors, 2) hazards likely to be associated with particular field locations, and 3) the risks involved with assigned tasks (eg, workload and pace, work/rest cycles, available resources, and team/supervisory dynamics). Personal-risk factors may include poorly controlled chronic illness (eg, hypertension, coronary artery disease, and diabetes), disability, needs for refrigerated medication or durable medical equipment, psychological flexibility and stress tolerance (coping), possession of requisite skills/training (including incident command and safety management), physical fitness, or other factors that could impact the well-being of workers and mission success. Such considerations are especially critical in chaotic, extreme, or austere environments.
where outside help may not be immediately available or access to water/food or electrical power is limited. Logistical preparations must include information management systems and reliable communication channels to facilitate decisions for real-time hazard control–especially given the dynamic nature of disaster scenes and issues surrounding compliance with safety decisions. Data will be needed on hazard assessments, who (personnel) is on scene, and on worker illness and/or injury. As has been described, preparedness and leadership are essential for protecting workers and promoting resiliency among personnel who are involved in disaster response, recovery, and cleanup.

OSHA electronically published information pertaining to safety and health for emergency response (http://www.osha.gov/SLTC/emergencyprepa redness/index.html) and planning tools for hurricane response and recovery (http://www.osha.gov/OshDoc/hurricaneRecovery.html), with expert input from the NRP Worker Safety and Health Support Coordination Committee. NIOSH has also developed several resources and tools to assist emergency preparedness and response, including the following: 1) general medical review guidelines for disaster workers (predeployment at http://www.cdc.gov/niosh/topics/flood/preexposure.html; postexposure at http://www.cdc.gov/niosh/topics/flood/MedScreenWork.html), 2) compiled portfolio (research and products) on worker emergency preparedness (http://www.cdc.gov/niosh/programs/epr/), 3) emergency response resources (http://www.cdc.gov/niosh/topics/emres/), and 4) a compiled portfolio on exposure assessment (http://www.cdc.gov/niosh/programs/expa/).

**FINAL REMARKS**

As increased emphasis has been placed on the speed of disaster recovery and cleanup efforts, there must be a proportionate effort to protect workers from associated hazards. Incident-wide safety management must be ramped up quickly, implementing scalable and coordinated plans for hazard assessment, data sharing, and real-time and consistent hazard control and communication strategies. Ongoing preparedness efforts need to implement joint planning and exercises that embrace practical and rational strategies for worker/responder safety and health. Integrated disaster safety management makes good business and political sense.

**DISCLAIMER**

The findings and conclusions of this report are those of the authors and do not necessarily represent the views of the NIOSH, Centers for Disease Control and Prevention, or the U.S. Public Health Service.

**REFERENCES**


