AMERICAN JOURNAL OF INDUSTRIAL MEDICINE 57:1285–1298 (2014)

Commentary

Protecting Worker and Public Health During Responses to Catastrophic Disasters—Learning From the World Trade Center Experience

David M. Newman, M.A., M.S.

Despite incremental lessons learned since 9/11, responder and community health remain at unnecessary risk during responses to catastrophic disasters, as evidenced during the BP Deepwater Horizon spill and Hurricanes Katrina, Rita, and Sandy. Much of the health harm that occurs during disaster response, as distinct from during the disaster event itself, is avoidable. Protection of public health should be an integral component of disaster response, which should "do no additional harm." This commentary examines how challenges and gaps the World Trade Center response resulted in preventable occupational and environmental health harm. It proposes changes in disaster response policies to better protect the health of rescue and recovery workers, volunteers, and impacted worker and residential communities.
Am. J. Ind. Med. 57:1285–1298, 2014. © *2014 Wiley Periodicals, Inc.*

KEY WORDS: 9/11; World Trade Center; disaster preparedness; disaster response; responder health

Protecting the health and safety of workers, volunteers, and residents should be an essential component of disaster preparedness and response. Much of the health harm that occurs during disaster response, as distinct from during the disaster event itself, is unnecessary and preventable. Following the September 11, 2001 attacks, concerns were raised about the adequacy of safety and health protection afforded workers and residents during the World Trade Center (WTC) response. Subsequent catastrophic disasters, including the BP Deepwater Horizon oil leak and Hurricanes Katrina, Rita, and Sandy, revealed continuing gaps in the safety and health programs utilized in large-scale, complex emergency responses [NIOSH, 2011a].

DISASTER AND AFTERMATH

The destruction of the WTC resulted in "arguably the worst environmental disaster in the history of New York City" [Technical Working Group, 2004]. A broad array of hazards and multifaceted exposure scenarios provided complex challenges to safe and effective disaster response.

In addition to the almost 3,000 initial fatalities, as many as 400,000 first responders, rescue and recovery workers, volunteers, area workers, residents, students, and bystanders may have been occupationally and/or environmentally exposed to WTC-derived contaminants on September 11 and in subsequent months and years [World Trade Center Health Panel, 2007].

Significant, persistent health harm occurred among diverse exposure populations, including respiratory illness among rescue and recovery personnel [Herbstman et al., 2005;

New York Committee for Occupational Safety and Health (NYCOSH), 61 Broadway, Suite 1710, New York City, New York,
*Correspondence to: David M. Newman M.A., M.S., New York Committee for Occupational Safety and Health (NYCOSH), 61 Broadway, Suite 1710, New York City, NY 10006. E-mail: dave@nycosh.org

Accepted 28 July 2014
DOI 10.1002/ajim.22386. Published online in Wiley Online Library (wileyonlinelibrary.com).

Banauch et al., 2006; Herbert et al., 2006; Aldrich et al., 2010; de la Hoz, 2010; de la Hoz, 2011; Kim et al., 2012], firefighters [Prezant et al., 2002; Banauch et al., 2006; Guidotti et al., 2011; Weakley et al., 2011; Cho et al., 2014], police [Kleinman et al., 2011], transit workers [Tapp et al., 2005], volunteers [de la Hoz, 2010; Debchoudhury et al., 2011], immigrant day laborer cleanup workers [Malievskaya et al., 2002; de la Hoz et al., 2008], and workers, residents, and students in adjacent areas [Lin et al., 2005; Reibman et al., 2005; Reibman et al., 2009; Caplan-Shaw et al., 2011; Friedman et al., 2011; Maslow et al., 2012;]. Additional health impacts include cardiovascular and cardiometabolic [Jordan et al., 2011a; Jordan et al., 2013; Trasande et al., 2013], dermal [Huang et al., 2012], pediatric [Lederman et al., 2004; Szema et al., 2004; Szema et al., 2009; Trasande et al., 2013], and mental health [Biggs et al., 2010; Adams and Boscarino, 2011; Chiu et al., 2011; Cukor et al., 2011; Pietrzak et al., 2012]. Working on the WTC debris pile was associated with an elevated risk of post-9/11 sarcoidosis [Crowley et al., 2011; Jordan et al., 2011b]. Responders evidenced elevated levels of dioxins in blood plasma [Horii et al., 2010].

Excess incidence for a variety of cancer sites has been identified in responders and residents, although study authors warn that caution is warranted in interpretation of these results given the long latency period for most cancers, the intensive medical surveillance of the cohort, and the small numbers of cancers at specific sites [Moline et al., 2009; Zeig-Owens et al., 2011; Li et al., 2012; Solan et al., 2013].

In September 2012, NIOSH added 50 types of cancers (later expanded) to the list of WTC-related health conditions covered under the James Zadroga 9/11 Health and Compensation Act of 2010 [National Archives, 2012]. The WTC Health Program Scientific and Technical Advisory Committee noted that:

> *Exposures resulting from the collapse of the buildings and high-temperature fires are likely to increase the probability of developing some or all cancers. This conclusion is based primarily on the presence of approximately 70 known and potential carcinogens in the smoke, dust, volatile and semi-volatile organic contaminants identified at the World Trade Center site. Fifteen of these substances are classified by the International Agency for Research on Cancer (IARC) as known to cause cancer in humans, and 37 are classified by the National Toxicology Program (NTP) as reasonably anticipated to cause cancer in humans; others are classified by IARC as probable and possible carcinogens. Many of these carcinogens are genotoxic and it is therefore assumed that any level of exposure carries some risk. [STAC, 2012].*

Contaminants were dispersed over a wide area of lower Manhattan, Brooklyn, and beyond. Over 400 WTC-derived contaminants have been identified in air, dust, and bulk samples [CDC, 2002; Lioy and Gochfeld, 2002; Lioy et al., 2002; McGee et al., 2003; Offenberg et al., 2003; Landrigan et al., 2004; IAFF, 2010]. These included approximately 70 carcinogens [STAC, 2012], such as asbestos, dioxins, and polycyclic aromatic hydrocarbons (PAHs). Additional substances of concern included respirable particulates, highly alkaline concrete dust, volatile organic compounds, silica, pulverized glass shards, man-made vitreous fibers, and heavy metals such as lead and mercury [Lorber et al., 2007].

The high volume, concentration, and explosive force of the dust cloud may have "overwhelm[ed] or impair[ed] nasal and upper airway clearance mechanisms resulting in large particle penetration to the depth of the small airways and alveoli" [IAFF, 2010]. Similarly, the thrust and mass of the dust cloud is likely to have generated increased particulate infiltration into indoor spaces, achieving entry through intact closed windows, closed mechanical ventilation system intakes, and other penetrations in building envelopes.

The vast majority of the hundreds of thousands of outdoor and indoor environmental samples collected were non-detect[1] or only minimally elevated. However, the usefulness of these data is undercut by the breadth and persistence of illness in populations exposed to the sampled conditions. These health impacts are consistent with a much smaller body of sampling results that indicated the possibility of wide geographic dispersion, outdoors and indoors, of 9/11-derived toxic substances at levels of concern.

Dioxin samples collected by EPA at and adjoining Ground Zero were up to 1,100 times typical background levels and up to 170 times the highest concentration previously recorded. These levels persisted for 3 months in areas that government agencies declared safe for re-occupancy [EPA National Center, 2002]. As much as 1,000 tons of PAHs were generated by the WTC collapse and ensuing fires, resulting in concentrations 10 to 214 times background levels. PAH concentrations at the WTC site did not return to background levels for over 3 months [Pleil et al., 2002]. Benzene was detected in 57 of 96 Ground Zero area air samples at concentrations up to 86 times OSHA's permissible exposure limit (PEL). Some measurements remained significantly elevated months after September 11 [EPA National Center, 2002]. Sixty percent of asbestos air samples collected at the WTC site by the International Union of Operating Engineers indicated concentrations in excess of the Asbestos Hazard Emergency Response Act (AHERA) clearance level

[1] Non-detect: The contaminant was not detectable above the lowest concentration (greater than zero) of the substance tested that can be measured and reported with confidence.

of 70 structures per square millimeter (s/mm^2), the standard referenced by EPA [Nash, 2002]. Twelve of 21 personal samples collected by the U.S. Public Health Service from workers sifting WTC debris at the Staten Island landfill exceeded the OSHA PEL for asbestos [Emilcott, 2001]. Twenty-seven percent of bulk samples collected by EPA and OSHA at Ground Zero were greater than 1% asbestos by weight, the legal definition of asbestos-containing material (ACM) [Lippy, 2001]. Independent indoor air monitoring commissioned by Congressperson Jerrold Nadler found asbestos concentrations up to 152 times the clearance level[2] in nearby residences [Chatfield and Kominsky, 2001].

DISASTER RESPONSE

Local response agencies included the Fire Department of New York (FDNY), the New York Police Department (NYPD), the Port Authority Police Department (PAPD), and the Mayor's Office of Emergency Management (OEM). Additional responses were undertaken by multiple federal agencies, including EPA, OSHA, the Federal Emergency Management Agency (FEMA), Centers for Disease Control, Health and Human Services, and others [National Commission on Terrorist Attacks, 2004]. Additional thousands of other public and private sector responders were dispatched by their employers or self-dispatched.

As many as 90,000 responders, workers, and volunteers responded on "the pile" and at associated waste transfer sites and forensic search operations, according to John Howard, Director of the National Institute for Occupational Safety and Health [email, December 24, 2012]. Thousands of building maintenance workers and day laborer cleanup workers removed debris and contaminants on a regular basis from adjacent commercial, institutional, and residential buildings. Hundreds of construction workers demolished highly contaminated high-rise buildings; thousands of electrical, telecommunications, and other infrastructure, and service workers worked to restore essential services. These workers regularly disturbed dust in indoor and underground spaces that may have been contaminated but were not tested or remediated.

Thousands of immigrant day laborers "shaped up"[3] to clean contaminated properties near Ground Zero, generally without proper training, respiratory protection, or personal protective equipment (PPE). They incurred rates of illness similar to those of other responders but typically lacked access to medical treatment and surveillance [Malievskaya et al., 2002; de la Hoz et al., 2008]. In addition, they were often the victims of wage and hour crimes by their employers [Sengupta, 2001].

Because the City of New York led the initial response, Mayor Giuliani was the nominal incident commander [National Clearinghouse, 2001]. Responsibility for site safety was assumed by the New York City Department of Design and Construction (DDC). Although DDC had extensive construction experience [NYC DDC, date unknown], it lacked expertise and experience in disaster response. DDC did not implement any "contractual mechanism to enforce safety requirements" [Lippy, 2003].

A site health and safety plan[4] (HASP) was not implemented until almost seven weeks after the attack [Lippy, 2003]. As a result, it was not clear "which occupational safety and health standards were applicable, whether enforcement agencies indeed had enforcement jurisdiction, and at what point in time [a HASP] would become effective and operative" [National Clearinghouse, 2001].

EPA did not designate the WTC site as either a hazardous waste site per the Resource Conservation and Recovery Act or a Superfund site per the Comprehensive Environmental Response, Compensation, and Liability Act. OSHA determined that the strong training requirements and worker protection provisions of the Hazardous Waste Operations and Emergency Response Standard (29 CFR 1910.120, "Hazwoper") would not be applied. Worker training requirements under Hazwoper, as well as under 1910.1200 (Hazard Communication) would have mandated comprehensive training on hazard identification, risk assessment, recognition of signs and symptoms of overexposure, hazard monitoring and control methods, PPE and safe work practices, and regulatory requirements and worker rights. On-site training (in abbreviated 3-hr format) was not implemented until November 29 [Lippy, 2003].

On-site experts observed that the confirmed presence of multiple hazardous substances, the disturbance activities of responders, and the instability of the debris pile made it difficult to determine precisely when increased exposures would occur. They characterized OSHA's decision that Hazwoper was not applicable as "inappropriate" [National Clearinghouse, 2001]. Others noted "the presence of multiple exposures and mixtures with the potential to act synergistically and to produce unexpected health effects [and] the potential for heterogeneous exposures and hot spots representing exceptionally high or unique exposures both

[2] Clearance level: The maximum acceptable post-remediation concentration, indicating that further environmental cleanup is not warranted.

[3] Shape-up: A labor system in which workers solicit employment on a daily basis while competing against each other for jobs for that day. Although some union hiring halls utilize a version of shape-up, day laborers tend to be non-unionized, often undocumented immigrants who shape-up on street corners and other informal locations with little or no control over employer labor practices.

[4] HASP: A written program that delineates the measures to be used to identify, evaluate, and control safety and health hazards and thereby eliminate or reduce fatalities, injuries, and illnesses.

on the WTC site and in surrounding communities" [STAC, 2012].

The Federal Response Plan (FRP) then in place defined OSHA's role as one of consultation, guidance, and technical assistance, omitting enforcement. OSHA's non-enforcement policy ultimately fostered rapid removal of debris at the expense of protection of worker health. [Newman, 2007]. OSHA asserted that enforcement would delay hazard resolution because cited employers are not required to abate violations until appeals are exhausted [Michaels, 2010]. However, most OSHA citations are not appealed and are corrected immediately or within 15 days, according to Celeste Monforton, DrPH, Department of Environmental and Occupational Health, George Washington University [email, December 12, 2012].

OSHA did not initiate personal sampling of workers at Ground Zero until September 20, even though the WTC site was clearly the locus of greatest exposure and risk [OSHA, 2001a; Platner, 2002; Lippy, 2003]. This delay was consistent with the effort of the Bush administration to achieve the appearance of a rapid return to normalcy, in part by ignoring or de-emphasizing risk [Rosner and Markowitz, 2003]. It was also consistent with pressure on the Giuliani administration from downtown real estate and banking interests:

> *The Mayor's office is under pressure from building owners and business owners to open more of the city to occupancy. According to OEM [Office of Emergency Management], some city blocks north and south of ground zero are suitable for reoccupancy. DEP [Department of Environmental Protection] believes the air quality is not yet suitable for reoccupancy [NYCDOH, 2001a].*

OSHA and other agencies eventually provided tens of thousands of respirators to workers and volunteers at Ground Zero. Respirator training was limited and initially excluded the fit tests and medical screening required by the OSHA Respiratory Protection Standard. Three weeks after 9/11, fewer than 20% of the construction workers at the site had been trained or medically cleared to use respiratory protection [National Clearinghouse, 2001]. In a 2004 study, 19% of study firefighters reported not using a respirator during the first 2 weeks at the WTC site. An additional 50% reported using a respirator only rarely [Feldman et al., 2004]. Almost 1,000 reports of respiratory injuries were filed at the WTC site during the first 9 weeks [Rand, 2002].

OSHA was well aware of ongoing, significant lapses in respiratory protection. The issue was documented in agency memoranda and emails at least 34 times between September 18 and November 14, 2001. The New York City Department of Health, calling it "a critical issue," requested on at least 11 occasions that OSHA enforce the Respiratory Protection Standard at the WTC site. FEMA and the International Brotherhood of Teamsters also requested enforcement, and Liberty Mutual Insurance and the contractors AMEC and Bechtel also complained about inconsistent respirator use. OSHA later acknowledged that "compliance rates fluctuated" but insisted that "respiratory protection was worn by employees when conducting operations with potential exposure to contaminants at or near OSHA PELs" [OSHA, 2002; Emails Show, 2007].

During at least the first 4 weeks of operations at the WTC site "there was no evidence or even suggestion that any safety and health program was operative…indeed the very opposite seemed to be the case. The lack of an operating safety and health program was confirmed by various support personnel, workers, and various government officials…" [National Clearinghouse, 2001].

The impressively low incidence of injuries reported by OSHA at Ground Zero excluded firefighters and police. When NIEHS investigators examined more inclusive data, they documented 995 injuries and illnesses from September 14 to September 25, 2001. They noted that if only 10% of the injuries to uniformed personnel were reportable according to OSHA criteria, "the injury and illness rate [would be] far above the national average for construction" [National Clearinghouse, 2001; Lippy, 2003; OSHA, 2003b]. Musculoskeletal injuries were the leading cause of responder requests for injury treatment (19%) in the month following 9/11 [September 11 Worker Protection, 2008]. Data from a 2011 study of WTC responders provide additional indication of elevated injury rates; 20% reported traumatic injuries and 15% reported eye injuries [Perritt et al., 2011].

The initial goals of disaster response are live rescue, establishment of an incident command system, hazard mitigation, and provision of food, shelter, and medical care. During the rescue phase, site conditions may be uncontrolled and can change rapidly. The ability to avoid or minimize responder exposure and risk may be limited, particularly in the emergency context of saving lives. When rescue efforts are complete or no longer feasible, hazard mitigation should continue, and response objectives should transition to cleanup and recovery tasks. Hazards can be controlled and risk-taking eliminated. [National Response Team, 2009a]. At the WTC site, the "rescue phase" was arbitrarily extended for the entire 9 months of debris removal operations. In fact, the last victim to be removed alive from WTC collapse debris was rescued less than 24 hr after the attacks [Cloud, 2002], a time frame consistent with earlier disasters [de Bruycker et al., 1983; Guha-Sapir and Carballo, 2000]. The extended rescue phase presented a significant obstacle to implementation of safe work practices, compliance with regulatory requirements, and enforcement. Adherence to health and safety standards was seen as an impediment not only to rescue of live victims but also to retrieval of body parts.

No government agency acknowledged responsibility for assessing or remediating potentially contaminated indoor spaces. Indoor environmental testing and cleanup were initially left to building owners and to commercial and residential tenants, including employers [Miele, 2002; Nadler, 2002; EPA Office of Inspector General, 2003]. There were no government standards or guidelines for reoccupancy of potentially contaminated indoor spaces. (This was also the case in the aftermath of Hurricanes Katrina, Rita, and Sandy.) EPA and OSHA statements that "the air is safe to breathe" [EPA, 2001b] provided strong disincentives to employers and property owners to test or clean habitable indoor spaces. Property owners, employers, and tenants lacked the technical expertise and financial resources to engage in environmental sampling and remediation. Consequently, private environmental sampling and remediation efforts occurred only on a haphazard, limited, and frequently ineffectual basis.

Although EPA has "lead responsibility for cleaning up buildings and other sites contaminated by chemical or biological agents as a result of an act of terrorism" [EPA, 2001a], the agency asserted that it had no responsibility to assess or remediate WTC-derived indoor contaminants [Mugdan, 2002; Nadler, 2002; EPA Office of Inspector General, 2003]. (After coming under intense public pressure, EPA reversed its position in May 2002 and acknowledged responsibility for indoor environmental conditions [EPA Region 2, 2002]).

Government agencies offered minimal clean-up guidance that often contradicted safe work practices and regulatory requirements. The New York City Department of Health advised tenants to clean up WTC dust (i.e., asbestos and other toxic substances, in many cases) with wet rags and indicated that respiratory protection was not necessary [NYCDOH, 2001b]. OSHA and EPA advised to "avoid inhaling" while cleaning up WTC dust [OSHA, 2001b]. Such advice "may have increased the long-term health risks for those [tenants] who cleaned WTC dust" [EPA Office of Inspector General, 2003].

Government risk communication mischaracterized sampling results and was altered in response to political directives from the White House. EPA's September 18, 2001 announcement that the "air is safe to breathe" was not supported by evidence [EPA, 2001b; EPA Office of Inspector General, 2003]. "Reassuring information was added …and cautionary information was deleted" [Nadler, 2002; EPA Office of Inspector General, 2003]. OSHA announced that "it is safe for New Yorkers to go back to work" even as it detected elevated concentrations (2.1%–3.3%) of asbestos in bulk samples from streets, double and triple the concentrations that would trigger requirements for abatement indoors [OSHA, 2001c]. Until subjected to White House revision, the original draft acknowledged "higher levels of asbestos" and health concerns "for workers at the cleanup site and for those workers who might be returning to their offices" [DePalma, 2011].

Government agencies withheld or delayed release of some environmental sampling results that indicated the presence of contaminants at concentrations of concern. In November 2006, NYC DEP posted for the first time data indicating elevated outdoor levels of asbestos five years earlier in neighborhoods adjacent to Ground Zero [NYC DEP, 2006]. In October 2001, EPA shared its dioxin sampling results with OSHA, noting, according to an internal OSHA email, that these were "the highest levels they have ever seen." Emails on this issue were exchanged between the OSHA Regional Administrator and the Assistant Secretary of Labor for OSHA. There is no indication that the dioxin data affected EPA or OSHA hazard assessment or risk communication. One year later, EPA released these data to the public and acknowledged that downtown dioxin levels had reached "the highest ambient concentrations that have ever been reported" [EPA National Center, 2002; DePalma, 2011]. Mischaracterization of risk by government agencies reduced the likelihood that workers and volunteers would use respiratory protection and that property owners and employers would engage in environmental testing or remediation. As late as 2007, EPA was still asserting that, other than those caught in the dust cloud on 9/11, people present in lower Manhattan after 9/11 were "unlikely to suffer short-term or long-term health effects from inhalation exposures" [Lorber et al., 2007].

Regulatory gaps presented challenges to exposure and risk reduction. Most of OSHA's approximately 470 permissible exposure limits (PELs) for chronic inhalational exposure are based on American Conference of Governmental Industrial Hygienists (ACGIH) voluntary threshold limit values (TLVs) from 1968. With advances in scientific knowledge, ACGIH strengthened the TLVs but political constraints prevented OSHA from updating the PELs. Although many PELs apply to known or presumed carcinogens, their regulatory limits are based on less hazardous, non-cancer health effects. Other carcinogens, such as dioxins and diesel exhaust, as well as other substances known to be hazardous, are not regulated. PELs assume exposure to a single chemical and at least a 16-hour recovery period prior to a second exposure to the same chemical. Such suppositions are not applicable in disaster situations, where simultaneous exposures to multiple substances may occur over extended work shifts [National Response Team, 2009b].

OSHA standards do not address extended work schedules. In disaster response, "strenuous work schedules combine with the unique hazards and exposures associated with disaster operations to impact worker fatigue" [National Response Team, 2009a]. For 9 months at the WTC site, 12-hour shifts and 7-day weeks resulted in prolonged periods of toil and exposure, with additional physical and mental

health consequences. Neither employers nor unions nor government agencies sought to address this issue.

MEDICAL RESPONSE

Despite early and extensive indications of illness, exposed worker, volunteer, and residential populations encountered numerous barriers to appropriate medical care. In the United States, as in other nations, there are relatively few medical professionals with expertise in identifying environmentally- or occupationally-induced illnesses, associating them with disaster-related exposures, or providing effective treatment or appropriate referrals [Alexander et al., 2006; Newman, 2011]. Although authoritative data regarding the number of occupational physicians nationally are lacking, credible recent estimates range from 1,455 to 2,579 [California Department of Public Health, date unknown; NIOSH, 2011b] In disaster scenarios, this situation results in "fragmented treatment by non-experts" and an absence of targeted outreach, public health education, and collection and sharing of data to inform clinical practice and public health policy [Lite, 2007]. In addition, catastrophic disasters may rapidly deplete the medical or financial resources of union- or employer-funded medical insurance plans or clinics.

New York City was fortunate to have several medical "centers of excellence" associated with the New York State Occupational Health Clinic Network (OHCN), the nation's only state-based occupational health clinic network. With minimal federal funding for screening of workers who were exposed to WTC contaminants and virtually no initial funding for treatment, these institutions provided the foundation for what ultimately became the NIOSH-coordinated and federally funded WTC Health Program established by the 9/11 Health and Compensation Act of 2010. The program provides medical monitoring and treatment for responders at the WTC and related sites in New York City, the Pentagon, and Shanksville, PA. It also provides medical monitoring and treatment for area workers and residents whose health was adversely impacted by exposure to WTC-derived contaminants. As of March 2014, 67,788 participants had enrolled in the WTC Health Program. Of this population, during the year ending March 31, 2014, 27,292 enrollees had monitoring or screening exams, 13,982 had diagnostic evaluations, 16,730 received medications, and 15,744 had inpatient or outpatient treatment [WTC Health Program, 2014].

The New York State Workers' Compensation system was neither able to ensure expert and timely medical care for workers who suffered delayed-onset illnesses, nor to adequately cover their medical costs. Maximum weekly benefits were limited to $400, lower than the federal poverty level for a family of four. Approximately 40% (4,670) of the 11,627 WTC-related claims filed were for rescue, recovery, and cleanup workers. Within these groups, nearly 90% of non-death claims involved respiratory system diseases, such as asthma and reactive airways dysfunction syndrome (RADS) [New York State Workers' Compensation Board, 2009]. Obstacles to successful WTC claims included lack of provision for access to medical care for non-acute injuries and illnesses, legal rules that bar claims due to time limitations, and challenges by employers and insurers. Greater than 50% of rescue, recovery, and cleanup worker claims were controverted, compared to a non-WTC controversion rate of approximately 16% [Workers Compensation Committee, 2011]. Anecdotal reports indicate that in some cases, medical conditions were exacerbated as treatment was delayed.

THE RESPONSE TO THE RESPONSE

In response to deficiencies in the "official" response, a broad, diverse, and sophisticated grassroots movement arose among impacted populations. The assertive intervention of broad-based coalitions composed of labor and community organizations and activists garnered increased attention to public health issues and challenged, and ultimately strengthened, government response efforts. These coalitions included labor, community, tenant, environmental, public health, immigrant rights, disability rights, and faith-based organizations; parent and student groups; and elected officials. Working separately and together, these groups and activists surmounted the artificial barriers that traditionally separate the occupational, environmental, and public health communities.

Activists overcame media silence and governmental denial of risk to earn public acceptance of the concept that exposure to WTC-derived contaminants could and did cause harm to human health. Arguing that effective remediation was beyond the financial and technical capabilities of property owners, employers, and tenants, they achieved public consensus that the federal government should be responsible for abating WTC-derived environmental contaminants.

They forced implementation of a participatory, transparent public process to oversee major aspects of disaster response operations. This process included public hearings at the city, state, and federal levels as well as meetings with EPA and OSHA. It also included labor and community representation on the EPA World Trade Center Expert Technical Review Panel and on the advisory boards for the WTC clinics and for the demolitions of heavily contaminated high-rise buildings. Activists also succeeded in enacting federal legislation to fund the medical centers of excellence and to ensure access to expert medical care for all impacted populations [Newman, 2011].[5]

[5] Detailed treatment of the "response to the response" is beyond the scope of this commentary. For more on these grassroots efforts, see Newman [2008] and Vanderlinden [2011]. For an example of a technical policy document resulting from grassroots efforts, see WTC CLC [2005].

DISCUSSION AND RECOMMENDATIONS

The protection of worker and community health during disaster response warrants additional focused attention. Although state and local agencies and private sector and voluntary organizations can and do play key roles in response efforts, they typically lack environmental and occupational health expertise and capacity. During the WTC response (and the ongoing response to Hurricane Sandy), no governmental entity assumed responsibility for defining and ensuring safe and effective remediation and reoccupancy of impacted residences and workplaces. The federal government should ensure administration of vital public health functions during catastrophic disaster response.

"The mission of public health is to promote physical and mental health, prevent disease, injury and disability, and protect the public from environmental hazards. It is distinct from health care in that public health focuses on the prevention of disease within populations, while health care focuses on the treatment of disease in individuals" [Salinsky, 2002]. Public health principles that should guide disaster response efforts include: identifying and assessing health hazards; informing, educating, and empowering impacted populations about health issues; mobilizing community partnerships to resolve health issues; ensuring enforcement of laws and regulations that protect worker and community health and safety; and ensuring access to medical care [HHS, 2008].

In the WTC response, direct intervention by the White House produced deliberate mischaracterization of risk and delays in and misdirection of occupational and environmental health efforts [Nadler, 2002; EPA Office of Inspector General, 2003; Rosner and Markowitz, 2003; Emails Show, 2007]. Disaster response should be driven by public health principles rather than by political imperatives.

After the 9/11 attacks, the charade of a rapid return to normalcy took precedence over prevention of additional harm to responders, workers, and residents [Rosner and Markowitz, 2003]. The premature reopening of Wall Street, the unwarranted extension of the rescue phase, and the failure to implement and enforce timely and effective risk assessment, respiratory protection, and environmental remediation contributed to unnecessary and avoidable health harm. Protection of the health and safety of rescue, recovery, and cleanup workers and volunteers and impacted communities must be an integral component of disaster response. Effective conduct of rescue operations should "do no additional harm" to rescue and recovery workers or to other exposure populations.[6]

[6] The author acknowledges the contributions of Eileen Senn, who originated the concepts of "do no additional harm" and of exposure assessments as "narratives informed by data."

Because workers, volunteers, and residents may be exposed to a wide range of unregulated or unidentified substances at unknown concentrations, the precautionary principle should inform safety and health efforts during disaster response: "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically…" [SEHN, 1998].

Quantitative sampling results may not provide adequate information for risk assessment. Sampling data are best evaluated in the context of comprehensive qualitative exposure and hazard assessments, including worst-case scenarios. Exposure assessments should be thorough "narratives informed by data" rather than simple characterization of sampling results. They should identify substances of concern and their hazards, tasks performed, equipment and tools utilized, exposure scenarios, and protective measures to be utilized. [Newman, 2011].

Exposure control is the primary method of protecting worker health and safety [NIOSH, 2011c; OSHA, 1992], including during disaster response. Traditionally, a hierarchy of controls is used in implementing feasible measures. Controls at the hazard source (elimination or substitution) are understood to be the most effective, followed with decreasing effectiveness by engineering controls (pathway interruption), administrative controls, and personal protective equipment. PPE is considered least effective because the hazard remains in place and the potential for human error, which could compromise protection, is high.

In the rescue phase of disaster response, the difficulty of eliminating or reducing hazards at the source makes respiratory protection essential [NIOSH, 2011a]. However, as the response transitions from rescue to recovery, efforts to ensure that hazard controls evolve from PPE to more effective methods are often lacking. For example, dust suppression using wet methods at Ground Zero and particularly at waste transfer stations was only nominally employed. As a result, measured concentrations of airborne respirable particulates at the Chambers Street waste transfer station were sometimes twice as high as those at the WTC site [Stuyvesant, 2002] In the author's experience, during the WTC response, asbestos abatement in adjacent impacted buildings without the use of containment, negative pressure, and wet methods was often the norm. During Sandy response, remediation of extensive mold growth without utilizing isolation and containment remains the norm. Disaster response should emphasize hazard elimination and reduction by moving rapidly toward the high end of the hierarchy of controls, as technically feasible.

Although inhalation is the primary chemical route of entry into the human body [Rand, 2002], reliance on respirators is the weak link in responder protection. In the initial chaos of a rescue effort, site characterization and job hazard assessment may not yet have been conducted;

utilization of the hierarchy of controls of hazards may not yet be possible; appropriate respirators may not be available; and responders may not have been trained about the necessity, proper use, and limitations of respirators. Unwarranted extensions of the rescue phase and delays in the implementation of an incident command system may further contribute to a lack of use of respirators or, alternatively, to an overreliance on their use to the exclusion more effective controls.

Respirator use (and misuse and non-use) during the WTC response occurred during heavy exertion, prolonged work shifts, and simultaneous exposure to multiple contaminants. Respiratory protection may not be adequately effective under such physically demanding conditions, which may also provoke deliberate removal of the respirator by the user. Distribution of respirators cannot be effective in the absence of training, fit-testing, and medical clearance. The WTC experience also indicates that provision of respirators to responders may not be adequately protective in the absence of direct supervision and regulatory enforcement.

WTC exposure populations were exposed or potentially exposed to hundreds of toxic substances, some of which have yet to be identified. Significantly, some of the known contaminants, such as dioxins, PAHs, and diesel exhaust, are known carcinogens, which lack regulatory inhalational limits. OSHA acknowledges that most PELs are out-of-date and insufficiently protective [OSHA, 2010], and that there are obstacles to revising them through the rulemaking process. It has published "recommended" exposure levels that are more stringent than their corresponding PELs [OSHA, 2013b]. It is imperative to revise and strengthen the PELs for chronic inhalational exposure as well as to develop acute, subchronic, and synergistic inhalational exposure guidelines. In the interim, increased reliance on more current, more protective science-based occupational exposure limits is warranted, as recommended by OSHA.

The complete absence of enforcement at the WTC site for 9 months was striking, as was the minimal enforcement at adjacent cleanup and demolition operations. OSHA opted not to apply or enforce applicable protective standards such as the Respiratory Protection Standard and the Hazardous Waste Operations and Emergency Response Standard (Hazwoper) at the WTC site. EPA declined to utilize the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund). Non-enforcement ultimately facilitated rapid debris removal at the expense of worker health.

Responders have a right to expect that their health and safety will be ensured by the strong worker protection and employer responsibility requirements of applicable OSHA and EPA standards. OSHA's current policy of voluntary compliance and non-enforcement during disaster response was first implemented during the 1989 Exxon Valdez oil spill and formalized after 9/11 [OSHA, 2003c]. A more effective approach would be to have OSHA mirror the function of the "competent person" in construction "who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them" (29 CFR 1926.32(f)). OSHA's role in disaster response should be expanded and proactive, utilizing consultation and technical assistance when effective and enforcement when necessary.

Currently, employers may postpone addressing cited hazards until appeals are exhausted. In the 10-year period ending in FY 2009, there were 33 fatalities in cited workplaces during the period where abatement was postponed during the appeal process. As OSHA head David Michaels has noted, "the only situation worse than a worker being injured or killed on the job by a senseless and preventable hazard is having a second worker felled by the same hazard" [Michaels, 2013]. The OSH Act should be revised to require employers to immediately abate serious, willful, or repeat hazards (i.e., when preliminary evidence indicates a substantial probability of death or serious harm to workers), even if appeals are pending.

Appropriate training about hazards, work procedures, protective measures, and available resources is "critical for the preparedness of the responder" [NIOSH, 2011a]. Training should be provided to a redefined and expanded population of rescue and recovery workers, including not only traditional first responders and skilled support personnel but also non-traditional responders such as area workers, day laborers, and volunteers. Pre-deployment and periodic refresher "readiness" training should emphasize precaution—i.e., assumption of and protection against worst-case scenarios, to be scaled back as assessments permit. It should include hazard recognition, the hierarchy of controls, proper use of PPE, recognition and avoidance of unusual conditions, and evacuation procedures [Lippy and Murray, 2002]. It should also emphasize worker rights and employer responsibilities under applicable OSHA standards for hazardous waste operations, hazard communication, respiratory protection and other PPE, and access to exposure and medical records. Last-minute deployment training should cover site-specific hazards and controls and should reinforce concepts already learned. OSHA has moved in this direction with the establishment of the Disaster Site Worker Outreach Training Program, a course for skilled support personnel (e.g., heavy equipment operators, truck drivers, iron workers, carpenters, laborers, etc.) and site clean-up workers. Finally, training must be conducted in a language and at a literacy level understandable to the workers involved, as required by OSHA [OSHA, 2007], using proven participatory, activity-based, adult learning techniques.

The longer shifts and longer work weeks frequent in disaster response may increase risk [National Response Team, 2009b]. At the WTC site, 12-hour work shifts and extended work weeks resulted in extended periods of exposure, with potential additional physical and mental

health consequences. Work shifts should be limited in length and number to minimize fatigue and stress, to reduce exposures, and to promote safe work practices [National Response Team, 2009a].

There is no scientific or regulatory basis for extending the rescue phase beyond the time frame necessary for retrieval of live victims and implementation of site control, an incident command system, and protective health and safety measures. At the WTC site, "significant risk-taking behavior became somewhat regularized … and continued long after the urgency from which it had stemmed had passed" [Rand, 2002]. The effective conduct of rescue operations should not preclude feasible efforts to protect the health and safety of rescue workers. While efforts to protect occupational health during disaster response should not impede immediate rescue efforts, these efforts should be conducted with responder risk minimized to the extent possible. The duration of the rescue phase must have a realistic time limit, informed by science and determined by site-specific conditions and the nature of the disaster event, rather than by politics or passions [Lippy and Murray, 2002; Newman, 2011].

The immigrant day laborers who "shaped up" to remove contaminated dust and debris from Lower Manhattan buildings comprised the least protected and most exploited work population. Protection of the health and rights of immigrant day laborers engaged in cleanup operations during disaster response, including wage and hour issues, health and safety training in a language and at a literacy level understandable by the participants, and access to medical monitoring and treatment, warrants targeted attention from government agencies [Newman, 2011].

The WTC experience demonstrates that diverse labor, community, and environmental organizations and constituencies can effectively unite around common environmental health concerns over a sustained period of time. It shows that local activists can achieve a high degree of expertise on technical and policy issues, and are capable of successful intervention with elected officials, government agencies, medical institutions, and contractors to effectuate concrete results in disaster response [Newman, 2008]. They will seek to partner with government agencies and will expect honest, timely, and accessible risk assessment and two-way communication. Risk communication should follow EPA's Seven Cardinal Rules of Risk Communication, including that "people and communities have a right to participate in decisions that affect their lives… [and] that the goal of risk communication should be to produce an informed public that is involved, interested, reasonable, thoughtful, solution-oriented, and collaborative" [Covello and Allen, 1988].

Government agencies involved in response efforts must be prepared to formalize a participatory, transparent public process for the active involvement of impacted communities. Such a process may include regular, open, participatory public meetings, oversight panels, advisory boards, and task forces, with experts and representatives chosen by and from impacted communities, as well as public hearings conducted by government bodies or elected officials [Newman, 2011]. This process should be informed by the principle of community-based participatory research (CBPR)—"an approach that promotes active community involvement in the processes that shape research and intervention strategies" [NIEHS, 2012].

In the aftermath of the WTC and Sandy disasters, potentially contaminated workplaces and residences were reoccupied without sampling, assessment, remediation, or technical guidance or oversight. Where post-Sandy remediation did occur, the authoritative guidelines of multiple government agencies [NIEHS, 2005; EPA, 2008; NYC DOHMH, 2008; OSHA, 2013a] were often ignored. Federal agencies should work with local governments to ensure uniform re-occupancy standards protective of public health for impacted workplaces and residences. These should be based on event- and site-specific criteria, with input from experts and the public. Residents, workers, property owners, employers, volunteers, and contractors should not be left on their own to determine how to safely and effectively address environmental contamination.

In catastrophic disasters, thousands of exposed responders, workers, volunteers, and residents may experience persistent adverse physical and mental health outcomes. Many workers, especially immigrant day laborers, may be under-insured or uninsured, and may have little or no effective access to medical care. Responders and other impacted populations must be afforded access to expert and long-term medical care for disaster-related health issues, if necessary. There is a need, in catastrophic disaster situations, for clinic- or hospital-based centers of excellence to engage in targeted outreach and public health education, appropriate medical monitoring and treatment, identification of late-emerging disease, and collection and sharing of data to inform clinical practice and public health policy [Newman, 2011]. Additional support from elected officials is needed to fund and sustain the World Trade Center Health Program. Reform is needed to address workers compensation rates that drive injured workers and their families into poverty and to eliminate obstacles that prevent workers from obtaining necessary and timely medical treatment. In the context of catastrophic disaster response, reform should include the creation of presumptions regarding causal connection between exposure and illness as well as expanded time frames for the filing of claims.

CONCLUSION

Despite incremental lessons learned from and since 9/11, responder, worker, and community health remain at unnecessary and avoidable risk during disaster responses, as evidenced by gaps in safety and health programs during

responses to the BP Deepwater Horizon oil spill and Hurricanes Katrina, Rita, and Sandy. Given current trends in global warming, technological change, and warfare, it is inevitable that additional catastrophic disasters will occur. If we are to protect public health in these circumstances, more proactive and fundamental policy changes are required in large-scale, complex emergency responses.

ACKNOWLEDGMENTS

NYCOSH received grants from New York City Health and Hospitals Corporation and New York Community Trust in partial support of work on this report.

REFERENCES

Adams RE, Boscarino JA. 2011. Perievent panic attack and depression after the World Trade Center disaster: A structural equation model analysis. Int J Emerg Ment Health1 3(2):69–79.

Aldrich TK, Gustave J, Hall CB, Cohen HW, Webber MP, Zeig-Owens R, Cosenza K, Christodoulou V, Glass L, Al-Othman F, et al. 2010. Lung function in rescue workers at the World Trade Center after 7 years. N Engl J Med 362(14):1263–1272.

Alexander GC, Larkin GL, Wynia MK. 2006. Physicians' preparedness for bioterrorism and other public health priorities. Acad Emerg Med 3(11):1238–1241.

APHA (American Public Health Association). Date unknown. Get the facts: Prevention and public health fund—Dedicated to improving our Nation's Public Health. Washington DC, fact sheet. www.apha.org/NR/rdonlyres/63AB0803-AC5B-41BE-82F8-790F446EAA28/0/PreventionPublicHealthfactsheet.pdf (Accessed March 12, 2014).

Banauch GI, Hall C, Weiden M, Cohen HW, Aldrich TK, Christodoulou V, Arcentales N, Kelly KJ, Prezant DJ. 2006. Pulmonary function after exposure to the World Trade Center collapse in the New York City Fire Department. Am J Respir Crit Care Med 174(3):312–319.

Biggs QM, Fullerton CS, Reeves JJ, Grieger TA, Reissman D, Ursano RJ. 2010. Acute stress disorder, depression, and tobacco use in disaster workers following 9/11. Am J Orthopsychiatry 80(4):586–592.

California Department of Public Health. Occupational safety and health professionals. Date unknown. www.cdph.ca.gov/programs/ohsep/Documents/Ind17Hand S00-05.pdf (Accessed July 7, 2014).

Caplan-Shaw CE, Yee H, Rogers L, Abraham JL, Parsia SS, Naidich DP, Borczuk A, Moreira A, Shiau MC, Ko JP, et al. 2011. Lung pathologic findings in a local residential and working community exposed to World Trade Center dust, gas, and fumes. J Occup Environ Med 53(9): 981–991.

CDC (Centers for Disease Control and Prevention). 2002. Occupational exposures to air contaminants at the World Trade Center disaster site-New York, September-October, 2001. MMWR Morb Mortal Wkly Rep 51(21):453–456.

Chatfield E, Kominsky J. 2001. Characterization of particulate found in apartments after destruction of the World Trade Center. http://www.old.911digitalarchive.org/objects/108.pdf (Accessed March 12, 2014).

Chiu S, Niles JK, Webber MP, Zeig-Owens R, Gustave J, Lee R, Rizzotto L, Kelly KJ, Cohen HW, Prezant DJ. 2011. Evaluating risk factors and possible mediation effects in posttraumatic depression and posttraumatic stress disorder comorbidity. Public Health Rep 126(2): 201–209.

Cho SJ, Echevarria GC, Kwon S, Naveed B, Schenck EJ, Tsukiji J, Rom WN, Prezant DJ, Nolan A, Weiden MD. 2014. One airway: Biomarkers of protection from upper and lower airway injury after World Trade Center exposure. Respir Med 108(1):162–170.

Cloud J. 2002. The survivor: A miracle's cost. Time. September 9, 2002.

Covello V, Allen F. 1988. Seven cardinal rules of risk communication. U.S. Environmental Protection Agency, OPA-87–020.

Crowley LE, Herbert R, Moline JM, Wallenstein S, Shukla G, Schechter C, Skloot GS, Udasin I, Luft BJ, Harrison D, et al. 2011. "Sarcoid like" granulomatous pulmonary disease in World Trade Center disaster responders. Am J Ind Med 54(3):175–184.

Cukor J, Wyka K, Jayasinghe N, Weathers F, Giosan C, Leck P, Roberts J, Spielman L, Crane M, Difede J. 2011. Prevalence and predictors of posttraumatic stress symptoms in utility workers deployed to the World Trade Center following the attacks of September 11, 2001. Depress Anxiety 28(3):210–217.

de Bruycker M, Greco D, Annino I, Stazi MA, de Ruggiero N, Triassi M, de Kettenis YP, Lechat MF. 1983. The 1980 earthquake in southern Italy: Rescue of trapped victims and mortality. Bull World Health Organ 61(6):1021–1025.

de la Hoz RE. 2010. Occupational asthma and lower airway disease among World Trade Center workers and volunteers. Curr Allergy Asthma Rep 10(4):287–294.

de la Hoz RE. 2011. Occupational lower airway disease in relation to World Trade Center inhalation exposure. Curr Opin Allergy Clin Immunol 11(2):97–102.

de la Hoz RE, Hill S, Chasan R, Bienenfeld LA, Afilaka AA, Wilk-Rivard E, Herbert R. 2008. Health care and social issues of immigrant rescue and recovery workers at the World Trade Center site. Occup Environ Med 50(12):1329–1334.

Debchoudhury I, Welch AE, Fairclough MA, Cone JE, Brackbill RM, Stellman SD, Farfel MR. 2011. Comparison of health outcomes among affiliated and lay disaster volunteers enrolled in the World Trade Center Health Registry. Prev Med 53(6):359–363.

DePalma A. 2011. New docs detail how feds downplayed ground zero health risks. ProPublica. www.propublica.org/article/new-docs-detail-how-feds-downplayed-ground-zero-health-risks (Accessed March 12, 2014).

E-Mails show OSHA refused enforcement role at WTC, Henshaw defends move. 2007. Inside OSHA. 14(14): http://www.in side-healthpolicy.com/Inside-OSHA/Inside-OSHA-07/09/2007/e-mails-show-osha-refused-enforcement-role-at-wtc-henshaw-defends-move/menu-id-219.html (Accessed March 12, 2014).

Emilcott Associates, Inc. 2001. Preliminary report on the H&S evaluation of the fresh kills landfill project supporting the WTC disaster recover [sic]. Prepared for New York City detectives endowment a ssociation.

EPA (U.S. Environmental Protection Agency). 2001a. Statement of Governor Christine Todd Whitman, Administrator, U.S. Environmental Protection Agency, before the Subcommittee on VA, HUD, and Independent Agencies of the Committee on Appropriations. November 28, 2001. http://www.yosemite.epa.gov/opa/admpress.nsf/12a74-4ff56dbff8585257590004750b6/98cdc2362a6eb7aa8525701a0052e-42f!OpenDocument (Accessed March 12, 2014).

EPA (U.S. Environmental Protection Agency). 2001b. Whitman Details Ongoing Agency Efforts to Monitor Disaster Sites, Contribute to Cleanup Efforts. EPA Press Release, September 18, 2001. http://www.yosemite.epa.gov/opa/admpress.nsf/b1ab9f485b098972852562e7004-dc686/75aef680e69adf6585256acc007c2fc8?OpenDocument (Accessed July 27, 2012).

EPA (U.S. Environmental Protection Agency). 2008. Mold remediation in schools and commercial buildings. www.epa.gov/mold/pdfs/moldremediation.pdf (Accessed July 10, 2014).

EPA (U.S. Environmental Protection Agency, National Center for Environmental Assessment). 2002. Exposure and human health evaluation of airborne pollution from the World Trade Center Disaster. EPA/600/P-2/002A, October 2002.

EPA (U.S. Environmental Protection Agency, Office of Emergency and Remedial Response). 2001. Environmental data trend report—World Trade Center disaster (Draft). November 29, 2001. http://www.old.911digitalarchive.org/objects/117.pdf (Accessed March 12, 2014).

EPA (U.S. Environmental Protection Agency, Office of Inspector General). 2003. EPA's response to the World Trade Center collapse: Challenges, successes, and areas for improvement. Washington, D.C. EPA 2003-P-00012, August 21, 2003.

EPA (U.S. Environmental Protection Agency, Region 2). 2002. EPA and City Outline Comprehensive Plan to address the concerns of lower Manhattan residents about the impacts of the World Trade Center collapse on indoor air quality. Press Release, May 8, 2002. www.yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/01d2bee13d698fbd852571650065cdaf!OpenDocument& Highlight=2,risk (Accessed July 27, 2012).

Feldman DM, Baron S, Mueller CA, Bernard BP, Lushniak BD, Kelly KJ, Prezant DJ. 2004. Initial symptoms, respiratory function and respirator use in New York City firefighters responding to the World Trade Center (WTC) disaster. Chest 125:1256–1264.

Friedman SM, Maslow CB, Reibman J, Pillai PS, Goldring RM, Farfel MR, Stellman SD, Berger KI. 2011. Case-control study of lung function in World Trade Center Health Registry area residents and workers. Am J Respir Crit Care Med 184(5):582–589.

Guha-Sapir D, Carballo M. 2000. Medical relief in earthquakes. J R Soc Med. 93(2):59–61.

Guidotti TL, Prezant D, de la Hoz RE, Miller A. 2011. The evolving spectrum of pulmonary disease in responders to the World Trade Center tragedy. Am J Ind Med. 54(9):649–660.

Herbert R, Moline J, Skloot G, Metzger K, Baron S, Luft B, Markowitz S, Udasin I, Harrison D, Stein D, et al. 2006. The World Trade Center disaster and the health of workers: Five-year assessment of a unique medical screening program. Environ Health Perspect 114(12):1853–1858.

Herbstman JB, Frank R, Schwab M, Williams DL, Samet JM, Breysse PN, Geyh AS. 2005. Respiratory effects of inhalation exposure among workers during the clean-up effort at the World Trade Center disaster site. Environ Res. 99(1):85–92.

HHS (U.S. Department of Health and Human Services, Public Health Functions Steering Committee). 2008. Public health in America. Washington DC. www.health.gov/phfunctions/public.htm (Accessed September 24, 2012).

Horii Y, Jiang Q, Hanari N, Lam PK, Yamashita N, Jansing R, Aldous KM, Mauer MP, Eadon GA, Kannan K. 2010. Polychlorinated dibenzo-p-dioxins, dibenzofurans, biphenyls, and naphthalenes in plasma of workers deployed at the World Trade Center after the collapse. Environ Sci Technol 44(13):5188–5194.

Huang MJ, Li J, Liff JM, Cohen DE, Cone J. 2012. Self-reported skin rash or irritation symptoms among World Trade Center Health Registry participants. J Occup Environ Med 54(4):451–458.

IAFF (International Association of Fire Fighters). 2010. Respiratory diseases and the fire service.

Jordan HT, Miller-Archie SA, Cone JE, Morabia A, Stellman SD. 2011a. Heart disease among adults exposed to the September 11, 2001 World Trade Center disaster: Results from the World Trade Center Health Registry. Prev Med 53(6):370–376.

Jordan HT, Stellman SD, Morabia A, Miller-Archie SA, Alper H, Laskaris Z, Brackbill RM, Cone JE. 2013. Cardiovascular disease hospitalizations in relation to exposure to the September 11, 2001 World Trade Center disaster and posttraumatic stress disorder. J Am Heart Assoc 24; 2(5):e000431.

Jordan HT, Stellman SD, Prezant D, Teirstein A, Osahan SS, Cone JE. 2011b. Sarcoidosis diagnosed after September 11, 2001, among adults exposed to the World Trade Center disaster. J Occup Environ Med 53 (9):966–974.

Kim H, Herbert R, Landrigan P, Markowitz SB, Moline JM, Savitz DA, Todd AC, Udasin IG, Wisnivesky JP. 2012. Increased rates of asthma among World Trade Center disaster responders. Am J Ind Med 55 (1):44–53.

Kleinman EJ, Cucco RA, Martinez C, Romanelli J, Berkowitz I, Lanes N, Lichtenstein D, Frazer S, Lit M, Moran W. 2011. Pulmonary function in a cohort of New York City Police Department emergency responders since the 2001 World Trade Center disaster. J Occup Environ Med 53 (6):618–626.

LaDou J. 2010. Workers' compensation in the United States: Cost shifting and inequities in a dysfunctional system. New Solut 20(3):291–302.

Landrigan PJ, Lioy PJ, Thurston G, Berkowitz G, Chen LC, Chillrud SN, Gavett SH, Georgopoulos PG, Geyh AS, Levin S., et al. 2004. Health and environmental consequences of the World Trade Center disaster. Environ Health Perspect 112(6):731–739.

Lederman SA, Rauh V, Weiss L, Stein JL, Hoepner LA, Becker M, Perera FP. 2004. The effects of the World Trade Center event on birth outcomes among term deliveries at three lower Manhattan hospitals. Environ Health Perspect 112(17):1772–1778.

Leigh JP, Robbins JA. 2004. Occupational disease and workers' compensation: Coverage, costs, and consequences. Milbank Q 82(4):689–721.

Li J, Cone JE, Kahn AR, Brackbill RM, Farfel MR, Greene CM, Hadler JL, Stayner LT, Stellman SD. 2012. Association between World Trade Center exposure and excess cancer risk. JAMA 308(23):2479–2488.

Lin S, Reibman J, Bowers JA, Hwang SA, Hoerning A, Gomez MI, Fitzgerald EF. 2005. Upper respiratory symptoms and other health effects among residents living near the World Trade Center site after September 11, 2001. Am J Epidemiol 162(6):499–507.

Lioy PJ, Gochfeld M. 2002. Lessons learned on environmental, occupational, and residential exposures from the attack on the World Trade Center. Am J Ind Med 42(6):560–565.

Lioy PJ, Weisel CP, Millette JR, Eisenreich S, Vallero D, Offenberg J, Buckley B, Turpin B, Zhong M, et al. 2002. Characterization of the dust/smoke aerosol that settled east of the World Trade Center (WTC) in lower Manhattan after the collapse of the WTC 11 September 2001. Environ Health Perspect 110(7):703–714.

Lippy B. 2001. Operating Engineers National Hazmat Program—World Trade Center disaster air monitoring overview. Presentation to Dr. Kenneth Olden, Director, National Institute of Environmental Health Sciences, Washington DC, October 4, 2001.

Lippy B. 2003. Protecting the health and safety of rescue and recovery workers. In: Levy B, Sidel V, editors. Terrorism and Public Health—A balanced approach to strengthening systems and protecting people. New York and Washington DC: Oxford University Press and American Public Health Association.

Lippy B, Murray K. 2002. Improving the training of skilled support personnel for responding to terrorist actions: A review of the problems and feasible solutions. National Clearinghouse for Worker Safety and Health Training, National Institute of Environmental Health Sciences, Worker Education and Training Program.

Lite J. 2007. That's a bad way to treat WTC Ills. New York Daily News. March 1, 2007. www.nydailynews.com/news/world/bad-treat-wtc-ills-article-1.217394 (Accessed March 12, 2014).

Lorber M, Gibb H, Grant L, Pinto J, Pleil J, Cleverly D. 2007. Assessment of inhalation exposures and potential health risks to the general population that resulted from the collapse of the World Trade Center towers. Risk Anal 27(5):1203–21.

Malievskaya E, Rosenberg N, Markowitz S. 2002. Assessing the health of immigrant workers near Ground Zero: Preliminary results of the World Trade Center day laborer medical monitoring project. Am J Ind Med 42(6):548–549.

Maslow CB, Friedman SM, Pillai PS, Reibman J, Berger KI, Goldring R, Stellman SD, Farfel M. 2012. Chronic and acute exposures to the world trade center disaster and lower respiratory symptoms: Area residents and workers. Am J Public Health 102(6):1186–1194.

McGee JK, Chen LC, Cohen MD, Chee GR, Prophete CM, Haykal-Coates N, Wasson SJ, Conner TL, Costa DL, Gavett SH. 2003. Chemical analysis of World Trade Center fine particulate matter for use in toxicologic assessment. Environ Health Perspect 111(7): 972–980.

Michaels D. (Assistant Secretary of Labor for Occupational Safety and Health). 2010. Comments at NYCOSH briefing session, New York City, May 20, 2010.

Michaels D. (Assistant Secretary of Labor for Occupational Safety and Health). 2013. Testimony before the Subcommittee on Workforce Protections, committee on Education and Labor, U.S. House of Representatives, March 16, 2010. www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=TESTIMONIES&p_id=1062 (Accessed September 9, 2013).

Miele J. (Commissioner, New York City Department of Environmental Protection). 2002. Testimony before United States Senate Subcommittee on clean air, wetlands, and climate change, Washington DC, February 11, 2002.

Moline JM, Herbert R, Crowley L, Troy K, Hodgman E, Shukla G, Udasin I, Luft B, Wallenstein S, Landrigan P, Savitz DA. 2009. Multiple myeloma in World Trade Center responders: A case series. J Occup Environ Med 51(8):896–902.

Mugdan W. 2002. Environmental law issues raised by terrorist events in 2001. Presentation to Environmental Law Section, New York State Bar Association, New York City, January 25, 2002.

Nadler J. 2002. White paper—Lower Manhattan air quality. Office of U.S. Congressman Jerrold Nadler: Washington DC. http://www.nycosh.org/uploads/listit/id25/Nadler white paper on Lower Manhattan air quality 041202.pdf (Accessed March 12, 2014).

Nash J. 2002. Cleaning up after 9/11: Respirators, power, and politics. Occupational hazards. May 2002. http://www.ehstoday.com/news/ehs_imp_35460 (Accessed March 12, 2014).

National Archives and Records Administration. 2012. World Trade Center Health Program; Addition of certain types of cancer to the list of WTC-related health conditions. Federal Register. September 12, 2012. www.federalregister.gov/articles/2012/09/12/2012-22304/world-trade-center-health-program-addition-of-certain-types-of-cancer-to-the-list-of-wtc-related (Accessed March 12, 2014).

National Clearinghouse for Worker Safety and Health Training. 2001. National Institute of Environmental Health Sciences (NIEHS) Worker Education and Training Program (WETP) response to the World Trade Center (WTC) disaster: Initial WETP Grantee Response and Preliminary Assessment of Training Needs. Contract #273-FH-013264, October 6, 2001.

National Commission on Terrorist Attacks Upon the United States. 2004. The 9/11 commission report. Washington DC. www.9-11commission.gov/report/911Report.pdf (Accessed March 12, 2012).

National Response Team. 2009a. Guidance for managing worker fatigue during disaster operations: Volume I—Technical assistance document. www.cdc.gov/niosh/topics/oilspillresponse/pdfs/NRT-Fatigue-for-Emergency-Workers.pdf (Accessed March 12, 2014).

National Response Team. 2009b. Guidance for managing worker fatigue during disaster operations: Volume II—Background document. www.cdc.gov/niosh/topics/oilspillresponse/pdfs/NRT-Fatigue-for-Emergency-Workers.pdf (Accessed March 12, 2014).

New York State Workers' Compensation Board. 2009. World Trade Center cases in the New York Workers' compensation system. www.wcb.ny.gov/content/main/TheBoard/WCBWTCReport2009.pdf (Accessed June 21, 2012).

Newman DM. 2004. Comprehensive indoor sampling for the potential presence of 9/11-related contaminants in lower Manhattan. Prepared for EPA World Trade Center Expert Technical Review Panel, April 20, 2004.

Newman DM. 2007. Oversight hearing on the U.S. environmental protection agency's response to air quality issues arising from the terrorist attacks of September 11, 2001: Were there substantive due process violations? Testimony to United States House of Representatives, Committee on the Judiciary, Subcommittee on the Constitution, Civil Rights, and Civil Liberties, Washington DC, June 25, 2007. http://www.nycosh.org/uploads/listit/id9/NadlerCongressionaltestimony062507 final.pdf (Accessed March 12, 2014).

Newman DM. 2008. Disaster response and grassroots environmental advocacy: The example of the World Trade Center Community Labor Coalition. New Solut 18(1):23–2356.

Newman DM. 2011. Protecting disaster responder health: Lessons (not yet?) learned. New Solut 21(4):573–590.

NIEHS (National Institute of Environmental Health Sciences). 2005. Guidelines for the protection and training of workers engaged in maintenance and remediation work associated with mold. http://www.tools.niehs.nih.gov/wetp/public/hasl_get_blob.cfm?ID=2034 (Accessed July 10, 2014).

NIEHS (National Institute of Environmental Health Sciences). 2012. Environmental justice and community-based participatory research, program description. www.niehs.nih.gov/research/supported/programs/justice/ (Accessed March 12, 2014.).

NIOSH (National Institute for Occupational Safety and Health). 2004. Worker training in a new era: Responding to new threats. NIOSH Publication No. 2004-173.

NIOSH (National Institute for Occupational Safety and Health). 2011a. Emergency responder health monitoring and surveillance—Draft guidance document. NIOSH docket number 223. www.cdc.gov/niosh/docket/archive/docket223.html (Accessed March 12, 2014).

NIOSH (National Institute for Occupational Safety and Health). 2011b. National assessment of the occupational safety and health workforce. 200–2000–0801 7, Task Order 18. www.cdc.gov/niosh/oshworkforce/pdfs/NASHW_Final_Report.pdf (Accessed July 7, 2014).

NIOSH (National Institute for Occupational Safety and Health). 2011c. Workplace safety and health topics: Engineering controls. www.cdc.gov/niosh/topics/engcontrols/ (Accessed March 12, 2014).

NYC DDC (New York City Department of Design and Construction). Date unknown. About DDC. www.nyc.gov/html/ddc/html/about/about.shtml (Accessed March 12, 2014).

NYC DEP (New York City Department of Environmental Protection). 2006. Air monitoring in lower Manhattan. www.nyc.gov/html/dep/html/asbestos/airmonit_wide.shtml (Accessed March 12, 2014).

NYC DOH (New York City Department of Health). 2001a. Environmental issues related to WTC disaster. Memorandum, October 6, 2001, obtained via Freedom of Information Act request.

NYC DOH (New York City Department of Health). 2001b. Response to the World Trade Center disaster—Recommendations for people re-occupying commercial buildings and residents re-entering their homes. September 17, 2001.

NYC DOHMH (New York City Department of Health and Mental Hygiene). 2008. Guidelines on assessment and remediation of fungi in indoor environments. www.nyc.gov/html/doh/downloads/pdf/epi/epi-mold-guidelines.pdf (Accessed July 10, 2014).

Offenberg JH, Eisenreich SJ, Chen LC, Cohen MD, Chee G, Prophete C, Weisel C, Lioy PJ. 2003. Persistent organic pollutants in the dusts that settled across lower Manhattan after September 11, 2001. Environ Sci Techno l37(3):502–508.

OSHA (Occupational Safety and Health Administration, U.S., Department of Labor). 1992. Summary and explanation of the final cadmium standard for general industries, agriculture, and maritime. https://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=PREAMBLES&p_toc_level=1&p_keyvalue=Cadmium (Accessed July 5, 2012).

OSHA (Occupational Safety and Health Administration. U.S., Department of Labor). 2001a. Email from Zoldan E to Henshaw J, September 20, 2001, obtained via Freedom of Information Act request.

OSHA (Occupational Safety and Health Administration. U.S., Department of Labor). 2001b. EPA-OSHA factsheet: Environmental information from lower Manhattan for residents, area employees and local business owners National News Release, USDL: 01-339, October 3, 2001. www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=NEWS_RELEASES&p_id=137 (Accessed July 26, 2012).

OSHA (Occupational Safety and Health Administration. U.S., Department of Labor). 2001c. OSHA, EPA update asbestos data. Continue to reassure public of contamination fears. OSHA National News Release, September 14, 2001. www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=NEWS_RELEASES&p_id=93 (Accessed July 27, 2012).

OSHA (Occupational Safety and Health Administration. U.S., Department of Labor). 2002. WTC emergency project partnership agreements—Final evaluation.

OSHA (Occupational Safety and Health Administration, U.S., Department of Labor). 2003a. A brief guide to mold in the workplace. https://www.osha.gov/dts/shib/shib101003.html (Accessed July 10, 2014).

OSHA (Occupational Safety and Health Administration. U.S., Department of Labor). 2003b. Inside the Green Line-OSHA responds to disaster.

OSHA (Occupational Safety and Health Administration. U.S., Department of Labor). 2003c. National Emergency Management Plan (NEMP). Directive number HSO 0100–001, December 18, 2003. https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=DIRECTIVES&p_id=3101 (Accessed March 12, 2014).

OSHA (Occupational Safety and Health Administration. U.S., Department of Labor). 2007. OSHA training standards policy statement. April 17, 2007. https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=INTERPRETATIONS&p_id=25658 (Accessed July 27, 2012).

OSHA (Occupational Safety and Health Administration. U.S., Department of Labor). 2010. Frequently asked questions on health hazards and protections. July 2, 2010. http://www.osha.gov/oilspills/interim-guidance-qa.html (Accessed July 26, 2012).

OSHA (Occupational Safety and Health Administration. U.S., Department of Labor). 2013a. OSHA factsheet: Mold hazards during disaster cleanup. https://www.osha.gov/Publications/OSHA-FS-3619.pdf (Accessed July 10, 2014).

OSHA (Occupational Safety and Health Administration. U.S., Department of Labor). 2013b. Permissible exposure limits—Annotated tables. https://www.osha.gov/dsg/annotated-pels/index.html (Accessed March 9, 2014).

Perritt KR, Herbert R, Levin SM, Moline J. 2011. Work-related injuries and illnesses reported by World Trade Center response workers and volunteers. Prehosp Disaster Med 26(6):401–407.

Pietrzak RH, Schechter CB, Bromet EJ, Katz CL, Reissman DB, Ozbay F, Sharma V, Crane M, Harrison D, Herbert R., et al. 2012. The burden of full and subsyndromal posttraumatic stress disorder among police involved in the World Trade Center rescue and recovery effort. J Psychiatr Res 46(7):835–842.

Platner J. 2002. Industrial hygiene at the World Trade Center disaster. Appl Occup Environ Hyg 17(2):84–85.

Pleil JD, Vette AF, Johnson BA, Rappaport SM. 2002. Air level of carcinogenic polycyclic aromatic hydrocarbons after the World Trade Center disaster. Proc Natl Acad Sci U S A. 101(32):11685–11688.

Prezant DJ, Weiden M, Banauch GI, McGuinness G, Rom WN, Aldrich TK, Kelly KJ. 2002. Cough and bronchial responsiveness in firefighters at the World Trade Center site. N Engl J Med 347(11):806–815.

Rand Science and Technology Policy Institute. 2002. Protecting emergency responders: Lessons learned from terrorist attacks. www.rand.org/pubs/conf_proceedings/CF176.html (Accessed March 12, 2014).

Reibman J, Lin S, Hwang SA, Gulati M, Bowers JA, Rogers L, Berger KI, Hoerning A, Gomez M, Fitzgerald EF. 2005. The World Trade Center residents' respiratory health study: New-onset respiratory symptoms and pulmonary function. Environ Health Perspect 113(4): 406–411.

Reibman J, Liu M, Cheng Q, Liautaud S, Rogers L, Lau S, Berger KI, Goldring RM, Marmor M, Fernandez-Beros ME, et al. 2009. Characteristics of a residential and working community with diverse exposure to World Trade Center dust, gas, and fumes. J Occup Environ Med 51(5):534–541.

Rosner D, Markowitz G. 2003. September 11 and the shifting priorities of public and population health in New York. Milbank Memorial Fund. www.milbank.org/uploads/documents/911/911.html (Accessed August 10, 2012).

Salinsky E. 2002. Public health preparedness: Fundamentals of the "System." National Health Policy Forum, George Washington University, Washington DC. http://www.nhpf.org/library/background-papers/bp_public_health_4-02.pdf (Accessed September 24, 2012).

SEHN (Science and Environmental Health Network). 1998. Wingspread Conference on the Precautionary Principle, January 26, 1998. www.sehn.org/wing.html (Accessed July 5, 2012).

Sengupta S. 2001. Day laborers at ground zero say they are not being paid. New York Times. October 19, 2001. www.nytimes.com/2001/10/19/nyregion/19WORK.html (Accessed August 10, 2012).

Solan S, Wallenstein S, Shapiro M, Teitelbaum SL, Stevenson L, Kochman A, Kaplan J, Dellenbaugh C, Kahn A, Biro FN., et al. 2013. Cancer incidence in world trade center rescue and recovery workers, 2001–2008. Environ Health Perspect 121(6):699–6704.

Spranger CB, Villegas D, Kazda MJ, Harris AM, Mathew S, Migala W. 2007. Assessment of physician preparedness and response capacity to bioterrorism or other public health emergency events in a major metropolitan area. Disaster Manag Response 5(3):82–86.

STAC (World Trade Center Health Program Scientific/Technical Advisory Committee). 2012. Letter from Elizabeth Ward, Chair, to John Howard, Administrator, World Trade Center Health Program, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. March 31, 2012. www.cdc.gov/niosh/docket/review/docket257/ (Accessed July 20, 2012).

Stuyvesant High School Parents' Association. 2002. Response to Deputy Chancellor Klasfeld, February 7, 2002. http://www.stuy-pa.org/Environment/02_0207PA.htm (Accessed July 10, 2014).

Szema AM, Khedkar M, Maloney PF, Takach PA, Nickels MS, Patel H, Modugno F, Tso AY, Lin DH. 2004. Clinical deterioration in pediatric asthmatic patients after September 11, 2001. J Allergy Clin Immunol 13(3):420–426.

Szema AM, Savary KW, Ying BL, Lai K. 2009. Post 9/11: High asthma rates among children in Chinatown, New York. Allergy Asthma Proc 30(6):605–611.

Tapp LC, Baron S, Bernard B, Driscoll R, Mueller C, Wallingford K. 2005. Physical and mental health symptoms among NYC transit workers seven and one-half months after the WTC attacks. Am J Ind Med 47(6):475–483.

Technical Working Group. 2004. 'Gold standard' for remediation of WTC contamination. New Solut 14(3):199–217.

Trasande L, Fiorino EK, Attina T, Berger K, Goldring R, Chemtob C, Levy-Carrick N, Shao Y, Liu M, Urbina E., et al. 2013. Associations of World Trade Center exposures with pulmonary and cardiometabolic outcomes among children seeking care for health concerns. Sci Total Environ 444:320–326.

Vanderlinden LK. 2011. Left in the dust: Negotiating environmental illness in the aftermath of 9/11. Med Anthropo l30(1):30–55.

Weakley J, Webber MP, Gustave J, Kelly K, Cohen HW, Hall CB, Prezant DJ. 2011. Trends in respiratory diagnoses and symptoms of firefighters exposed to the World Trade Center disaster: 2005–2010. Prev Med 53(6):364–369.

Workers Compensation Committee. 2011. Update to 2009 report and recommendations to September 11th worker protection task force—Internal draft, not for public distribution. September 19, 2011. www.workcompcentral.com/pdf/2011/misc/WTCDraftReport.pdf (Accessed July 25, 2014).

World Trade Center Health Panel. 2007. Addressing the Health Impacts of 9/11: Report and recommendations to Mayor Michael R. Bloomberg.

World Trade Center Health Program, Centers for Disease Control and Prevention. 2014. Annual status as of 3/31/2014. www.cdc.gov/wtc/pdfs/WTCHPWebsiteRpt20140331Status2014-04-24.pdf (Accessed July 7, 2014).

WTC CLC (World Trade Center Community Labor Coalition). 2005. Comments on EPA's "Draft proposed sampling program to determine extents of World Trade Center impact to the indoor environment." Prepared for EPA World Trade Center Expert Technical Review Panel, New York City, January 18, 2005. http://www.nycosh.org/uploads/listit/id29/WTC CommunityLaborCoalitionComments 2005.pdf (Accessed March 12, 2014).

Zeig-Owens R, Webber MP, Hall CB, Schwartz T, Jaber N, Weakley J, Rohan TE, Cohen HW, Derman O, Aldrich TK, et al. 2011. Early assessment of cancer outcomes in New York City firefighters after the 9/11 attacks: An observational cohort study. Lancet 378(9794):898–905.

NYCOSH, the organization for which the author works, received grants from New York City Health and Hospitals Corporation and New York Community Trust in partial support of work on this report. NYCOSH receives funding from OSHA, NIEHS, and NYS DOL to conduct occupational safety and health training, including disaster preparedness and response training. NYCOSH receives funding from NIOSH to conduct outreach for the World Trade Center Health Program. NYCOSH previously received funding from New York Community Trust, Red Cross, and United Church of Christ Disaster Response Ministries for its World Trade Center disaster work.