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### Health Consequences of the 11 September 2001 Attacks

The central question confronting the environmental health research community in the aftermath of the terrorist attacks on the World Trade Center and the Pentagon is to determine whether these horrific events on 11 September 2001 will have continuing consequences for the health of the public. Workers, community residents, policy makers, and the press are asking us daily about the possible short- and long-term health threats of asbestos, silica, airborne dust, heavy metals, and the products of combustion. They are asking about risks to rescue, recovery, and construction workers as well as to office workers and residents of nearby communities. Our responsibility is to undertake the studies that will answer these questions and to convey the results of our work on a timely and ongoing basis to public health authorities, clinical colleagues, and the public. The ultimate goal is to guide the prevention of disease.

Asbestos is a major threat to the health of workers at the World Trade Center site. Asbestos was used as fireproofing in construction of the north tower up to approximately the fortieth floor, and it was used also in the north tower elevator shafts (1). Some of this asbestos had been removed from the building in the years since its construction, but much still remained on 11 September. That asbestos was blasted free during the attacks. Much of it fell into the dust and debris at Ground Zero. Air samples obtained by the U.S. Environmental Protection Agency (U.S. EPA) and the Occupational Safety and Health Administration (OSHA) in the weeks since the attacks have shown that 8-hr time-weighted average (TWA) levels of airborne asbestos fibers are generally below OSHA standards (2). However, bulk samples of dust at the site show concentrations of asbestos ranging as high as 20%. This material is unevenly distributed at the site, but the potential for exposure is constant. Whenever workers pick up a steel beam or overturn a piece of rubble, the threat exists that a puff of asbestos can be thrown into the air and then inhaled. The long-term health risks of those exposures include lung cancer and malignant mesothelioma. Risks will be greatest for those with the most intense and prolonged exposures. Protection against these risks requires the provision of proper respirators to workers and the undertaking of health and safety training programs that emphasize the need for constant wearing of respirators, for proper fit testing, and for frequent changing and cleaning of filters. Workers at the site are also at risk of exposure to silica, lead, benzene, dioxin, and other combustion products. Fortunately, the same respirators and training programs that protect against asbestos will protect against most of those hazards.

To assess the long-term consequences of occupational exposures to workers at the sites, the urgent need exists to establish a registry of all workers and to conduct baseline physical examinations of those at highest risk. Detailed information needs to be collected on the timing and nature of each worker's job and on when and where he/she performed it. Time-activity logs need to be constructed and kept up.



Respiratory questionnaires need to be administered, and pulmonary function tests performed. Baseline chest X rays may be desirable. Blood samples should be taken for analyses of PCBs, dioxins, and other products of combustion.

A consortium of five National Institute of Environmental Health Sciences (NIEHS) centers has met already under the leadership of Kenneth Olden, director of the NIEHS, to consider these issues. A collaborative plan for moving forward with an occupational health research program has been developed. Close liaison has been established with the Centers for Disease Control and Prevention, the National Institute for Occupational Safety and Health, the U.S. EPA, the New York State Department of Health, and the New York City Department of Health, as well as with contractors and the major labor unions. Only through such joint effort can this program succeed.

The communities near the World Trade Center were enveloped in dust as a consequence of the fires and explosions on 11 September. For many weeks thereafter, these communities have continued intermittently to be subjected to the smell of acrid smoke from the long-burning fires at the base of the site. Many offices and apartments were coated with dust that came in through shattered windows or inadequately protected air handling systems. One piece of bright news is that many office buildings with alert maintenance staffs rapidly shut down their air intake systems on 11 September and thus kept out much of the dust. Residential buildings, where staff were fewer in number and generally less well trained, fared less well.

Air sampling undertaken by the U.S. EPA in lower Manhattan has shown that asbestos is there but that levels have generally been low (2). The index used by the U.S. EPA to assess risks has been the extremely health-protective standard developed for use in schools under the Asbestos Hazard and Emergency Response Act (AHERA). This standard employs transmission electron microscopy for examination of airborne asbestos and therefore is able to detect even the smallest airborne fibers.

Although levels of airborne asbestos are generally low, concern arises from the fact that many of those at risk of exposure are children. Several factors have the effect of increasing children's potential risk (3). Children live closer to the ground than adults and thus are more likely to inhale any materials stirred up from dust. Children breathe more air per kilogram of body weight per day. Also, children have more years of future life in which to develop mesothelioma or other delayed diseases that may result from exposures to asbestos or to other toxic materials. Almost no data exist on the possible long-term consequences of low-level asbestos exposure in early childhood.

Cases of mesothelioma have, however, been reported in the grown children of asbestos workers (4), among nonworking women in the asbestos-mining townships of Quebec (5), and among long-term residents of a community near an asbestos plant in Italy (6). The need exists therefore to take aggressive steps to minimize pediatric exposure and also to create a registry of children of all ages who have been potentially exposed to dust. No physical examination or chest X rays of these children is warranted at this time (7), but names and other identifying information should be held in a register with the goal of long-term follow-up.

Children are also at risk of exposure to toxic products of combustion that may have been generated during the explosions and fires. These materials include benzene, dioxins, furans, and polycyclic aromatic hydrocarbons. It may be advisable to obtain samples of venous blood from the children deemed to have been at highest exposure and then to analyze those samples for whichever toxic products of combustion are identified in environmental samples.

Toxicity *in utero* is another possible dimension of the disaster. The possible consequences of physical and psychological exposures on pregnant women and their children are not known and need to be investigated. To this end, researchers at the Columbia University Center for Children's Health and the Mount Sinai School of Medicine have developed a joint proposal to examine infants born to women who were pregnant on 11 September 2001 and who were either acutely or chronically exposed. The acute exposure group will consist of pregnant women who actually were in the World Trade Center towers or in nearby office buildings at the time of the attacks. The chronic exposure group will consist of women who live and work in the communities of lower Manhattan. Samples of blood and other biological fluids will be taken from these women during pregnancy to assess their possible exposures. The infants will be evaluated at birth and periodically over the first several years of life. Psychological examinations of mothers and their babies will be conducted in conjunction with the physical assessments.

The consequences for mental health of disasters such as the World Trade Center and Pentagon attacks will be profound. Past experience with military and civilian disasters, as well as the follow-up of veterans from the Korean, Vietnam, and Gulf Wars, has shown that a range of disorders can result (8). The most serious is full-blown post-traumatic stress disorder (PTSD). Many people whose reaction to stress is not as extreme as PTSD will nevertheless suffer from a range of symptoms including flashbacks, blackouts, and feelings of grief and devastation. Alcoholism, depression, and even suicide are possible. Careful assessments of psychological status and the provision of extensive counseling to survivors are important needs, and programs for providing such counseling are already in place. It is important that we realize that the psychological consequences of disasters such as those of 11 September can last in some people for years or even decades.

Concern has existed since the earliest moments on 11 September that the attacks on the buildings might be the precursors of chemical or biological attacks. To protect against those possibilities, federal, state, and city health officials immediately set up monitoring programs to track any unusual patterns of illness. This sophisticated system included monitoring hospital admissions, emergency room visits, and even 911 emergency calls. Although these efforts undoubtedly contributed to early detection of the anthrax cases that have occurred in Florida, Washington, and New York, they underscore how weak, in general, disease tracking systems are in the United States. They underscore also how ill prepared most doctors and hospitals are to recognize, respond, and care for the victims of chemical or biological

attack. Most American physicians have never seen anthrax or smallpox, the two agents judged the most likely to be used in biological terrorism. Most hospitals have no plans for the proper isolation of victims or the protection of their staff (9).

The lack of preparedness for chemical weapons is equally low. It is sobering to note that in the aftermath of the Tokyo subway attack with sarin in 1995 many secondary cases of chemical poisoning occurred in hospital workers caring for the victims of the attack. These cases resulted because health care workers were untrained and because hospitals had no plans in place for the chemical decontamination of the victims prior to treatment (10).

A major need exists in the United States to strengthen programs for disease tracking. The extremely sensible recommendations of the Pew Commission on Public Health (11) need to be heeded by health officials at every level of government. Training programs need to be established for doctors, nurses, and other health care providers. Hospitals, particularly major hospitals in urban centers, need to be provided the resources and materials needed to develop response plans. These plans need to be closely coordinated with prehospital responders including fire departments, emergency medical technicians, and the Federal Emergency Management Agency.

Many questions of profound importance for public health were raised by the attacks on 11 September. Many of these questions remain to be answered, and some will not be answered for decades. The urgent need now is to put in place the studies and to establish the registries and the disease tracking systems that will enable us to answer these questions in the future. New York, Washington, and all of the United States need to press forward and not be paralyzed by these terrible attacks. At the same time, we must put in place the prudent safeguards that will prevent further loss of life.

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