Occupational Exposures to Air Contaminants at the World Trade Center Disaster Site—New York, September–October, 2001

AMID CONCERNS ABOUT THE FIRES AND suspected presence of toxic materials in the rubble pile following the collapse of the World Trade Center (WTC) buildings on September 11, 2001, the New York City Department of Health (NYCDOH) asked CDC for assistance in evaluating occupational exposures at the site. CDC’s National Institute for Occupational Safety and Health (NIOSH) collected general area (GA) and personal breathing zone (PBZ) air samples for numerous potential air contaminants. This report summarizes the results of the assessment, which indicate that most exposures, including asbestos, did not exceed NIOSH recommended exposure limits (RELS) or Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs). One torch cutter was overexposed to cadmium; another worker was overexposed to carbon monoxide (CO) while cutting metal beams with an oxyacetylene torch or a gasoline-powered saw, and two more were possibly overexposed to CO. NIOSH recommended that workers ensure adequate on-site ventilation when using gas-powered equipment and use rechargeable, battery-powered equipment when possible.

Toxic substances of concern included asbestos (from insulation and fireproofing materials), concrete (made from Portland cement and used in the buildings’ construction) and the crystalline silica it contained, CO (from fires and engine exhaust), diesel exhaust (from vehicles and equipment), mercury (from fluorescent lights), chlorodifluoromethane (Freon™-22, from air conditioning systems), heavy metals (from building materials), hydrogen sulfide (from sewers, anaerobically decomposing bodies, and spoiled food), inorganic acids, volatile organic compounds (VOCs), and polynuclear aromatic hydrocarbons (PAHs) (from fires and engine exhaust). Environmental sampling during September 1–October 4 focused on search-and-rescue personnel, heavy equipment operators, and workers cutting metal beams but also included various other occupations. A total of 1,174 air samples was collected, including 804 for asbestos. NYCDOH contractors collected most of the asbestos samples; NIOSH personnel collected all other samples. In addition, NIOSH collected 33 bulk samples of dust, debris, and other materials. All samples were collected and analyzed according to the NIOSH Manual of Analytic Methods3 with some modifications.

A total of 29 bulk samples of undisturbed settled material from various locations was analyzed for asbestos; 27 of these also were analyzed for crystalline silica and metals. Of the 29 samples, 26 (90%) had <1% asbestos (by mass); the three others had 1%-3%. All but one of 27 samples had crystalline silica; concentrations (by mass) ranged from 0-18%, with a median (for all 27 samples) of 3.2%. The most abundant metals in the samples were calcium, magnesium, aluminum, iron, and zinc. Lead, arsenic, cadmium, and beryllium concentrations (by mass) were <0.1%. Three bulk samples of fireproofing material on I-beams from the main debris pile were analyzed for asbestos; one was negative, and two had <1% asbestos. A sample of paint from a metal beam had 0.3% lead.

Phase contrast microscopy (PCM) revealed fibers in 358 (45%) of the 804 asbestos air samples. Excluding 30-minute samples, 23 samples had fiber concentrations that, if the fibers had been asbestos, would have exceeded the REL of 0.1 fibers per cubic centimeter of air (f/cc). None of the 30-minute sample concentrations exceeded the OSHA short-term excursion limit of 1.0 f/cc. Of the 25 samples with fiber concentrations 0.1 f/cc (range: 0.1-0.5 f/cc) by PCM, 18 were analyzed by transmission electron microscopy (TEM), which can distinguish between asbestos and nonasbestos fibers. All had asbestos concentrations <0.1 f/cc. The seven samples not analyzed by TEM had fiber concentrations ranging from 0.1-0.2 f/cc. Differential analysis by polarized light microscopy of these same 25 air samples revealed most nonasbestos fibers to be fibrous glass, gypsum, and cellulose.

Air concentrations of total (36 samples) and respirable (18 samples) particulate ranged up to 2.3 milligrams per cubic meter (mg/m³) and 0.3 mg/m³, respectively, which are below the corresponding RELs of 10.0 mg/m³ and 5.0 mg/m³ for Portland cement.1 Respirable crystalline silica was not detected in any of 18 air samples. Of 45 air samples analyzed for various metals, one from a 6½-hour PBZ sample from a torch cutter had a cadmium concentration (8.6 microgram per cubic meter [µg/m³]) that would have exceeded the PEL (8-hour time-weighted average [TWA]) of 5.0 µg/m³ even without further exposure during the remainder of the 8-hour shift. None of the samples had concentrations of lead, arsenic, beryllium, or other metals that exceeded NIOSH or OSHA exposure limits.

Two instantaneous peak CO measurements (1,239 and 1,368 parts per million [ppm]) exceeded 1,200 ppm, the level NIOSH considers an immedi-
ate danger to life and health.\(^1\) One was from a torch cutter and the other from a gasoline-powered saw operator. In 99 air samples, concentrations of CO ranged from 0.2 to 242.0 ppm; the highest finding (in a 321⁄2-minute PBZ sample from a saw operator) exceeded the NIOSH limit of 200 ppm and would have exceeded the PEL of 50 ppm (8-hour TWA) had it been sustained for 2 hours.\(^1,2\) CO concentrations of 41 ppm and 45 ppm in PBZ samples from torch cutters and 40 ppm in a GA sample near a saw operator, with sampling durations of 1⁄2, 5, and 2 1⁄2 hours, respectively, would have exceeded the REL of 35 ppm had they represented full-shift exposures.\(^1,2\)

Hydrogen sulfide was present in seven of 10 samples, one or more inorganic acids in all 27 samples, mercury in five of 16 samples, and one or more VOCs in 14 of 76 samples; all concentrations were below applicable NIOSH and OSHA exposure limits except for two benzene concentrations (0.4 mg/m\(^3\) and 0.5 mg/m\(^3\)) that exceeded the REL of 0.3 mg/m\(^3\).\(^1,1\) Both were in GA samples from a smoke plume and did not represent any specific worker's exposure. The highest concentration of elemental carbon (an indicator of diesel exhaust) was 0.023 mg/m\(^3\). Neither NIOSH nor OSHA has a numerical exposure limit for diesel exhaust, but the American Conference of Governmental Hygienists has proposed a limit of 0.2 mg/m\(^3\) (measured as elemental carbon).\(^4\) No Freon™-22 was detected in any of five samples. Small amounts of various PAHs were present in all 12 samples, but not at concentrations that exceeded individually or collectively any applicable NIOSH or OSHA exposure limit.

Toxic dusts and gases were suspected initially. Asbestos exposure, in particular, was an occupational and community health concern. The findings of this survey documented no occupational exposure to asbestos, at least after September 18, in excess of NIOSH or OSHA occupational exposure limits. The seven air samples that had fiber concentrations (determined by PCM) higher than the REL for asbestos probably would have had asbestos concentrations <0.1 fiber/cc if analyzed by TEM. In many other samples, asbestos concentrations determined by TEM tended to be lower than those determined by PCM. The NIOSH asbestos sampling did not provide data about occupational exposures before September 18 and was designed to assess occupational exposures, not community exposures, which probably were lower.

The absence of exposure to respirable crystalline silica, despite its presence in the bulk samples, indicates either that the crystalline silica in the dust at the site consisted of larger, nonrespirable particles or that work activities were not causing the dust to become airborne. In the absence of effective dust-control measures, the former explanation seems more likely. Although the air sampling indicated the presence of respirable airborne particles, this material was apparently not crystalline silica. One torch cutter had cadmium overexposure, and excess CO was associated with workers using oxyacetylene torches and gasoline-powered saws. To reduce CO exposure, NIOSH recommended replacing gasoline-powered saws with rechargeable, battery-powered saws.

At the time of the NIOSH sampling, the ambient air did not appear to be contaminated with toxic substances from the buildings or their contents or with combustion products to an extent that posed an occupational health hazard. However, the presence of hazards related to specific work activities at the WTC disaster site underscores the importance of assessing suspected occupational exposures. In response to the WTC disaster, NIOSH has issued guidelines for addressing a variety of occupational safety and health hazards at disaster sites.\(^3\)

**Acknowledgments**

This report is based on data contributed by: New York City School Construction Authority. Data Chem Laboratories, Salt Lake City, Utah. B Bernard, MD, D Booher, G Burr; E Esswein, MSPH, R Hall, MS, J Harney, MS, D Hewlett, MS, B King, MPH, S Lenhart, MSPH, B Luthriak, MD, R McClery, MSPH, K Martinez, MSE, D Mattorano, MS, A Weber, MS, Div of Surveillance, Hazard Evaluations, and Field Studies; K Linch, MS, P Middendorf, PhD, Div of Respiratory Disease Studies; S Earnest, PhD, A Echt, MPH, J Fernback, A Grote, C Neumeister, E Kennedy, PhD, T Zimmer, PhD, Div of Applied Research Technology, National Institute for Occupational Safety and Health, CDC.

**REFERENCES**

1. National Institute for Occupational Safety and Health. NIOSH pocket guide to chemical hazards. Cincinnati, Ohio: U.S. Department of Health and Human Services, CDC, National Institute for Occupational Safety and Health, 1997 (DHHS publication no. 97-140).
2. Occupational Safety and Health Administration. Toxic and hazardous substances. 29 CFR 1910 Subpart Z. U.S. Department of Labor. Occupational Safety and Health Administration. Available at http://www.osha-slc.gov/OshStd_toc/OSHA.Std_toc.1910_SUBPART_Z.html.
3. National Institute for Occupational Safety and Health. NIOSH manual of analytical methods, 4th ed. Cincinnati, Ohio: U.S. Department of Health and Human Services, CDC, National Institute for Occupational Safety and Health, 1994 (DHHS publication no. 94-113).
4. American Conference of Governmental Industrial Hygienists. Threshold limit values for chemical substances and physical agents & biological exposure indices. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 2001.
5. National Institute for Occupational Safety and Health. Suggested guidance for supervisors at disaster sites. Cincinnati, Ohio: U.S. Department of Health and Human Services, CDC, National Institute for Occupational Safety and Health. Available at http://www.cdc.gov/niosh/emhaz2.html.

**Rabies in a Beaver—Florida, 2001**

MMWR. 2002;51:481-482

On November 25, 2001, a beaver exhibited aggressive behavior by charging canoes and kayaks on the Ichetucknee River in Alachua County, Florida. The beaver was captured by park personnel and submitted to a Florida Department of Health (FDoH) laboratory for rabies testing. Park rangers contacted the Alachua County Health Department after they identified five persons who were in the vicinity of the
animal before capture. These five persons were interviewed by county health department personnel, who reported that although the beaver had made aggressive actions, the animal had not bitten anyone. This report summarizes the investigation of this case of animal rabies. Mammals that exhibit aggressive or other unusual behavior should be reported promptly to local health officials and should not be approached or handled by the public.

On November 27, the FDOH laboratory diagnosed rabies in the brain tissue of the beaver by using a fluorescent-antibody test. Monoclonal antibody strain typing indicated that the virus belonged to the antigenically distinct group of viruses found in raccoons in the eastern United States. Park personnel involved in the capture of the animal received postexposure prophylaxis. No treatment was recommended for the five persons who had been in the vicinity.

Of 3,751 animal specimens submitted for rabies testing to the FDOH during 2001, a total of 198 (5.3%) tested positive for rabies. In addition to the beaver, specimens included 124 raccoons, 34 foxes, 19 bats, 15 cats, two otters, one dog, one bobcat, and one horse. In 2001, no other rabid animals were identified in Alachua County. However, seven raccoons, four bats, three foxes, and one dog were reported with rabies in neighboring counties.

REFERENCES
1. Fishbein DB, Belotto AJ, Pacer RE, et al. Rabies in rodents and lagomorphs in the United States, 1971-1984: increased cases in the woodchuck (Marmota monax) in mid-Atlantic states. J Wildl Dis 1986;22:151-5.
2. Krebs JW, Strine TW, Smith JS, Noah DL, Rupprecht CE, Childs JE. Rabies surveillance in the United States during 1995. J Am Vet Med Assoc 1996;209:2031-44.
3. Krebs JW, Smith JS, Rupprecht CE, Childs JE. Rabies surveillance in the United States during 1996. J Am Vet Med Assoc 1997;211:1525-39.
4. Krebs JW, Smith JS, Rupprecht CE, Childs JE. Rabies surveillance in the United States during 1997. J Am Vet Med Assoc 1998;213:1713-28.
5. Krebs JW, Smith JS, Rupprecht CE, Childs JE. Rabies surveillance in the United States during 1998. J Am Vet Med Assoc 1999;215:1786-98.
6. Krebs JW, Smith JS, Rupprecht CE, Childs JE. Rabies surveillance in the United States during 1999. J Am Vet Med Assoc 2000;217:1799-1811.
7. Krebs JW, Mondul AM, Rupprecht CE, Childs JE. Rabies surveillance in the United States during 2000. J Am Vet Med Assoc 2001;219:1687-99.
8. Childs JE, Colby L, Krebs JW, et al. Surveillance and spatiotemporal associations of rabies in rodents and lagomorphs in the United States, 1985-1994. J Wildl Dis 1997;33:20-7.
9. CDC. Human rabies prevention—United States, 1999: recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR 1999;48 (No. RR-1).

©2002 American Medical Association. All rights reserved.
unknown, the field hospital was closed to all but patients with gastrointestinal symptoms. Because of the field conditions at the base and the severity of illness in the initial patients, one patient was evacuated to a U.S. military hospital in Germany, and 10 were evacuated to England. Two medical staff who treated the patients on the flight to England and a third contact at the hospital in England subsequently developed gastroenteritis; two of these persons were hospitalized for several days. All patients recovered rapidly and were discharged. The field hospital has since reopened with enhanced infection-control precautions.

In England, fecal specimens were tested for NLVs by electron microscopy (EM), a new antigen-capture enzyme-linked immunosorbent assay (ELISA), and reverse transcription-polymerase chain reaction (RT-PCR). By EM, clumps of small, round-structured viruses were observed and considered to be consistent with NLVs. This finding was confirmed by ELISA and RT-PCR in specimens from five patients. Partial sequence analysis of the polymerase gene identified the virus as belonging to genogroup II, the most common NLV genogroup in the United Kingdom and the United States.

The diagnosis of NLVs from stool specimens is difficult and depends on the identification of the viral RNA by RT-PCR, direct visualization of the viral particles by EM, and/or evidence of a specific antibody response in acute- and convalescent-phase serum specimens. Further characterization of the NLV into genogroups is possible by sequence analysis at reference laboratories. In the United States, detection by PCR is limited to some state health department and reference laboratories. Health-care providers generally consider the diagnosis on clinical grounds without seeking laboratory confirmation. As a result, many more outbreaks probably occur, but attribution to NLVs has been infrequent because of the difficulty of diagnosis. Simpler, less time- and labor-intensive diagnostic methods are under development. New antigen-capture assays, such as the ELISA used in this outbreak investigation, are being tested in Japan and Europe but have not yet been evaluated fully in the United States.

In this outbreak, the inability to identify an etiologic agent promptly and the unusual severity and atypical presentation of disease in the initial cases resulted in the illness being termed a “mystery infection.” This uncertainty led to the air evacuation of ill soldiers, during which secondary spread of the infection to health-care providers aboard one of the military flights occurred. The diagnosis was ultimately made in England, where EM and the new ELISA identified the etiologic agent as an NLV. Confirmation and characterization of the virus as a genogroup II strain was obtained by PCR and sequencing analysis. Field laboratory capacity for NLV diagnosis might have given on-site health-care providers information useful for limiting secondary spread of illness more effectively and allayed the fear and anxiety associated with the label of “mystery infection.” The same observation can be made for most acute gastroenteritis outbreaks in the United States that elude an etiologic diagnosis.

This outbreak demonstrates that NLV-associated illness occurs commonly and needs to be identified promptly so that patterns of transmission can be identified and interrupted. The development of simple and sensitive detection techniques remains a high priority. When these become available, the true burden of illness can be measured and more effective control measures implemented.

REFERENCES

1. Mead PS, Slutsker L, Dietz V, et al. Food-related illness and death in the United States. Emerg Infect Dis 1999;5:607-25.
2. Public Health Laboratory Service. Illness in military personnel in Bagram, Afghanistan. Commun Dis Rep CDR Weekly 2002;12. Available at http://www.phls.co.uk.
3. Glass RI, Noel J, Ando T, et al. The epidemiology of enteric caliciviruses from humans: a reassessment of enteric caliciviruses from humans: a reassessment. J Infect Dis 2002;185:525-61.
4. McCarthy M, Estes MK, Hyams KC. Norwalk-like virus infection in military forces: epidemic potential, sporadic disease, and the future direction of prevention and control efforts. J Infect Dis 2000;181:387-91.
5. Cohen D, Monroe SS, Haim M, et al. Norwalk virus gastroenteritis among Israeli soldiers: lack of evidence for flyborne transmission. Infection 2002;30:3-6.
6. Chadwick PR, Beards G, Brown D, et al. Management of hospital outbreaks of gastroenteritis due to small round structured viruses. J Hosp Infect 2000;45:1-10.
7. Bolyard EA, Pabian OC, Williams WW, et al. Guidelines for infection control in health care personnel. Am J Infect Control 1998;26:289-354.
8. Hutson AM, Atmar RL, Graham DY, Estes MK. Norwalk virus infection and disease is associated with ABO histo-blood group type. J Infect Dis 2002;185:1335-7.