

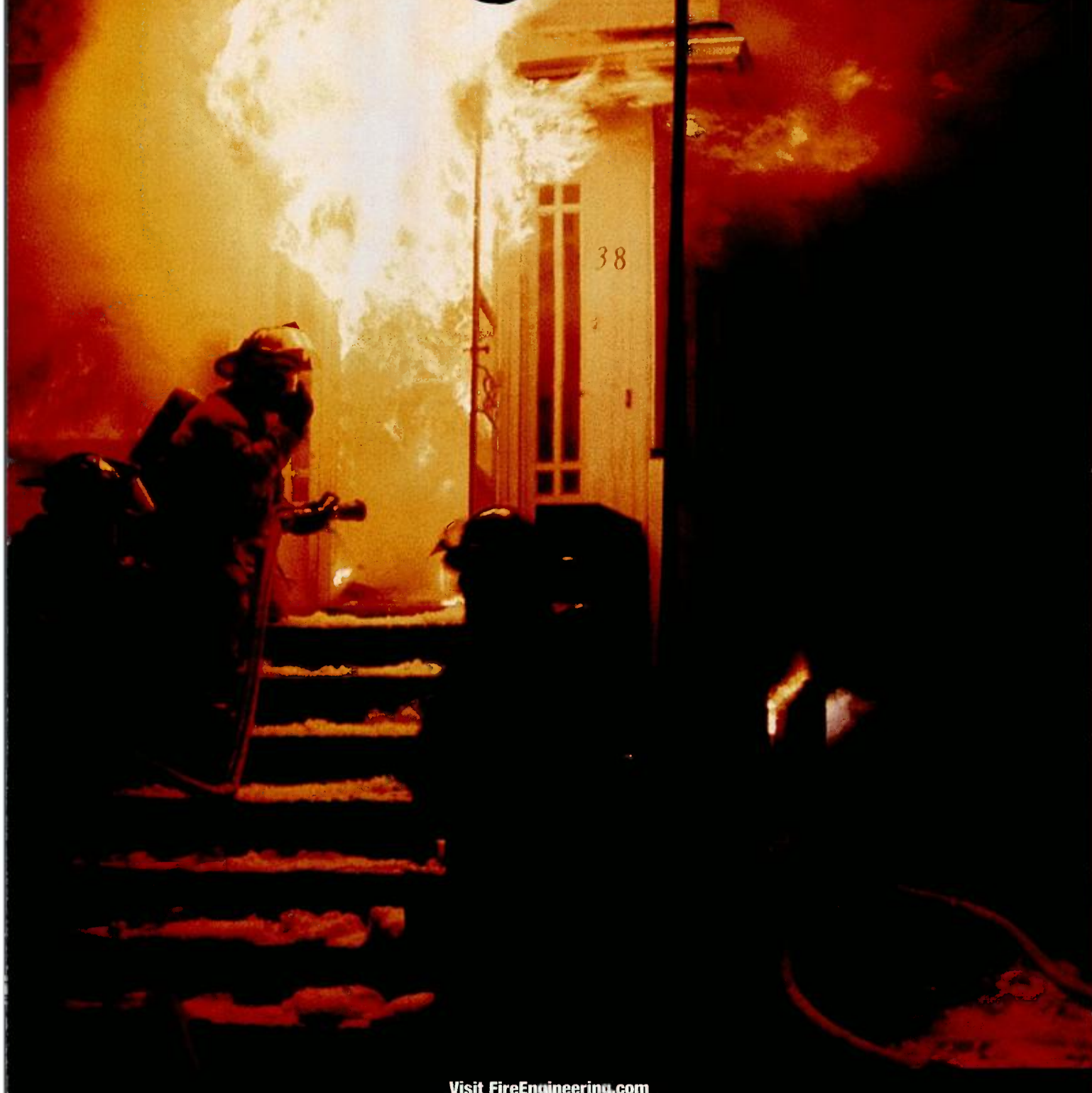
SAFETY AND HEALTH ♦ BACKUP HANDLINES ♦ SHREDDED TIRE FIRE ♦ CLOSE CALLS ♦ DETOX CLINIC

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DOWNTOWN MEDICAL: A DETOXIFICATION PROGRAM FOR WTC RESPONDERS

BY DAVID E. ROOT, M.D., MPH

For most Americans, the attacks on the World Trade Center (WTC) are a traumatic memory that grows less painful with the passage of time. For the firefighters and rescue workers who spent months at Ground Zero, however, time is bringing more questions than consolation.

The attack on the towers, and their collapse, brought toxic exposures that were unprecedented, beginning with a dust storm of pulverized concrete, steel, asbestos, carpeting, office equipment, and other matter.

"When we arrived at the site, what hit me at first was that there were still people on the ground trying to get the dust out of their throats," recalls Eddie Zielman, a firefighter with Fire Department of New York (FDNY) Rescue 4 in Queens. "Even with their mouths closed, the force that came at them just pushed it into their mouths. They were actually suffocating, and they were sticking their fingers in their mouths, trying to clear an airway."

Exposures of varying severity continued for months, as firefighters and rescue workers spent 18 or more hours a day at Ground Zero. Self-protection was the least of priorities—for that matter, virtually all of the truly effective protective equipment had been buried with the members who were wearing it.

BEYOND RESPIRATORY EFFECTS

Toxicologist and physician James Dahlgren, a clinician and associate professor at the UCLA School of Medicine, has spent the past three decades studying the effects of toxic chemical exposures and has examined hundreds of firefighters. Since the WTC attacks, Dr. Dahlgren has made numerous trips to New York to join in the effort to document the

health effects now being experienced by firefighters.

"Attention so far has been on the lungs," he notes. "But the men who were at the site have many, many other health problems besides. What's noticeable are the effects on neurological systems—headaches, confusion, dizziness, decreased memory, decreased concentration, decreased libido, severe fatigue, fuzzy thinking, irritability—all of the classic symptoms associated with various neurotoxins."

"The danger is that the body doesn't have any defenses against very small particles in gases or vapors," he adds. "They go straight into the lung sacks, called 'alveoli.' They are one cell membrane thick, so things very readily cross that membrane and go into the bloodstream and then are distributed throughout the body. We have better protective mechanisms for ingested materials than inhaled materials—before something is absorbed into the bloodstream from the stomach, it goes to the liver, and the liver has a chance to filter out some of the more bothersome chemicals."

DETOXIFYING THE RESCUE WORKERS

Since the mid-1980s, Dr. Dahlgren has shared research findings with staff at the nonprofit Foundation for Advancements in Science and Education (FASE). Over the past two decades, FASE has participated in a series of research projects assessing the public health use of a procedure developed by L. Ron Hubbard to reduce body burdens of toxic chemicals. The program involves a precise regimen of daily sauna bathing; exercise; and vitamin, mineral, and oil supplements (see sidebar on page 62).

As Dr. Dahlgren and other physicians worked to grasp the impact of the exposures, FASE President Keith Miller began to receive calls from firefighters who knew about Hubbard's program and wanted to make it available in New York.

"We had the first call within weeks of the event," recalls Miller, who administered an occupational health clinic providing detoxification for more than 10 years before coming to FASE. "Given what we'd seen in our research projects, we agreed that exposed rescue workers would benefit from detoxification. There was really no option but to see how we could help."

After weeks of phone calls, Miller and other FASE associates traveled to New York in January 2002, to gain a first-hand view of the situation and the possibilities for treatment. One of their first meetings was with Israel Miranda, health and safety coordinator for the Uniformed EMTs and Paramedics of Local 2507.

"They made contact with me through the Uniformed Firefighters

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ELEMENTS OF THE DETOXIFICATION PROGRAM

- **Daily doses of immediate-release niacin.** Niacin stimulates lipid mobilization by triggering the release of free fatty acids into the bloodstream. It has been demonstrated that, while free fatty acid levels drop initially after taking immediate-release niacin, they rise markedly within two hours and continue at high levels for some time.
- **Moderate aerobic exercise.** This increases circulation, which ensures quick distribution of the niacin throughout the body and carries mobilized toxins to the excretory routes. Running is preferred, but this can be changed if medically indicated.
- **Intermittent sauna to force sweating.** As shown in several studies on this procedure, sweat is a primary elimination route for toxins. Sauna temperatures are lower than the typical health-club sauna. The sauna must be well ventilated. Subjects take frequent showers, to cool down and to remove substances from the skin and prevent their reabsorption. Liquids are administered, and participants are monitored for signs of dehydration and heat exhaustion.
- **Ingestion of cold-pressed oils.** They prevent mobilized toxins from being reabsorbed by the intestines. Polyunsaturated oils have been found to enhance excretion of extremely persistent chemicals, without depositing fat in the liver.
- **Vitamin and mineral supplementation.** The oil taken to prevent reabsorption of mobilized toxins may also reduce absorption of important nutrients. A resulting deficiency could increase the toxicity of mobilized chemicals such as PCBs. An increased intake of vitamins and minerals prevents such toxic effects and also balances the intake of niacin.

Note: For complete details, see L. Ron Hubbard's book *Clear Body Clear Mind*.

Additional information regarding studies of the program or public health concerns related to environmental toxins can be found at www.detoxacademy.org/.

Woodworth and Apryl McNeil, M.D., can be reached at Downtown Medical, P.C., in Manhattan at (212) 587-3961.

Association," Miranda said. "They told me about their program and explained the detoxification process. It sounded interesting; it sounded like there was something there. But being a New Yorker, I was a little leery. I was waiting for, where's the catch here, where's the hook?"

Despite his initial skepticism, Miranda knew that he needed help. "Before 9/11, a lot of the injuries to my people were musculoskeletal or stress-related injuries because of handling so many calls and seeing children, elderly women, mothers, and fathers in distress.

"Two or three days after the WTC came down, people starting getting different symptoms," he said. "The most common was a hacking cough that you just couldn't get rid of. Every time you coughed, your throat was raw—you just didn't want to cough because it hurt so much. People complained of always being tired, of acid reflux, indigestion, heartburn, headaches, restlessness, and inability to sleep at night. This was besides the regular musculoskeletal disorders—the bruises, cuts, banged-up bones—and the stress of being there every day looking at the scene. It was more than enough to tear anybody up little by little."

In addition to Miranda, Miller and other FASE associates met with safety officers for the Uniformed Firefighters Association and Port Authority, and with medical officers for FDNY and the New York Police Department (NYPD). A project advisory board was formed in March 2002; members included a former New York State Department of Health official who oversaw all Love Canal toxicology studies and a member of a Presidential advisory committee on Gulf War illness.

Another milestone was reached when New York physician Apryl

McNeil, M.D., expressed a desire to direct a clinic that could provide detoxification to rescue workers. "Whatever we eventually discover about the toxic chemicals released by the attacks," she said, "the simple truth is that they don't belong in the body at any level. It seemed obvious to me that a noninvasive treatment that could flush even some of these toxins out of the body could only be helpful, and I was convinced by the available research that the program would not cause harm."

ESTABLISHING A CLINIC

Miller and the growing body of project supporters faced a significant barrier, however. Though word of mouth within the unions and the rescue force was leading to a growing list of rescue workers eager to participate in the program, detoxification did not fit clearly within any existing initiatives in the city. It would be the only program attempting to address body burdens of toxins. Though the Hubbard program had been established as a compensable treatment for occupational exposures in some states, this was not true yet in New York. The city and state were facing the worst budget crisis in decades and were straining to meet the demands of an unprecedented public health emergency. Funds for new programs were scarce.

"One thing we knew," said Dr. McNeil, "is that we were not going to ask the rescue workers to pay for treatment themselves. It had already been more than a year since the first exposures, and we knew we had to start treating—so that meant finding funding outside the healthcare infrastructure."

At the recommendation of Miranda and other advisors, Miller established a fund that could receive donations to cover the costs of treatment. In partnership with project supporters, he set out to find the resources necessary to establish a clinic in New York.

Essential help came from actor Tom Cruise, long known for his involvement in environmental issues. Cruise stepped forward as a cofounder of the project and personally ensured that the first clinic—Downtown Medical, just blocks from Ground Zero—fully met its immediate capital and operating needs.

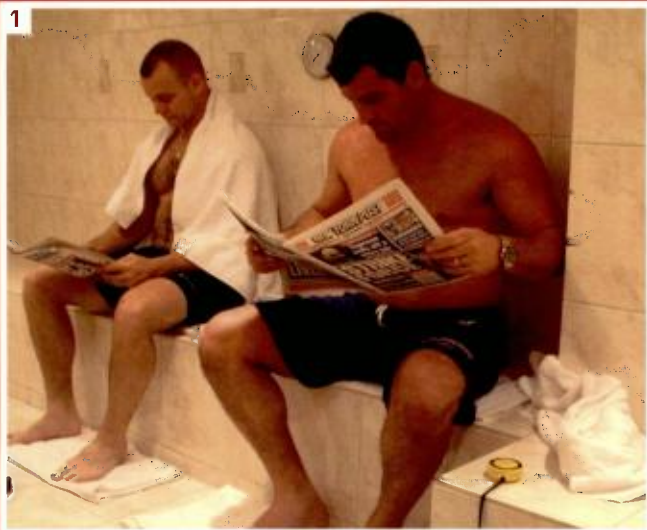
"I don't know how many people know what EMTs and paramedics make in New York City, but they don't make a whole lot of money," said Miranda. "My members usually live check to check. That's why it was important that people donated grants so we could put some of our people on the Hubbard program."

BLUE SWEAT

The first rescue workers started the program on September 28, 2002. From the beginning, it was apparent that the program was causing changes. "One of the men was in the sauna, and he touched his towel to his skin and it turned blue," said Dr. Dahlgren. "His sweat was really blue, a bright blue color. We cut out a section of the towel and sent it to the laboratory for analysis, and it came back with very high levels of manganese and other metals, too."

The finding had considerable interest for Dr. Dahlgren. "Manganese is present in structural steel—about three percent of the steel is manganese," he said. "So when the Trade Towers came down, they undoubtedly exposed people to manganese vapor and dust. Manganese has some interesting characteristics—it causes a disease identical to Parkinson's that usually ends up appearing anywhere from 5 to 10 years after the exposure."

To date, more than 50 rescue workers—including more than 30 fire-



(1) Daily sessions in a well-ventilated sauna, punctuated by frequent breaks to cool down and rehydrate, are an essential part of the detoxification program. In the sauna, Firefighter Joe Higgins (left) and James Carchietta, whose construction firm spent months at the WTC cleanup site. (Photos courtesy of FASE/Downtown Medical.) (2) Sweat comes in many colors in the saunas at Downtown Medical. Program participants have stained their towels purple, blue, orange, yellow, and black. A section of the imprint in this photo was sent for analysis. The primary toxin found was manganese, used as an alloy in steel and associated with a disease virtually identical to Parkinson's.

fighters—have completed the program. Clients continue to relate a variety of manifestations to clinic director Jim Woodworth. “Men have come in to tell me their bowel movements have been green or blue, or smelled like smoke. Some have had black paste coming out of the pores of their skin in the sauna. Their sweat has stained towels purple, blue, orange, yellow, and black,” he said.

“One client complained that he could taste soot from the site in his sweat in his mouth,” said Woodworth. “We collected about two tablespoons of his sweat and held it up to the light. There were millions of little bits of dust—you could see it with the naked eye; his sweat was grey.”

“We’re interested in capturing and analyzing these substances,” said Arlene Rich, treatment supervisor at Downtown Medical. “But right now the main focus is addressing the complaints that come consistently from those who arrive for treatment—shortness of breath, cough, headache, unrelenting fatigue, inability to sleep, acid reflux, skin rash, joint pain, memory loss, and extreme irritability, among other symptoms. We’ve had very encouraging results with all of these problems.”

RESTORING QUALITY OF LIFE

“I had a few people that I wanted to test this program with,” recalled Miranda. “One of them was a paramedic. He was on three steroids, a nebulizer, and two other pumps. The fire department told him there was nothing else they could do for him.

“He was about to lose his job, because if you can’t pass the pulmonary function test, obviously you’re not fit for full duty; you can’t work in the field. This is a guy who is a former pilot, is about 36 or 37, has three children, and had just bought a house. He didn’t make a lot of money, but he made ends meet.

“For the first three months after the WTC, he was missing at least 10 to 15 days of work each month because of his respiratory problem. He couldn’t go up a flight of stairs without wheezing. He became an instructor after 9/11, but he couldn’t do lectures. He had to keep stopping the lecture, go outside, take a couple of hits on his pump, and

come back in and keep talking.

“I got him in this program. After the fifth day or so, he was no longer on medication. When he completed it, he called me up. You know what he told me? Instead of telling his daughter why he was too tired to go to her soccer practice like he used to, he’s going with her to every game, he’s running two miles a day, he was flying again. His marriage, which was being disrupted by the situation, is back to normal. I felt so good that I would be able to help somebody to that extent, that they could have a quality of life. After that, I knew there was no hook—this program could help people.”

“YOU VS. TOXINS”

One person who has been helped is Joe Higgins, an FDNY member held in high esteem by his peers. In addition to fighting more than 1,000 inner-city fires, Higgins has trained more than 4,800 firefighters—almost half of the current FDNY force—as a drill instructor.

“I don’t point fingers or want to blame anybody for not giving me a respirator on day one, because it was so chaotic,” he said. “It’s very hard to point fingers at people. You have OSHA, you have all these folks that want to make sure we’re safe, and we appreciate that. But, when you’re in the middle of something like that, it looks like a hundred Iraqs. There were fires burning; there were toxins in the air. As time went on, we knew we were toxic.

“The truth is that people who fight inner-city fires are probably the most toxic people walking the earth,” Higgins said. “It’s not just the fires; we’re talking about even the smaller jobs—the oil burners, the food on the stoves, the 100-year-old insulation. It’s constant exposure to toxins and carcinogens. When you’re in the inner city, that’s what you’re doing, that’s your battle: You vs. toxins.”

After 9/11, the battle escalated. Higgins, who previously had no health problems, developed asthma. “I wasn’t paying a whole lot of attention to it, because I thought I would recover from it. It got bad for me. I was hospitalized, and I nearly died,” he said. “The fire depart-

ment took very good care of me. My doctor, Dr. Prezant, genuinely cares and is concerned about his patients, especially the firemen."

Higgins gained control over his asthma, but he was far from his pre-9/11 condition. When he arrived for an interview at Dr. McNeil's clinic, he had been sleeping an average of two hours per night for 13 months, waking from nightmares of the disaster. An athlete accustomed to exceptional health, he was troubled by side effects from the drugs he was now taking.

Things began to turn around once he began the program. "I could feel toxins exiting my body—almost a bit of a strange feeling, but I could feel it actually working," he said. "After a week or two, I felt like I was shot out of a cannon. I felt vibrant again. I was sleeping at night. That was important to me because I had lost my sleeping pattern, and I was always a good sleeper. Suddenly, I'm sleeping like a baby again, no more nightmares."

BATTLING THE TOXINS WITHIN

The New York project is not the first time that firefighters or public health specialists have used this detoxification program. On March 16, 1981, in the middle of the night, Firefighter David Werner responded to a hazardous-materials spill. After spending hours containing a 2,000-gallon lake of industrial solvent, he returned to the "safe zone" and took off his breathing apparatus. An hour later, he was in the hospital. He left feeling only slightly ill, but over the next five years he was plagued increasingly by headaches, fatigue, coughing fits, rashes, memory problems, and periods of extreme irritability. The worst thing, he recalls, was "knowing I was sick, knowing how and when it happened, yet having the experts tell me that I was not sick because nothing was confirmed by their tests."

Out of frustration, he decided to research the subject of chemical toxicity himself. As Werner discovered that the range of toxins he encountered on the job was bigger than he realized, he also found out about detoxification. After he completed the Hubbard program, most of his symptoms were entirely gone or greatly improved. "I felt fantastic," he said. "The thing that I notice the most is that I do not feel that I am constantly under the influence of toxins in my body."

As early as the 1950s, L. Ron Hubbard—mostly known as the founder of Dianetics and Scientology—had observed that drug addicts continued to manifest the effects of the substances they had abused after they had stopped using them. He postulated that drug residues that remained in their bodies were responsible; by the late 1970s, he had developed a program to reduce both these residues and the traces of man-made chemicals increasingly being found in fat and blood.

At the time, Hubbard's observation that low-level accumulations of chemicals or drugs could cause changes in health or behavior was radical. The suggestion that it might be possible—or beneficial—to reduce such residues was initially met with skepticism.

Nonetheless, the program intrigued occupational physicians and environmental health specialists. In 1982, the journal *Medical Hypothesis* published a paper reviewing the cases of 103 individuals who completed the program. The paper firmly established the safety of the procedure and offered insight into its potential health benefits.

Further studies and pilot programs continued to examine how the Hubbard program could reduce levels of dangerous toxins known to lodge in body tissue. In 1984, *Ambio*, the journal of the Royal Swedish Academy of Sciences, documented post-treatment reductions of PCBs, PBBs, and chlorinated pesticides as great as 35 percent.

The following year, the World Health Organization's International Agency for Research on Cancer published a study of the procedure that also noted PCB reductions, this time in a group of electrical workers. Perhaps more importantly, both research projects and clinical reports indicated that detoxification could reduce symptoms associated with toxic exposure dramatically.

These findings would have special meaning for a group of 14 firefighters in Shreveport, Louisiana, who responded to a powerhouse fire in April 1987. When a transformer containing PCBs exploded and leaked, the members inhaled fumes and smoke for as much as 30 minutes without protective breathing apparatus. The gloves of some were soaked; others wore no gloves. Though none felt ill immediately, within two to three months they began to report symptoms including extreme fatigue, headache, muscle weakness, aching joints, memory loss, insomnia, irritability, impaired balance, and hypertension. Many of these symptoms are associated with toxic-induced nerve damage; a published paper examining the detoxification of these firefighters concluded that "permanent" nerve damage may in some cases be partially reversible through detoxification.

Researchers continued to examine the public health applications of detoxification through the end of the 1980s and throughout the 1990s, well aware that mainstream medicine offered no therapy that addressed the problem of accumulated toxins.

A project conducted in cooperation with the government of Slovenia, then a part of the former Yugoslavia, involved detoxification of a group of Slovenian and Croatian workers in an electrical equipment factory who were exposed to PCBs and other chemicals at levels unthinkable in the industrialized West. Findings of this project, reported at the annual meeting of the American Society of Civil Engineers, led the researchers to advise that detoxification be implemented as a response to worker exposures.

In the aftermath of the Chernobyl disaster, researchers at the Medical Radiological Research Institute of the Russian Academy of Medical Sciences teamed with detoxification specialists from the United States and Europe to evaluate how Hubbard's program could help workers made ill during the cleanup effort. One of the most interesting findings of this work was a pronounced rebound of immune function following detoxification.

The improvements manifested by Gulf War veterans who completed the Hubbard program led to testimony before a Presidential Oversight Board and a recommendation for detoxification studies from a research planning conference sponsored by the Centers for Disease Control and Prevention, the National Institutes of Health, and the U.S. Department of Health and Human Services.

International conferences in Los Angeles and Stockholm brought together a growing group of researchers, physicians, environmental health specialists, government officials, writers, and others convinced that the detoxification program Hubbard had developed near-

**SOME OF THE
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LATE DATE.**

ly 20 years earlier should be an essential part of the public health response to large-scale environmental exposure incidents.

Though the scope of this work was broad, none could have envisioned what awaited rescue workers on September 11, 2001.

REACHING MORE RESCUE WORKERS

Higgins, who no longer requires medication and has resumed a vigorous training schedule, has become a vocal proponent of the Hubbard program. He recently joined several other firefighters on a trip to Washington, D.C., to meet with members of Congress and discuss how more treatment could be funded.

"I know a lot of firemen are going through this program, and I wish it would become a mandatory program for all firemen to do every five or 10 years," Higgins said. "People who walk around the streets today are toxic; but if that's so, what's a fireman, crawling down all those hallways and choking all those years? This is something that would be tailor-made for people in that type of position."

"We're well aware that this program is still new to many people," said Miller. "But the fact that men like Joe Higgins have completed it and have made dramatic recoveries is not going unnoticed. The clinic has had a steady stream of visitors from all over the country—researchers, physicians, government officials, and representatives of public interest groups—who are fascinated by what we're doing."

One of the main priorities for the project is to establish additional clinics in areas where the majority of firefighters live. "On the days when they're not working, it can be quite a strain for our clients to make it into Manhattan," said Woodworth. "Some have had to travel two hours or more each way. We've heard repeatedly that there are already hundreds of men just waiting for the day we open a clinic on Long Island."

STUDIES PLANNED

As details of case completions accumulated, Dr. Dahlgren contacted Miller and FASE to develop a WTC treatment study. "The studies to date have focused only on lung function," he said. "That to me is a disservice to individuals who were poisoned at the WTC. We need to look at markers of exposure—some of the chemicals that were present at the WTC will still be present in the body even at this late date. We can do dioxins and PCBs and other chemicals of interest in blood samples. Individual firefighters should have those results, and all of us should know so that we can extrapolate it to others who might possibly need treatment."

In collaboration with research staff at FASE, Dahlgren has evolved a protocol for a study that will proceed in two stages. The first phase of this work will involve the health screening of 1,000 firefighters that will include examining the full range of effects that might be associated with the WTC exposures. After these data are gathered and analyzed, a treatment study involving 100 firefighters will track the impact of detoxification on the levels of chemicals that have been found and the symptoms observed in the firefighters.

In the meantime, Dr. McNeil and her staff are capturing a variety of before and after tests in an on-site database, including balance and reaction tests that can detect toxic-induced damage to the nervous system.

"The focus of the clinic is helping the firefighters regain their pre-9/11 health status," she said; "and we have been achieving this on a routine basis. But we can't ignore the fact that we have a unique opportunity to gain knowledge that could be important for all firefighters who face exposures to the kinds of toxins released at the WTC site."

TOWARD THE FUTURE

As Miller and other project supporters work to find funding for the study, word of mouth within the firefighting community has led to a growing waiting list for treatment. While the legwork necessary to gain insurance compensability continues, treatment is being funded by foundation and private source donations to the treatment fund.

"The men that come to the clinic are in very bad shape. We've been able to do something about that, and we will do whatever it takes to meet the demand to help more of them," said Woodworth.

"Working with the unions has been a remarkable experience," he added. "The rescue workers are public servants in the highest sense. Their dedication to each other, to their families, and to the public seems to have no limits. Each time the process of detoxification helps one of these individuals regain vigor and hope, the effects are magnified many times over."

It's now been more than 20 years since Firefighter David Werner made this discovery himself. The body of knowledge and experience that has accumulated since that time may prove to be a crucial part of New York's rebuilding effort.

"We've honored the dead," said Miranda. "It's time to do something for the living." ■

References

- Schnare, D.W., G. Denk, M. Shields, S. Brunton, "Evaluation of a Detoxification Regimen for Fat Stored Xenobiotics," *Medical Hypothesis*; 9:265-282, 1982.
- Shields M., S.L. Beckmann, G. Cassidy-Brinn, "Improvement in Perception of Transcutaneous Stimulation Following Detoxification in Firefighters Exposed to PCBs, PCDDs and PCDFs," *Clinical Ecology*; VI(2): 47-50, 1989.
- Schnare, D.W., M. Ben, M. Shields, "Body Burden Reductions of PCBs, PBBs, and Chlorinated Pesticides in Human Subjects," *Ambio*; 13(5-6): 378-380, 1984.
- Schnare, D.W., P.C. Robinson, "Reduction of the Human Body Burdens of Hexachlorobenzene and Polychlorinated Biphenyls." In *Hexachlorobenzene: Proceedings of an International Symposium*, Lyon: Inter-national Agency for Research on Cancer, 1986. FASE: Proceedings of the First International Conference on Chemical Contamination and Human Detoxification, 1996.
- Tsyb, A.F., E.M. Parshkov, J. Barnes, V.V. Yarzutkin, N.V. Vorontsov, V.I. Dedov, "Rehabilitation of a Chernobyl Affected Population Using a Detoxification Method." US EPA: Proceedings of the 1998 International Radiological Post-Emergency Response Issues Conference.
- Tretjak, Z., S.B. Beckmann, A. Tretjak, C. Gunnerson, "Occupational, Environmental and Public Health in Semic: A Case Study of Polychlorinated Biphenyl (PCB) Pollution," Proceedings of the Annual Meeting of the American Society of Civil Engineers, 1989.
- Tretjak, Z., M. Shields, S.L. Beckmann, "PCB Reduction and Clinical Improvement by Detoxification: An Unexploited Approach?" *Human and Experimental Toxicology*; Vol. 9, 1991.
- Wisner, R.M., D. Root, M. Shields, S.L. Beckman, "Neurotoxicity and Toxic Body Burdens: Relationship and Treatment Potentials," Proceedings of the International Conference on Peripheral Nerve Toxicology, 1993.