

Just as it has for the nation as a whole, the world in which emergency responders work has changed in fundamental ways since September 11, 2001. Members of professions already defined by their high levels of risk now face new, often unknown threats on the job. At a basic level, the September 11 terrorist events have forced emergency responders to see the incidents they are asked to respond to in a new light. At the World Trade Center, 450 emergency responders perished while responding to the terrorist attacks—about one-sixth of the total number of victims. Hundreds more were seriously injured. In this light, the terrorist events are also forcing emergency responders to reconsider the equipment and practices they use to protect themselves in the line of duty.

Preparation is key to protecting the health and safety of emergency responders, and valuable lessons can be learned from previous responses. To this end, the National Institute for Occupational Safety and Health (NIOSH) sponsored and asked the RAND Science and Technology Policy Institute to organize a conference of individuals with firsthand knowledge of emergency response to terrorist attacks. The purpose of the conference was to review the adequacy of personal protective equipment (PPE) and practices, such as training, and to make recommendations on how the equipment and practices worked and how they might be improved. Attendees included persons who responded to the 1995 attack on the Alfred P. Murrah Federal Building in Oklahoma City, the September 11 attacks on the World Trade Center and the Pentagon, and the anthrax incidents that occurred during autumn 2001. They represented a wide range of occupations and skills: firefighters, police, emergency medical technicians, construction workers, union officials, and government representatives from local, state, and federal agencies. The conference was held December 9–11, 2001, in New York City, and this report synthesizes the discussions that took place there.

NEW RISKS, NEW ROLES FOR EMERGENCY RESPONDERS

Although the terrorist incidents shared some characteristics with large natural disasters, the NIOSH/RAND conference participants highlighted ways in which those incidents posed unique challenges. They were large in scale, long in duration, and complex in terms of the range of hazards presented. As a result of these characteristics, these events thrust responders into new roles for which they may not have been properly prepared or equipped. The themes of scale, duration, and range of hazards were repeated frequently during the discussions at the conference because they were seen as having critical implications for protecting the health and safety of emergency responders—during both the immediate, urgent phase and the sustained campaign phase of the responses.

The September 11 terrorist incidents were notable for their large scale—in terms of both the damage incurred and the human and material resources needed to respond. Conference participants spoke extensively about the difficulty of conducting search and rescue, fire suppression, and shoring and stabilization operations, as well as hazard monitoring. Responses were hampered by collateral developments, in particular the grounding of commercial air transport, which slowed the implementation of command and logistical support infrastructures.

The responses to the terrorist attacks involved days and weeks of constant work. At the World Trade Center, an initial urgent phase persisted for several days and then gradually transitioned into a sustained campaign that lasted for several months. An important message of the conference was that PPE generally worked well for its designed purpose in the initial response. However, such equipment typically was not designed for the continuous use associated with a sustained response campaign. Firefighter turnout gear, for example, is constructed to be worn for, at most, hours. Accordingly, responders spoke of being hampered by basic problems such as wet garments and blistered feet.

Furthermore, at major terrorist-attack sites, emergency workers face a staggering range of hazards. Not only do they confront the usual hazards associated with building fires—flames, heat, combustion by-products, smoke—they also must be prepared to deal with rubble and debris, air choked with fine particles, human remains, hazardous materials (anhydrous ammonia, freon, battery acids), and the potential risk of secondary devices or a follow-on attack. Conference participants indicated that many currently available PPE ensembles and training practices were not designed to protect responders from this range of hazards or were not supplied in sufficient quantity at the attack sites to meet the scale of the problem.

The scale of the terrorist events, their duration, and the range of hazards required that many emergency responders take on atypical tasks for which they were insufficiently equipped and trained. The nature of the destruction at the World Trade Center and the Pentagon reduced opportunities for primary reconnaissance and rescue—important tasks for firefighters in large structural fires. Conversely, firefighters became engaged in activities they usually do not do: “busting up and hauling concrete,” scrambling over a rubble pile, and removing victims and decayed bodies and body parts.

Construction workers were also deployed at the scenes and placed in hazardous environments early on. In all of the terrorist-incident responses, emergency medical personnel were on-scene, performing rescue operations, for example, in the rubble pile at the World Trade Center. Complicating activity at these already chaotic, hazardous, and demanding attack sites was the fact that the sites are also crime scenes. In addition, there were massive influxes of skilled and unskilled volunteers that created a significant challenge in managing the incident sites and assuring that all were properly protected.

In sum, the definition and roles of an *emergency responder* expanded greatly in the wake of the terrorist attacks, but few of the responders had adequate PPE, training, or information for such circumstances.

PERSONAL PROTECTIVE EQUIPMENT PERFORMANCE AND AVAILABILITY

From the experiences at these attack sites, it is clear that there were significant shortfalls in the way responders were protected. Many responders suggested that the PPE even impeded their ability to accomplish their missions.

Within the overall PPE ensemble used by responders at these sites, some equipment performed better than others. While head protection and high-visibility vests functioned relatively well for most responders, protective clothing and respirators exhibited serious shortcomings. Conference participants reported that the available garments did not provide sufficient protection against biological and infectious disease hazards, the heat of fires at the sites, and the demanding physical environment of unstable rubble piles, nor were they light and flexible enough to allow workers to move debris and enter confined spaces. Attendees also indicated that the available eye protection, while protecting well against direct impact injury, provided almost no protection against the persistent dust at the World Trade Center site.

Of all personal protective equipment, respiratory protection elicited the most extended discussion across all of the professional panels. Attendees indicated that under most circumstances, the self-contained breathing apparatus (SCBA)

was grossly limited by both the weight of the systems and the short lengths of time (about 15 to 30 minutes) they can be used before their air bottles must be refilled. Most participants complained that respirators reduced their field of vision at best, and their facepieces fogged up at worst. Filters for air-purifying respirators (APRs) often did not match available facepieces, and many responders questioned the level of protection they provided, especially during anthrax responses.

For almost all protective technologies, responders indicated serious problems with equipment not being comfortable enough to allow extended wear during demanding physical labor. It was frequently observed that current technologies require a tradeoff between the amount of protection they provide and the extent to which they are light enough, practical enough, and wearable enough to allow responders to do their jobs. While conference attendees were concerned about having adequate protection, many were even more concerned about equipment hindering them from accomplishing their rescue and recovery missions in an arduous and sustained campaign. Respirators available at the sites were uncomfortable, causing many wearers to use them only intermittently (one participant dubbed them “neck protectors”) or to discard them after a short period.

For many firefighters at the conference, PPE availability was as important a concern as PPE performance. Some health-and-safety panelists expressed a similar view. There was an acute shortage of respirators early in the response at the World Trade Center, for example. Subsequently, providing appropriate equipment to the large numbers of workers at these sites was made even more difficult because of the many types and brands of equipment that were being used by the various responder organizations or were being supplied from various sources. The problem was further exacerbated by a lack of interoperability among different types of equipment. These issues, coupled with the very large volume of equipment sent to the World Trade Center site, in particular, made it very difficult to match responders with appropriate equipment and supplies.

PERSONAL PROTECTIVE EQUIPMENT TRAINING AND INFORMATION

The responses to the terrorist attacks uncovered a range of PPE training and information needs. Before an incident occurs, those who are likely to be involved in a response should be trained on the proper selection and operation of personal protective equipment. Emergency medical technicians who were themselves treating casualties in the heart of the disaster site should have been wearing PPE but frequently were not, in large part because this equipment was not part of their standard training regimen.

The experiences in these incidents also showed that there is a need for significant on-site training to protect the health and safety of workers. The attack sites involved large numbers of workers, particularly construction workers and volunteers, many of whom were not familiar with most PPE. They needed to be trained in the proper selection and fitting of respirators, how to maintain them, and when to change filters. The situation with anthrax was more severe. Health and safety panel members felt that training support during the anthrax attacks was inadequate on all fronts: The response protocols were being developed *during* the actual responses.

Emergency responders repeatedly stressed the importance of having timely and reliable health and safety information. “What kills rescue responders is the unknown,” commented an emergency medical services (EMS) panel member. Several shortcomings were noted by conference participants. Special-operations and law-enforcement responders reported problems caused by different information sources telling them different things. Such information conflicts were often attributed to differences in risk assessment and PPE standards among reporting parties. Especially in the case of the anthrax incidents, keeping up with changing information being provided by numerous agencies was a serious challenge for front-line responder organizations. For many conference participants, the problem was not a lack of information on hazards. Rather, they spoke of difficulties trying to manage and make sense of a surplus of information. Finally, conference attendees suggested that better and more consistent information provision could motivate responders to wear PPE and could decrease the tendency to modify it or take it off when it becomes uncomfortable.

SITE MANAGEMENT

One message that emerged clearly from virtually all panel discussions is that proper site management had a decisive effect on whether personal protective equipment was available, appropriately prescribed, used, and maintained.

The most critical need for site management is a coherent command authority. An effective command structure is essential to begin solving three critical issues affecting PPE: information provision, equipment logistics, and enforcement. Due to logistical problems early in the response, for example, supplies of PPE were misplaced, the stocks of equipment that were available were largely unknown, and responders often did not receive or could not find the equipment they needed.

Conference attendees also emphasized the need for immediate and effective perimeter or scene control. Initially, this entailed responders personally “holding people back” and isolating the scene. As the response evolved, it was

necessary to erect a “hard perimeter,” such as a chain-link fence, to make sure only essential personnel operating under the direction of the scene commander were on-site.

Conference attendees also indicated that enforcement of PPE use is very important. Although panelists acknowledged that there is a period early in a chaotic response when it is not practical to rigorously enforce the use of protective equipment, they indicated that strict enforcement must eventually begin in order to protect the health of the responders. Other factors that complicated enforcement of PPE use were the large number of organizations (with different PPE standards) operating on-site, the lack of a unified command, and shortcomings in scene control. Because of the difficulty of defining when it is appropriate to begin enforcing PPE use—and removing workers from the site if they do not comply with use requirements—attendees indicated that this role might be best played by an organization not directly involved in or affected by the incident.

RECOMMENDATIONS

After having discussed PPE performance, information and training, and site-management issues, NIOSH/RAND conference participants were asked to put forward concrete recommendations about technologies and procedures that could help protect the health and safety of emergency workers as they respond to acts of terrorism. The following points represent a brief sample of the themes that emerged and the solutions put forth by conference discussants.

Personal Protective Equipment Performance

- Develop guidelines for the appropriate PPE ensembles for long-duration disaster responses involving rubble, human remains, and a range of respiratory threats. If appropriate equipment is not currently available, address any roadblocks to its development. Such equipment could be applicable to other major disasters, such as earthquakes or tornadoes, as well as to terrorist attacks.
- Define the appropriate ensembles of PPE needed to safely and efficiently respond to biological incidents, threats, and false alarms. Key considerations include providing comparable levels of protection for all responders and addressing the logistical and decontamination issues associated with large numbers of responses in short time periods.

Personal Protective Equipment Availability

- Explore mechanisms to effectively outfit all responders at large incident sites with appropriate personal protective equipment as rapidly as possible.
- Examine any barriers to equipment standardization or interoperability among emergency-responder organizations. Strategies could include coordination of equipment procurement among organizations or work with equipment manufacturers to promote broader interoperability within classes of equipment.

Training and Information

- Define mechanisms to rapidly and effectively provide responders at incident sites with useful information about the hazards they face and the equipment they need for protection. Approaches could include more-effective coordination among relevant organizations and development of technologies that provide responders with individual, real-time information about their environment.
- Explore ways to ensure that responders at large-scale disaster sites are appropriately trained to use the protective equipment they are provided. All types of responders must be addressed, and mechanisms that provide training and experience with the equipment before a disaster occurs should be investigated.
- Consider logistical requirements of extended response activities during disaster drills and training. Such activities provide response commanders with information on the logistical constraints that could restrict response capabilities.

Management

- Provide guidelines and define organizational responsibilities for enforcing protective-equipment use at major disaster sites. While such guidelines must address the risks responders are willing to take when the potential exists to save lives, they must also consider that during long-term responses, the health and safety of responders should be a principal concern.
- Develop mechanisms to allow rapid and efficient scene control at disaster sites as early as possible during a response.