

Protective Equipment for Health Care Facility Decontamination Personnel: Regulations, Risks, and Recommendations

John L. Hick, MD
Dan Hanfling, MD
Jonathan L. Burstein, MD
Joseph Markham, MD
Anthony G. Macintyre, MD
Joseph A. Barbera, MD

From the Department of Emergency Medicine, University of Minnesota, and Hennepin County Medical Center, Minneapolis, MN (Hick); Emergency Management and Disaster Medicine, Inova Health System, Falls Church, VA, and the Department of Emergency Medicine, The George Washington University, Washington, DC (Hanfling); Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA (Burstein); the Department of Emergency Medicine, St. Joseph Hospital Health Center, and the Department of Emergency Medicine, SUNY Upstate Medical University, Syracuse, NY (Markham); the Department of Emergency Medicine, The George Washington University, Washington, DC (Macintyre); and the Department of Engineering Management (Crisis & Emergency Management) and The Institute for Crisis, Disaster, and Risk Management, The George Washington University, Washington, DC (Barbera).

Copyright © 2003 by the American College of Emergency Physicians.

0196-0644/2003/\$30.00 + 0
 doi:10.1067/mem.2003.305

See related article, p. 381, and editorial, p. 391.

After recent terrorist attacks, new attention has been focused on health care facility decontamination practices. This article reviews core issues related to the selection of appropriate personal protective equipment for health care facility decontamination personnel, with an emphasis on respiratory protection. Existing federal regulations focus primarily on scene response and not on issues specific to health care facility decontamination practices. Review of existing databases, relevant published literature, and individual case reports reveal some provider health risks, especially when the exposure involves organophosphate agents. However, reported risks from secondary exposure to contaminated patients at health care facilities are low. These risks should be adequately addressed with Level C personal protective equipment, including air-purifying respirator technologies, unless the facility determines that specific local threats require increased levels of protection.

[*Ann Emerg Med.* 2003;42:370-380.]

INTRODUCTION

The conventional and biologic terrorist events of 2001 underscored the importance of health care facilities in community emergency response to disasters. In many cases, the health care facility is the first contact that mass casualty victims have with a community response system. The increasingly recognized risks and responsibilities associated with the health care facility role, coupled with changes in Joint Commission on Accreditation of Healthcare Organizations (JCAHO) emergency preparedness requirements¹ and preparedness grants from the Health Resources and Services Administration, have led to a high priority being placed on health care facility emergency response planning.

Lack of focus, shrinking health care facility resources, and decreasing reimbursement have limited the commitment of appropriate resources for emergency preparedness.² Health care facility capacity to manage chemically or radiologically contaminated victims has traditionally been marginal.³⁻⁶ Most health care facilities are inadequately prepared for the large numbers of patients that might seek care after a terrorist attack.⁶

The sarin release in the Tokyo subway system in 1995 resulted in more than 100 of 472 hospital workers reporting symptoms of exposure. Analysis of the incident suggested that communication breakdown and lack of proper planning, decontamination facilities, and personal protective equipment were contributing factors. None of these 100 workers required specific medical treatment, although one was admitted overnight for observation.⁷ More than 80% of the casualties from the scene self-referred directly to nearby hospitals, and even those transported by public safety personnel did not receive out-of-hospital decontamination.⁸

Personal protective equipment for personnel performing patient decontamination is therefore a critical issue for health care facility preparedness and response.⁹⁻¹¹ The recommended level of personal protective equipment for this group is controversial because of a paucity of regulatory guidance and research directly applicable to health care facility decontamination procedures.

Health care facility-based decontamination operations are markedly different from traditional field operations because they generally “are removed from the site of the emergency and the point of release ... their potential exposures result from proximity to or contact with a patient whose skin and/or clothing may be chemically contaminated.”¹² Thus, potential exposures for health care facility personnel are significantly different than for personnel entering the release site “hot zone.” Also, at the release site, a primary objective is often spill containment, whereas health care workers are faced with medical or traumatic emergencies in potentially contaminated patients. Ambulatory patients are unlikely to wait for hazardous materials teams to deploy, arrive, stage, and then come to their aid with decontamination equipment and often will self-refer to the closest health care facility.

Self-referred patients and nonambulatory patients whose contamination was not recognized at the scene will require decontamination at the health care facility. Each facility should determine what level of response they are prepared to provide in conjunction with their community response partners. Planning should also be based on hazard vulnerability analyses at both the institution and in the surrounding community.

This article focuses on the personal protective equipment requirements of a health care facility-based decontamination team caring for patients whose clothing and body were contaminated at the scene of a hazardous materials release and now present to the facility seeking care. Key federal regulations and health care worker injury data are reviewed, and recommendations are proposed.

REGULATIONS

Federal, state, and local regulations affect health care facility hazardous materials operations. Health care facilities might benefit from participation on their hazardous materials local emergency planning committee, which is responsible for defining the local response to a community hazardous materials incident.¹³ The local emergency planning committee does not specify a level

of hospital response but might help health care facilities to better define their role during an event. JCAHO Standard EC 1.4 specifies that each facility be able to provide decontamination, but does not further define this capacity in their compliance standards.¹

The *Hazardous Waste Operations and Emergency Response* standard 29CFR1910.120 provides specific guidance for employees who are engaged in an emergency response to a hazardous materials incident with the intent of handling or controlling the release. However, health care facility decontamination personnel are not “responders” as defined in this regulation and are removed from the point of release. The definition states “emergency response or responding to emergencies means a response effort by employees from outside the immediate release area or by other designated responders (ie, mutual-aid groups, local fire departments, etc.) to an occurrence which results, or is likely to result, in an uncontrolled release of a hazardous substance.”¹⁴ Health care facility–based decontamination teams are not dealing with “uncontrolled releases” in the same sense as those at the scene of the release. No formal interpretation has been made by the Occupational Safety and Health Administration (OSHA) as to the applicability of this definition to health care facility patient decontamination.

Many other agencies have regulations that apply to health care facility patient decontamination (eg, National Fire Protection Association, Environmental Protection Agency), but none are as focused on personnel protection as those of OSHA. OSHA has recognized the “unique situation” of health care facilities^{12,15,16} and confirmed that health care facility personnel providing decontamination are not the same as scene responders and “do not need to be trained or equipped for control, containment, or confinement operations as is required of the [hazardous materials] team.”¹² This applies only to a patient decontamination situation and not to a release occurring at the health care facility, in which case *Hazardous Waste Operations and Emergency Response* standards for emergency responders apply.

With regard to training, OSHA has specified that health care facility personnel decontaminating patients must be trained to the operations level (8 hours or to a level demonstrating competency).^{15,17,18} Unfortunately, most of the available curricula deal with scene response issues that are not as relevant to the health care facility role.

The selection of appropriate respiratory protection for health care facility–based decontamination personnel is controversial. Some facilities have adopted Level B respiratory protection (Table) on the basis of the fol-

Table.
Levels of personal protective equipment: Advantages and disadvantages.

Level	Description	Advantages	Disadvantages
A	Completely encapsulated suit and self-contained breathing apparatus	Highest level of protection available for both contact and inhaled threats	Expense and training requirements restrict use to hazardous materials response teams; lack of mobility; heat and other physical stresses; limited air supply
B	Encapsulating suit or junctions seams sealed, supplied air respirator or self-contained breathing apparatus	High level of protection adequate for unknown environment entry, supplied air ensemble with increased mobility and dexterity	Dependence on airline or limited air supply; heat and physical stresses; expense and training significant; fit testing required
C	Splash suit and air-purifying respirator	Significantly increased mobility, decreased physical stress, extended operation time with high levels of protection against certain agents; no fit testing required for hood type	Not adequate for some high-concentration environments or less than atmospheric oxygen environments or high levels of splash contamination; expense and training moderate
D	Work clothes, including standard precautions for health care workers (eg, gloves, splash protection)	Increased mobility, decreased physical stresses, extended operation time	Offers no protection against chemical or other agents; expense and training minimal

lowing passage of *Hazardous Waste Operations and Emergency Response*: “employees engaged in emergency response [note previous discussion, our italics] and exposed to hazardous substances presenting an inhalation hazard shall wear positive pressure self-contained breathing apparatus while engaged in emergency response until such time that the individual in charge of the ICS (incident command system) determines through the use of air monitoring that a decreased level of respiratory protection will not result in hazardous exposures to employees.”¹⁹ Other facilities have made the decision to use Level B protection on the basis of their specific community hazards, which are believed to require a higher degree of respiratory protection. It should be noted that many of the supplied-air respirators sold to health care facilities do not actually meet the technical-regulatory requirements of Level B protection because they do not provide an escape air bottle if the supply hose is disrupted.

Others have proposed that Level C respiratory protection is adequate for health care facility personnel performing decontamination out of the zone of release.¹¹ This level is considered adequate respiratory protection in the federal Chemical Stockpile Emergency Preparedness Program,²⁰ in which the health care workers must be prepared for exposure to chemical warfare agents; however, Level C is generally not allowed in environments in which the agent is either unknown or cannot be monitored.

The following question was recently posed to OSHA: “When health care facility staff do not know the airborne concentration of a hazardous substance created by a chemically contaminated patient or do not know specifically what the contaminant is, would staff members decontaminating the patient be required to wear a positive pressure self-contained breathing apparatus?” Despite the regulatory language in *Hazardous Waste Operations and Emergency Response*, OSHA again recognized the distinction between “response” personnel and health care facility providers and declined to require any specific level of protection, instead stating that “the personal protective equipment they [health care facility providers] need must be sufficient for the

type and level of exposure the health care facility anticipates under those conditions (eg, what airborne or absorption hazards can be anticipated from a patient whose skin or clothing is wetted with hazardous liquids or contaminated with hazardous particles?).”¹² Similar guidance was provided in another recent letter.¹⁶

It is important to note that these discussions do not address worker protection when the health care facility is located in the “hot” or release area. A decision should be made whether the facility will provide no protection, escape masks, or protective ensembles adequate for these environments. It is unlikely that the equipment for the decontamination team will be the same as that chosen for such an event because the mobility issues and goals of protection are significantly different for the 2 situations.

Because air monitoring at the health care facility site is difficult with current technology, the authors investigated the available scientific and operational research to assess the actual risk to health care facility personnel exposed to contaminated patients. We explored the validity of the assumption that the anticipated secondary contamination risk from the bodies of living patients, controlled by rapid clothing removal and containment (the major reservoir of residual contamination), ventilation of the decontamination area, and appropriate patient decontamination, would not approach the type of life-threatening environments that require supplied-air respirators (Level B). The goal was to define situations posing chemical hazards to health care workers and to then define appropriate personal protective equipment for these situations.

RISK TO HEALTH CARE PROVIDERS

Often, the assumption is made that health care facility provider exposures are similar to other responder exposures. One of the reasons that responders at a release site wear supplied air respirators into the hot zone is the possibility of an oxygen-deficient environment.²¹ This is an unlikely risk for health care facility personnel in a well-ventilated health care facility decontamination area. Other factors also differ, and therefore, the authors

sought to define the types and severities of injuries that health care workers have actually sustained from chemically contaminated patients.

MEDLINE and Pre-MEDLINE searches were performed from 1966 through October 2002 for the key words “hazardous materials + hospitals,” “personal protective equipment + hospitals,” “hospitals + terrorism,” “wounds and injuries + hospitals,” “respirators + hospitals,” “hospitals + decontamination,” and “chemical terrorism + hospitals.” Relevant articles were selected, and primary and review articles on hazardous materials response were hand searched for additional references. Additional injuries and exposures were sought by polling toxicologists by means of a list server coordinated by the American College of Medical Toxicology. The authors contacted subject-matter experts in environmental health, emergency medicine, emergency preparedness, and other disciplines in military and civilian practice to uncover other cases. Data and assistance from the Agency for Toxic Substance and Disease Registry of the Centers for Disease Control and Prevention were also obtained.

The Hazardous Substances Emergency Events Surveillance database, collected as a voluntary multi-state cooperative since 1993 by the Agency for Toxic Substance and Disease Registry, is the largest data set available on hazardous materials injuries. From 1993 to 2001, Hazardous Substances Emergency Events Surveillance has data on 44,015 events, 3,455 (7.8%) of which involved victims. There were 13,149 victims reported, of which 74% were transported to a health care facility.²² Only 5% of patients brought to the health care facility after hazardous chemical exposures were admitted in one analysis of Hazardous Substances Emergency Events Surveillance data; the vast majority had self-limited respiratory or contact symptoms. The respiratory exposures tended to require less treatment than contact exposures.²³ The Hazardous Substances Emergency Events Surveillance database does not include petroleum releases or spills.

An analysis of Hazardous Substances Emergency Events Surveillance data from 1996 to 1998 of first-responder injuries detailed 348 responders injured in

126 (0.7%) of 16,986 events. The vast majority of those injured were police officers and firefighters. Respiratory irritation and nausea were the most common symptoms. Most symptoms did not require a health care facility visit. No deaths were reported, and only 6.6% were admitted after evaluation.²⁴

Further analysis specifically focused on health care facility providers in 17 states from 1995 to 2001 (13 states participated for the full 6 years). This revealed 6 events in which 15 health care facility personnel were secondarily affected by emergency department (ED) contact with contaminated patients and an additional 5 events in which health care facility personnel were injured by releases occurring in the health care facility. This represented 0.3% of the total hazardous materials events and 0.1% of the victims. Of 15 personnel affected, respiratory irritation predominated, no lasting effects occurred, none of the employees required health care facility admission or more than symptomatic therapy, and none were wearing personal protective equipment. Hazardous materials involved in these events included organophosphate compounds, hydrofluoric acid, pepper spray, mixed solvents from methamphetamine laboratories, and chlorine gas.²²

Finally, Hazardous Substances Emergency Events Surveillance data were used to review exposures from methamphetamine laboratory-based incidents, which sickened 112 individuals reported between 1996 and 1999. This included 7 health care facility employees, 3 of whom are included in the aforementioned data set. The other 4 health care facility personnel exposures were not detailed but did not require admission.²⁵

Organophosphate compounds are extremely toxic, prone to off-gassing, might have prolonged clinical effects,²⁶ and have secondarily injured health care providers in several instances. In the most infamous example, the nerve agent sarin caused more than 100 health care facility providers in Tokyo to report symptoms of exposure in a retrospective review. Contributing to the toxicity in this case was a failure of providers to use personal protective equipment and a decision to cohort still-clothed contaminated patients in a poorly ventilated hospital chapel.⁷ Nozaki et al²⁷ reported on

13 of the most symptomatic personnel, physicians who cared for 2 initial victims of the event. One victim was apneic, and one was in cardiac arrest. Neither was decontaminated. Eleven of the physicians began to complain of dim vision and other symptoms consistent with organophosphate exposure during a 40-minute resuscitation effort. Ventilation to the area was increased without further worsening of symptoms. Although 6 providers received atropine and 1 received pralidoxime, all continued their patient care duties essentially uninterrupted.

A recent report from Georgia detailed significant illness in health care workers from contact with patients poisoned by suicidal ingestions of organophosphate agents. In the most severe case, one health care worker who had direct contact with secretions and emesis required atropine, pralidoxime, and intubation for 24 hours. Two other health care workers also received antidotal therapy, and one was admitted overnight for observation. Notably, patient decontamination was not performed, and providers did not use personal protective equipment. Four similar incidents involving organophosphate ingestions were located, but the health care worker's symptoms were reportedly more transient and less severe (one case via personal communication, Paul Penn, MS, CHEM, December 14, 2002).^{28,29}

According to the National Institute of Occupational Safety and Health (NIOSH) databases on pesticide poisoning, a total of 46 injuries involving health care workers and pesticide agents were reported between 1987 and 1998.²⁸

In Great Britain, 2 health care workers experienced transient and mild mucous membrane irritation after caring for 11 patients contaminated with ethyldichlorosilane in an emergency ward. They were exposed to the nondecontaminated patients for a 25-minute period of time.³⁰ In Australia, reports of transient nausea occurred after a patient presented with a fatal ingestion of aluminum phosphide.³¹ In both these examples, no personal protective equipment was used by the health care workers, and increased ventilation of the area terminated symptoms.

Limited research has been done to document the degree of off-gassing from chemically contaminated

patients. Modeling has been performed in which a mannequin's clothing was saturated with 800 mL of acetone or *p*-xylene, followed by breathing-zone measurements in 2 workers performing decontamination in an unventilated 16 × 20-foot room. Mannequin clothing was removed and contained 5 minutes into the study. Mean vapor exposure levels were far less than both the short-term exposure limit and the immediate danger to life and health value for both chemicals (67 ppm for *p*-xylene and 328 ppm for acetone per 10 minutes). The maximum exposure to *p*-xylene was 148 ppm per 10 minutes.³² Sarin has a vapor pressure of 2.9 mm Hg at 25°C (77°F), approximately 3 times lower than that of *p*-xylene (8.9 mm Hg), and thus, it might be extrapolated that even if 800 mL of sarin was off-gassing in an unventilated space under these conditions (an extraordinary level of contamination), the maximum concentration would have been threefold lower, roughly 23 ppm for the mean and 50 ppm for the highest value observed. A commonly used organic vapor combination cartridge exhibited no breakthrough after a 6-hour sarin challenge at 52 ppm,³³ and at far higher (698 ppm) concentrations exhibited 0.007 ppm of breakthrough at 83 minutes.³⁴

DISCUSSION AND RECOMMENDATIONS

On the basis of the aforementioned evidence, a contaminated patient presenting to an ED poses a definite health risk to providers. However, even without personal protective equipment, the risks of significant injury appear to be low, as reflected in this review and analysis of published cases. The one significant outlier case was caused by a combined contact and vapor exposure to organophosphates from a patient with a very large, suicidal ingestion of the toxin.

Organophosphate agents are similar in structure and physical properties to the chemical warfare nerve agents. Organic vapor filters for air-purifying respirators can provide high levels of protection against these and other chemical hazards. Simple air-purifying respirators are used to protect US military forces from chemical and biologic agents on the battlefield (eg, Scott

M95). Powered air-purifying respirators rely on small motors rather than inspiratory effort to move air through the filters and thus reduce the risk of contaminated air entering around the edges of the mask. In the civilian market, a common, hooded, powered air-purifying respirator challenged with corn oil as a chemical-biologic exposure model passed 100% of government-sponsored tests at a protection factor of 20,000 (personal communication, Alex Pappas and Frank J. Depietro, Soldier Biologic and Chemical Command, to Susan Danisch, 3M Corporation, December 21, 2001). Powered air-purifying respirators have been recommended for response in communities adjacent to military facilities that store or dispose of organophosphate nerve agents.²⁰ In general, most manufactured filters pass high-level challenges to chemical and biologic agents, but the hoods and cartridge-mask ensemble may allow penetration of vapor or liquid agent unless proper use, fitting, and donning procedures are carefully followed. For example, failure to properly tuck an inner hood into the wearer's chemically protective suit may significantly effect the wearer's level of protection (personal communication, Erik W. Johnson, 3M Corporation, December 4, 2002, and personal communication from Alex Pappas and Frank J. Depietro, Soldier Biologic and Chemical Command, to Susan Danisch, 3M Corporation, December 21, 2001).³³

Acid gases are another frequently released hazardous material³⁵ and potential terrorist weapon and have caused respiratory irritation in responders.²² Fortunately, secondary exposure symptoms seem to be mild and transient for health care facility workers. Chlorine in particular is a commonly released and potent agent.³⁶ Acid-gas filters on air-purifying respirators can provide appropriate protection against chlorine.³⁴

Other potential chemical and biologic threats should be considered. The vesicants pose primarily a contact risk and off-gas to a much lesser extent than organophosphates. Secondary inhalation exposure to vesicants should be adequately prevented with an organic vapor cartridge. Cyanide, fortunately, is so volatile that it is extremely unlikely for a live and unprotected patient to carry significant residual contaminant from a vapor

exposure to the health care facility, and organic vapor cartridges on an air-purifying respirator would suffice in the unlikely case of liquid contamination. Biologic agent protection is achieved with high-efficiency particulate air (HEPA) filtration, which is widely available in combination with organic vapor cartridges. These filters also would trap radiologically contaminated particulate matter if present.

Certain forms of personal protective equipment (eg, self-contained breathing apparatus, simple air-purifying respirators) require fit testing of the employees to the specific equipment. This might be problematic for some staff, especially those with beards and mustaches, and requires an additional time commitment. Maintaining appropriate fit is important because any leak around a mask will significantly reduce the effectiveness of the personal protective equipment, especially with an air-purifying respirator that relies on inspiratory force to pull air through the canister. For that reason, as well as to reduce the work of breathing, a hooded, powered air-purifying respirator might be preferred over a simple air-purifying respirator. The hooded variety does not require fit testing. These units, when equipped with HEPA-filtering canisters, might also be used in the health care facility to care for patients with illnesses requiring airborne precautions (eg, smallpox).

Planners must also recognize that the use of personal protective equipment itself carries significant health risks for responders, and higher levels of protection confer greater potential risk from both heat stress and physical restrictions. Reported adverse events in responders include 2 heat-related seizures (one during search and rescue operations [JB] and one during hospital decontamination preparations in a hot environment [personal communication, Reuben G. Pinkson, Jr., to Paul Christoph, December 9, 2002]) and a fractured wrist during personal protective equipment training (DH). It is also worth noting that significant complications were observed from personal protective equipment use during the Gulf War^{37,38} and during military training, especially in high ambient temperature conditions.^{39,40} No research that we are aware of

specifically compares the physical limitations and physiologic effects of different types of protective equipment.

Physical stresses of impermeable suits and respirators might be significant for the health care worker. Training, awareness of environmental conditions, staff rehabilitation, and adherence to safety standards need to be emphasized. In general, the higher the level of personal protective equipment, the less time the health care worker should stay in the ensemble. It is preferable to rotate staff frequently: 20 to 30 minutes might be an appropriate target, but this will be affected by climate, personal health, type of personal protective equipment worn, and job responsibilities. For example, those performing nonambulatory decontamination will need rotation more often than those who are passing out towels, for example. The facility should have a rapid lock-down policy and clearly outline expectations for preservation of contaminated and clean areas of the facility. Aside from the decontamination areas, chemical personal protective equipment should not be required within the facility except in the event that the facility was either the site of release or close enough to the release zone to be in a high-concentration (hot zone) environment.

Compared with Level C respiratory protection, the use of Level B protection (supplied air respirators) presents significant limitations. For a self-contained breathing apparatus, time restrictions on the use of a standard tank (20 to 30 minutes of operational time at best) and the carrying weight of tanks make them impractical for health care facility personnel. A simple full face mask air-purifying respirator (Level C) with canister weighs 0.7 kg, and a sample industrial aluminum cylinder self-contained breathing apparatus (Level B) weighs 13.8 kg, excluding mask, regulator, and air hose.^{41,42} Supplied-air respirators attached to hose lines present problems during decontamination operations, including length of supply line, line security, trip hazards, and availability of rescue bottles. These problems would probably be magnified as the scale of the decontamination operation increased. Flexibility of response is also an issue because air-supply connections must be available. Level B equipment is generally

costly to purchase and repair and necessitates a more complex employee respirator screening and training program. Additionally, the more cumbersome the equipment, the less likely it is to be used during an event when health care workers have to choose between managing equipment and providing patient care. The advantages of Level B protection are a supply of air that is known to be contaminant free and contain an appropriate amount of oxygen.

Level C air-purifying respirators do not require an air supply, are lighter, are less bulky, and can operate for hours without the need to change equipment. Filtration of a broad spectrum of chemical and biologic agents can be accomplished by using a single canister. In the historical cases mentioned previously, health care workers did not apparently encounter vapor concentrations that would have exceeded the capacity of Level C equipment. Examining the limited modeling data available and looking at the capacity of these units to handle common chemical and biologic terrorist agents also seem to support the use of Level C protection with organic vapor and HEPA filtering as a minimum. Filtration for acid gases and other chemicals might provide an additional margin of safety. A Level C approach has been endorsed by a number of authors.^{11,28,43-45} Proximity to a potential release site and other factors might require higher levels of protection and should be considered in community and facility planning.

Health care facility decontamination teams also require dermal protection against splash and contact exposure. Many terrorist and industrial agents pose contact threats and should be addressed by impermeable protective suits that offer adequate protection against penetration by organic substances, as well as general resistance to corrosive agents. Particular agents that might be problematic are the vesicants, such as mustard, and the persistent nerve agents, such as VX. Double gloving (eg, nitrile and butyl rubber) and boots or booties to provide foot-abrasion resistance are accepted practice. In addition, gloves and boots should be taped to the suit, thus decreasing leak potential. Lighter-weight protective suits permit easier movement but are also much more likely to tear, especially if not

sized generously. Chemically protective suits do not offer a barrier to gamma radiation, and thus, it is important to have some means available to assess radiation levels and determine staff exposure rates. A radiation safety officer or health physicist can provide significant assistance with radiation preparedness planning.

After careful consideration of the applicable regulations and aforementioned data outlining provider risks and recognizing that future data might alter these recommendations, the authors agree on the following general principles for health care decontamination teams:

1. Health care facilities can anticipate contaminated victims to self-refer, to expect immediate treatment, and to attempt to access clean areas of the facility in the pursuit of treatment.

2. Joint planning between the health care facility and relevant local agencies on the basis of hazard analyses should guide the level of health care facility response to a hazardous materials incident.

3. Regional standardization of equipment and training for health care facilities should be encouraged.

4. Health care facilities should have a plan for decontamination of ambulatory and nonambulatory casualties that does not rely on community resources that might be committed to the site of a chemical release. Health care facilities should ideally have decontamination capabilities that can be operational within minutes.

5. Health care facilities should plan with public safety agencies to ensure appropriate coordination when a community hazardous materials response is required because of a release at the facility.

6. Level C personal protective equipment (eg, splash suits, gloves, boots, air-purifying respirators) should be available for the health care facility patient decontamination team. Hooded, powered air-purifying respirators might be preferred because they do not require fit testing and generally provide higher levels of protection than standard air-purifying respirators.⁴⁶ Filters should protect against, at a minimum, organic vapors and also contain a HEPA cartridge. Incorporating acid-gas and other chemical filtration capability might confer greater protection for the decontamination team.

7. Facilities that wish to equip their teams with Level

A or B personal protective equipment and train their teams to a higher level of response capability should do so in conjunction with a community plan and should also maintain Level C equipment for use when higher levels of protection are not required.

8. Recognition of a cholinergic toxidrome in a patient presenting for care should prompt strong consideration for moving the patient to a decontamination area and staff use of personal protective equipment until after decontamination. When off-gassing is possible from the patient's respirations (after a massive ingestion), ventilator exhaust should vent directly to the outside or be appropriately filtered.

9. Scientific evidence and health care stakeholder input should guide federal efforts to modify current hazardous materials regulations for health care facilities. OSHA, NIOSH, and stakeholder health care organizations and agencies must work together to consider and craft regulations that are appropriate for areas secondarily contaminated by persons leaving a chemical release zone.

10. Further research on best practices for patient decontamination, appropriate personal protective equipment for health care workers, magnitude of off-gassing from patients, effect of clothing removal on patient decontamination, and risk to providers is needed. Standardized nationwide data collection on incidents involving responders would be of significant benefit. Incorporation of new and valid scientific evidence into the regulatory process is encouraged.

Victims presenting to EDs contaminated with hazardous materials can pose a threat to health care facility providers. The available scientific literature documents particular risk when organophosphate agents are involved. In general, the risk to providers from secondary contamination has been limited. On the basis of available literature, these risks do not seem sufficient to require supplied-air respirators for health care workers providing patient decontamination. Unless there are facility-specific reasons for higher levels of respiratory protection, organic vapor and HEPA combination canister air-purifying respirators (with optional acid-gas filtration if desired) should provide adequate protec-

PROTECTIVE EQUIPMENT FOR HEALTH CARE FACILITY DECONTAMINATION PERSONNEL

Hick et al

tion to health care facility decontamination teams operating in well-ventilated environments.

Received for publication January 13, 2003. Revision received March 2, 2003. Accepted for publication April 28, 2003.

The authors report this study did not receive any outside funding or support.

Reprints not available from the authors.

Address for correspondence: John L. Hick, MD, Emergency Medicine, MC 825, Hennepin County Medical Center, 701 Park Avenue South, Minneapolis, MN 55415; 612-347-3020, fax 612-904-4241; E-mail John.hick@co.hennepin.mn.us.

REFERENCES

1. Joint Commission on Accreditation of Healthcare Organizations. *The 2001 Joint Commission Accreditation Manual for Hospitals*. EC 1.4 and 1.6 (rev). Oakbrook Terrace, IL: Joint Commission on Accreditation of Healthcare Organizations; 2001.
2. Barbera JA, Macintyre AG, DeAtley CA. Ambulances to Nowhere: America's Critical Shortfall in Medical Preparedness for Catastrophic Terrorism. Presented at: Executive Session on Domestic Preparedness (ESDP) John F. Kennedy School of Government; October, 2001; Boston, MA.
3. Cox RD. Decontamination and management of hazardous materials exposure victims in the emergency department. *Ann Emerg Med*. 1994;23:761-770.
4. Burgess JL, Blackmon G, Brodtkin CA, et al. Healthcare facility preparedness for hazardous materials incidents and treatment of contaminated patients. *West J Med*. 1997;167:387-391.
5. Burgess JL. Healthcare facility evacuations due to hazardous materials incidents. *Am J Emerg Med*. 1999;17:50-52.
6. Wetter DC, Daniell WE, Treser CD. Healthcare facility preparedness for victims of chemical or biological terrorism. *Am J Public Health*. 2001;91:710-716.
7. Okumura T, Suzuki K, Fukada A, et al. The Tokyo subway sarin attack: disaster management, part 2: healthcare facility response. *Acad Emerg Med*. 1998;5:618-624.
8. Okumura T, Suzuki K, Atsuhiko F, et al. The Tokyo subway sarin attack: disaster management, part 1: community emergency response. *Acad Emerg Med*. 1998;5:613-617.
9. Levitin HW, Siegelson HJ. Hazardous materials: disaster medical planning and response. *Emerg Med Clin North Am*. 1996;14:327-348.
10. Occupational Safety and Health Administration. *Hazardous Waste Operations Emergency Response*. Washington, DC: Occupational Safety and Health Administration; July 1, 2002. 29 CFR 1910.120.(c)(5).
11. Macintyre AG, Christopher GW, Eitzen E, et al. Weapons of mass destruction events with contaminated casualties: effective planning for healthcare facilities. *JAMA*. 2000;4:261-269.
12. OSHA interpretation letter, September 5, 2002, from Richard E. Fairfax to Francis J. Roth. Washington, DC: US Department of Labor, Occupational Safety, and Health; 2002. Available at: http://www.hazmatforhealthcare.org/download/pdf/misc_pdfs/OSHA_Interp.pdf. Accessed July 25, 2003.
13. *The Superfund Amendments and Reauthorization Act of 1986*. Public Law No. 99-499.
14. Occupational Safety and Health Administration. *Hazardous Waste Operations Emergency Response*. Washington, DC: Occupational Safety and Health Administration; July 1, 2002. 29 CFR 1910.120.(a)(3).
15. OSHA interpretation letter, March 31, 1992, from Dorothy L. Strunk to Randy Ross. Washington, DC: US Department of Labor, Occupational Safety, and Health; 1992. Available at: http://www.hazmatforhealthcare.org/download/pdf/misc_pdfs/OSHA_Interp.pdf. Accessed July 25, 2003.
16. OSHA interpretation letter, Dec. 2, 2002, from Richard E. Fairfax to Kevin J. Hayden. Washington, DC: US Department of Labor, Occupational Safety, and Health; 2002. Available at: http://www.hazmatforhealthcare.org/download/pdf/misc_pdfs/OSHA_Interp.pdf. Accessed July 25, 2003.
17. OSHA interpretation letter, April 25, 1997, from John B. Miles to Thomas Whittaker. Washington, DC: US Department of Labor, Occupational Safety, and Health; 1997. Available at: http://www.hazmatforhealthcare.org/download/pdf/misc_pdfs/OSHA_Interp.pdf. Accessed July 25, 2003.
18. OSHA interpretation letter, Oct. 21, 1992, from Colleen K. O'Toole to Larry Bloomfield. Washington, DC: US Department of Labor, Occupational Safety, and Health; 1992. Available at: http://www.hazmatforhealthcare.org/download/pdf/misc_pdfs/OSHA_Interp.pdf. Accessed July 25, 2003.
19. Occupational Safety and Health Administration. *Hazardous Waste Operations Emergency Response*. Washington, DC: Occupational Safety and Health Administration; July 1, 2002. 29 CFR 1910.120.(q)(3)(iii-iv).
20. Department of Health and Human Services, Centers for Disease Control and Prevention. CDC recommendations for civilian communities near chemical weapons depots: guidelines for medical preparedness, 60 *Federal Register* 3308 (1995).
21. National Fire Protection Association 471. *Recommended Practice for Responding to Hazardous Materials Incidents*. Quincy, MA: National Fire Protection Association; 2002.
22. Horton DK, Berkowitz Z, Kaye WE. Secondary contamination of emergency department personnel from hazardous materials events, 1995-2001. *Am J Emerg Med*. 2003;21:199-204.
23. Burgess JL. Risk factors for adverse health events following hazardous materials incidents. *J Occup Environ Med*. 2001;43:558-566.
24. Zeitz P, Berkowitz Z, Orr MF, et al. Frequency and type of injuries in responders of hazardous materials substances emergency events, 1996-1998. *J Occup Environ Med*. 2000;42:1115-1120.
25. Centers for Disease Control and Prevention. Public health consequences among first responders to emergency events associated with illicit methamphetamine laboratories—selected states, 1996-1999. *MMWR Morb Mortal Wkly Rep*. 2000;49:1021-1024.
26. Merril D. Prolonged toxicity of organophosphate poisoning. *Crit Care Med*. 1982;10:550-551.
27. Nozaki H, Hori S, Shinozama Y, et al. Secondary exposure of medical staff to sarin vapor in the emergency room. *Intensive Care Med*. 1995;21:1032-1035.
28. Centers for Disease Control and Prevention. Nosocomial poisoning associated with emergency department treatment of organophosphate toxicity—Georgia, 2000. *MMWR Morb Mortal Wkly Rep*. 2001;49:1156-1158.
29. Merril N. Malathion overdose: when one patient creates a departmental hazard. *J Emerg Nurs*. 1989;15:463-465.
30. Thanabalasingham T, Beckett MW, Murray V. Healthcare facility response to a chemical incident: report on casualties of an ethyldichlorosilane spill. *BMJ*. 1991;302:101-102.
31. Nocera A, Levitin HW, Hilton JMN. Dangerous bodies: a case of fatal aluminum phosphide poisoning. *Med J Aust*. 2000;173:133-135.
32. Schultz M, Cisek J, Wabeke R. Simulated exposure of healthcare facility emergency personnel to solvent vapors and respirable dust during decontamination of chemically exposed patients. *Ann Emerg Med*. 1995;26:324-329.
33. Campbell LE, Lins R, Pappas AG. *Domestic Preparedness: Sarin Vapor Challenge and Corn Oil Protection Factor (PF) Testing of 3M BE10 Powered Air-Purifying Respirator With AP3 Cartridge*. Aberdeen Proving Ground, MD: Soldier Biologic and Chemical Command; 2001.
34. 3M Corporation Technical Data Bulletin #155—test criteria for the 3M cartridge FR57 against various military and industrial chemical agents. Minneapolis, MN: 3M Corporation; 2002.
35. *Hazardous Substances Emergency Events Surveillance 1998 Annual Report*. Atlanta, GA: US Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Division of Health Studies, Epidemiology and Surveillance Branch; 1998.

**PROTECTIVE EQUIPMENT FOR HEALTH CARE FACILITY
DECONTAMINATION PERSONNEL**

Hick et al

-
36. Kales SN, Polyhronopoulos GN, Castro MJ, et al. Injuries caused by hazardous materials accidents. *Ann Emerg Med.* 1997;30:598-603.
 37. Rivkind AI, Eid A, Weingart E, et al. Complications from supervised mask use in post-operative surgical patients during the Gulf War, prehealthcare facility. *Disaster Med.* 1999;14:107-108.
 38. Hiss J, Arensburg B. Suffocation from misuse of gas masks during the Gulf War. *BMJ.* 1992;304:92.
 39. Carter BJ, Cammermeyer M. Biopsychological responses of medical unit personnel wearing chemical defense ensemble in a simulated chemical warfare environment. *Mil Med.* 1985;150:239-249.
 40. Carter BJ, Cammermeyer M. Emergence of real casualties during simulated chemical warfare training under high heat conditions. *Mil Med.* 1985;150:657-663.
 41. Scott M95 APR product data. Available at: www.scottsafety.com/enbc.htm. Accessed March 2, 2003.
 42. ISCBA product data. Available at: www.scotthealthsafety.com/hsliterature/download/6253_iscba.pdf. Accessed March 2, 2003.
 43. Kirk MA, Cisek J, Rose SR. Emergency department response to hazardous materials incidents. *Emerg Med Clin North Am.* 1994;12:461-481.
 44. Burgess JL, Kirk MA, Borron SW, et al. Emergency department hazardous materials protocol for contaminated patients. *Ann Emerg Med.* 1999;34:205-212.
 45. McLaughlin SB. *The Case for Decontamination Facilities in Healthcare Facilities*. Chicago, IL: American Society for Healthcare Engineering—American Healthcare Facility Association. Management monograph 055976.
 46. TB II—Respirator Information. Protect yourself against tuberculosis. Atlanta, GA: National Institute for Occupational Safety and Health. US Department of Health and Human Services, Centers for Disease Control and Prevention; 1995 Publication no. 96-102. Available at: www.cdc.gov/niosh/tb-ii.html. Accessed March 2, 2003.