Lack of Hospital Preparedness for Chemical Terrorism in a Major US City: 1996–2000

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Abbreviations:
COBRA = US Consolidated Omnibus Reconciliation Act
HazMat = hazardous materials
HAZWOPER = Hazardous Waste Operations for Emergency Response
JCAHO = Joint Commission on Accreditation of Healthcare Organizations
OSHA = Occupational Safety and Health Administration
PPE = personal protective equipment
US = United States of America
WMD = weapons of mass destruction
WMD-T = terrorism using weapons of mass destruction

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Abstract

Introduction: The [US] Nunn-Lugar-Domenici Defense Against Weapons of Mass Destruction (WMD) Act (the WMD Act of 1996) heralded a new wave of spending by the federal government on counter-terrorism efforts. Between 1996 and 2000, the United States of America (US) federal government allocated large sums of funding to the States for bioterrorism preparedness. Distribution of these funds between institutions involved in first-responder care (e.g., fire and safety departments) and hospitals was uneven. It is unknown whether these additional funds had an impact on the level of hospital preparedness for managing mass casualties involving hazardous materials at the local level, including potential terrorist attacks with chemical agents.

Objectives: (1) To compare 1996 and 2000 measures of preparedness among hospitals of a major US metropolitan area for dealing with hazardous material casualties, including terrorism that involved the use of weapons of mass destruction; and (2) To provide guidance for the improvement of emergency preparedness and response in US hospitals.

Methods: In July 1996 and again in July 2000, 21 hospitals in one major US city were surveyed by questionnaire. A survey was used to assess the amounts of antidote stocks held available for treatment of casualties caused by toxic chemical agents and institutional response capabilities including the number of showers for decontaminating patients, the level of worker protection, and the number of staff trained to decontaminate patients.

Results: Hospital preparedness for treating and decontaminating patients exposed to toxic chemical agents was inadequate in 1996 and in 2000. From 1996 to 2000, there was no statistically significant change in the lack of hospital preparedness for stocking of nerve agent and cyanide antidotes. Capacity for decontamination of patients, which included appropriate hazardous material infrastructure and trained staff, generally was unimproved from 1996 to 2000 with the exception of an increase of nearly 30% in hospitals with at least one decontamination shower facility.

Conclusion: Hospitals surveyed in this study were poorly prepared to manage chemical emergency incidents, including terrorism. This lack of hospital preparedness did not change significantly between 1996 and 2000 despite increased funds allocated to bioterrorism preparedness at the local level.

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Introduction

Hazardous materials (HazMat) Emergencies and Chemical Terrorism

The public health threat of terrorism using weapons of mass destruction (WMD-T), involving nuclear, biological or chemical weapons has become increasingly real.[1-9] From 1996 to 2000, the National Response

Center, a United States of America (US) Coast Guard clearinghouse for federal interagency monitoring of hazardous materials (HazMat) release events, reported 102 incidents involving terrorist events associated with HazMat that did not result in an environmental release of materials.[10] HazMat is defined as substances dangerous to life and health. The US Nunn-Lugar-Domenici Defense Against Weapons of Mass Destruction Act (the WMD Act of 1996) galvanized federal efforts to combat terrorism. Since then, federal spending to counter terrorism from 1996 to 2000 amounted to more than US$36 billion, divided among 23 major federal departments and agencies.[11,12] In 2001, the US Congress allocated US$1.1 billion to state public health departments for bioterrorism preparedness for the fiscal year 2002. However, federal programs for countering terrorism have been criticized for being based upon a less-than-complete analysis of credible threats or risk.[13]

The US population is at significant risk for HazMat emergencies involving both intentional and unintentional exposures to toxic chemicals.[14-18] One survey of hospital safety officers revealed that 47% of responding hospitals had received at least one chemically contaminated patient during 1994; the median was two patients.[14] During the 1996 to 2000 period, the National Response Center documented 120,076 events involving release of HazMat in the United States.[10] The character of HazMat risk also has changed in the wake of recent acts of terrorism. Emergency responders, including both law enforcement and emergency medical services care providers, not only are potential victims, but also potential targets.[19-25]

Hospital Preparedness for HazMat Emergencies and Chemical Terrorism

Preparedness to reduce loss of life from any HazMat incident, including those involving a biological or chemical weapon, depends upon the availability of local resources.[26] Therefore, prevention of mortality is critically dependent on hospital preparedness at the local level. The standards of the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) and the regulations of the Occupational Safety and Health Administration (OSHA) for participation in HazMat incident emergency response plans, require hospital emergency departments to have emergency procedures that describe the specific precautions, procedures, and protective equipment used during HazMat waste spills or exposures[27,28] Unfortunately, hospital preparedness for chemical emergencies and disasters is often reported as inadequate.[29-37]

Indicators of Hospital Preparedness for Chemical Disasters

Prior studies have defined preparedness according to two basic criteria: (1) the ability to treat one chemically contaminated patient;[34-37] or (2) the ability to treat mass casualties.[29,33] Criteria for the former scenario are based upon the premise that every hospital should have the minimum capability to treat at least one or two contaminated patients, which is the number of victims in most HazMat accidents.[38-40] The JCAHO accreditation also is based upon the requirement of hospital preparedness to be able to treat at least one HazMat-contaminated patient.[27]

However, WMD-T, by definition, has the potential to create mass casualties that are likely to exceed the capacity of any one-hospital service area. Therefore, hospital preparedness for chemical emergencies resulting from WMD-T also must include a contingency for mass casualties. Effective preparedness and response also must employ a more comprehensive approach to include community-wide coordination among healthcare facilities and the public safety community.

Preparedness efforts must match emergency needs on the basis of realistic expectations of hospital inventories and surge capacity. *Surge capacity* may include the need for stockpiling drugs and medical supplies.[29] Wetter and colleagues defined hospital preparedness within the context of a WMD-T scenario involving 50 casualties. Indicators of preparedness were based upon stocking drug supplies that include nerve-agent antidotes, as well as "resource preparedness". Resource preparedness includes the presence of a HazMat plan and the availability of at least one HazMat shower, one OSHA Level-B breathing apparatus, and one chemical protective garment.[33]

Emergency treatment of chemical casualties involves two primary interventions: (1) patient decontamination; and (2) antidote therapy. Both have been reported as critical for a hospital response to chemical emergencies.[33,41-47] In the present study, these same two interventions were defined as measures of hospital preparedness. For comparison, hospital preparedness was quantified in terms similar to those of Wetter and colleagues, i.e., capacity to manage at least 50 patients.[33] However, both intentional and unintentional chemical releases have the potential to create many more casualties than the conservative thresholds selected for this study. For example, the methyl-iso-cyanate poisonings in Bhopal injured an estimated 30,000 persons.[3]

The purpose of this study was to determine if there was any change in hospital preparedness for WMD-T in a major US metropolitan area after the enactment of the WMD Act of 1996, which enabled an increase in federal spending on bioterrorism preparedness in the US. Decontamination preparedness was defined for each hospital as the collective presence of: (1) at least one on-site decontamination shower facility; (2) at least one set of personal protective equipment (PPE) to include OSHA Level-B protection or higher; and (3) hospital staff training in the tenets of HazMat emergency response to afford staffing availability of at least three trained workers per any given eight-hour shift (approximated >10 trained workers per hospital for the purposes of this study). Antidote preparedness was defined as the stocking of at least 300 mg of atropine, 100 g of 2-pralidoxime (2-PAM), and 50 cyanide antidote kits, based upon current recommendations for the treatment of 50 moderately intoxicated patients.[48] The commercially available cyanide antidote kit includes triple drug therapy (amyl nitrate, sodium nitrite, sodium thiosulfite).

Methods

In July 1996, before passage of the WMD Act of 1996, and again in July 2000, a one-page, seven-question survey was distributed by mail to hospital emergency department

Antidote	1996	2000	*p*-value
Atropine			
Amount (g)			
Total	584.298	1,213.237	NS
Average	30.753	57.773	NS
Median	0.5	0.25	NS
Range	0–261.4	0.02–1,116	NS
Total number of emergency treatments (6mg/adult)	97,383	202,206	NS
Hospitals with at least 300mg (%)	0	4.8	NS
2-Pralidoxime			
Amount (g)			
Total	1,323	625	NS
Average	66.15	29.762	NS
Median	6	6	NS
Range	0–600	0–384	NS
Total number of emergency treatments (2g/adult)	662	313	NS
Hospitals with at least 100g (%)	23.8	4.8	NS
Cyanide antidote kits			
Total number	276	9.5	NA
Hospitals with at least 50 (%)	35	0	NA

Table 1—Comparison of citywide antidote stocks between 1996 and 2000 (NS = not significant statistically; NA = not applicable)

directors of 21 hospitals in the greater metropolitan area of one major US city with a population of approximately 4 million people. Respondents were emergency department directors and hospital pharmacy directors. Follow-up reminders were made using telephone calls and facsimile 10 to 14 days after the initial contact.

Results of the survey were analyzed using SAS System for Windows Version 8.2 (SAS Institute, Cary, North Carolina USA). The 1996 data were compared with the 2000 data using a paired analysis. In addition, university affiliation and the annual census of the emergency department were evaluated as possible predictors of the level of hospital preparedness. The continuous data (atropine and 2-PAM) were found to be non-parametric, even after log transformation, and thus, were compared using the Wilcoxon signed rank test for paired data and the Wilcoxon rank sum test for independent samples. The remaining variables (cyanide kits, HazMat showers, HazMat PPE, trained staff, and isolation plan) were categorized and analyzed using the McNemar's test when the data were paired, and the Fisher's Exact test when independent samples were compared.

Results

All 21 questionnaires distributed were returned by mail, fax, or e-mail. The response rate for every question was 100% in 2000, but varied from 71% to 96% for 1996 except for the question related to hospital isolation plans, which had a response rate of 52% in 1996.

The mean and median values for the 1996 annual emergency department census for all 21 hospitals were 39,290 and 34,518 patients, respectively. The range of emergency department censuses was 13,050 to 105,315. Nine of the 21 hospitals were affiliated with universities.

Hospital preparedness was insufficient for nerve-agent emergencies during both 1996 and 2000 (Table 1). Although hospital atropine stocks were adequate on a citywide basis, no single hospital had at least 300 mg of atropine in stock in 1996, whereas in 2000, only one hospital met this criterion (4.8%). Citywide inventories of the co-therapeutic 2-PAM were insufficient to match the atropine stocks in both 1996 and 2000; thus limiting the total number of treatments citywide to 662 in 1996 and 313 in 2000. Only 23.8% of hospitals had at least 100 mg of 2-PAM in 1996 compared to 4.8% in 2000. Of note, no single hospital had at least 300 mg of atropine and 100 g of 2-PAM. There were no statistically significant changes in 2000 from the 1996 mean inventories of nerve-agent antidotes: atropine (p = 0.74) and 2-PAM (p = 0.18).

There also was inadequate hospital preparedness for cyanide emergencies. There were a total of 276 cyanide antidote kits in the city in 1996 compared to 35 in 2000. In 1996, two hospitals met the minimum criterion of 50 or more cyanide-antidote kits in inventory, whereas by 2000, the inventory of cyanide antidote kits in the 21 hospitals ranged from zero to four.

To perform HazMat decontamination safely and effectively, it first is necessary that each hospital have all three components of one complete system in place: PPE, training, and showers. In 1996, 10 of the 21 hospitals (47%) had a complete system. By 2000, this had only increased by one, to 11 out of the 21 hospitals (52%). During both 1996 and 2000, a minority (20% and 24% respectively) of hospitals provided adequate PPE for hospital staff to wear during HazMat decontamination. However, a majority (67% and 91%) of these same hospitals reported offering some staff training involving emergency decontamination (Table 2).

There was a statistically significant increase of 28.6% in

Decontamination Capacity	1996	2000	p-value
Showers available			
% hospitals with ≥1	57.1	85.7	0.01
Personal Protective Equipment			
% hospitals with Level-A or B protection	20.0	23.8	NS
Staff Training			
% hospitals with some training	66.7	90.5	NS
% hospitals with >10 trained staff	30.0	47.6	NS
Isolation Plan			
% hospitals with plan	0	23.8	NA

Table 2—Comparison of HazMat infrastructare between 1996 and 2000 (NS = not significant statistically; NA = not applicable)

the number of HazMat showers available from 1996 (n = 16) to 2000 (n = 27), but there were no statistically significant changes in the other decontamination capacities of availability of sufficient numbers of PPE and adequately trained staff.

To minimize the potential for exposure of hospitalized patients to an airborne chemical terrorist attack that may occur outside of the hospital, but close enough to represent a threat, hospitals must have the ability to comply with population protection measures. One common element of population protection involves shelter-in-place measures in which persons are recommended to stay inside their buildings with the air inputs from external air sources shut down. In 1996, none of the 11 respondents had an emergency plan for isolation of external air sources. By 2000, five of 21 respondents (24%) had developed such a plan.

In 1996, but not in 2000, there were statistically significant differences between the five university-affiliated and the 16 non-university-affiliated hospitals for stocks of atropine, 2-PAM, and cyanide antidote kits. University affiliation did appear to be associated with a better institutional capability for decontamination compared to non-university-affiliated hospitals. This appeared to be true during 1996 and 2000 for both PPE availability and staff training (data not shown).

The nine hospitals with an annual emergency department census of >40,000 were compared with the 12 hospitals with ≤40,000 visits per year. There were no statistically significant differences between these groups with respect to both antidote preparedness and decontamination preparedness for both 1996 and 2000 (data not shown).

Discussion

Many US hospitals depend upon their local Metropolitan Medical Response System team or fire departments to provide patient decontamination; however, most contaminated victims receive decontamination at the hospital, and not in the field.[49] In one six-year review of 72 chemically exposed patients presenting to a community hospital emergency department, none had received prehospital decontamination.[43] Hospitals must be prepared to receive, triage, and care for patients that arrive to the hospital in a contaminated state.

A coordinated national strategy likely would improve community-based hospital capabilities to meet the challenges of modern chemical emergencies. This strategy should include: (1) education of hospital administrators and care providers; (2) enforcement of existing HazMat laws and regulations; (3) engineering controls that facilitate safe and effective hospital-based HazMat responses; (4) economic incentives for development of hospital preparedness; and (5) enhancement of community coordination, planning, and communication.

1. Education

The need for continuing medical education on clinical toxicology is obvious. However, HazMat decontamination is not commonly taught to hospital-based emergency care providers. Training is needed to familiarize and train hospital-based care providers in the basic principles and procedures of HazMat decontamination, along with the important associated principles of occupational health and personal protection. At a minimum, all hospital emergency department staff should be trained and assisted in maintaining up-to-date certification to the Hazardous Waste Operations for Emergency Response (HAZWOPER) First Responder: "Awareness Level".[28] Personnel who actually are likely to be involved in a decontamination operation, must be trained to the First-Responder: "Operation Level".[28] Such certification of capabilities should be linked to specialty training, board examination, hospital privileges, and continuing medical education requirements.

Hospitals also would benefit from public health education regarding the selection and maintenance of a local stockpile of pharmaceutical antidotes based upon an assessment of the vulnerability of the hospital and the hazard profile of the community.

2. Enforcement

Both the US OSHA and the Environmental Protection Agency have established regulations to help protect workers dealing with hazardous waste and emergency operations. Title III of the US Superfund Amendments and Reauthorization Act of 1986 (SARA Title III) directed OSHA to establish a comprehensive rule to protect employee health and safety during emergency responses to the release of hazardous substances. Accordingly, OSHA published the HAZWOPER standard (Title 29 Code of Federal Regulations (CFR) 1910.120), which requires employers, including hospitals, to plan for emergencies involving hazardous substances that they expect their employees to handle. An emergency department whose staff has not received appropriate training and personal protective equipment would be in violation of OSHA standards 29 CFR 1910.120, 1910.1200, 1910.132, and 1910.134(c).[49,50]

The US Consolidated Omnibus Reconciliation Act (COBRA), 42 U.S.C., Section 1395(d) requires that every individual presenting to an emergency department must receive a medical screening examination. Choosing not to provide care to a contaminated individual, due to a lack of HazMat preparedness, is a potential COBRA law violation.

Finally, the Joint Commission on Accreditation of Healthcare Organization (JCAHO), which develops hospital accreditation standards for more than 17,000 US hospitals, also has established specific HazMat preparedness guidelines for hospitals.[27]

Enforcement of already existing legislation and guidelines likely would contribute to improving hospital preparedness for HazMat decontamination, PPE, and training.

3. Engineering Controls

Some of the challenges facing hospitals on the safe treatment of HazMat exposures may be mitigated by engineering controls. Hospitals should have controlled access points to prevent contaminated patients from entering prior to decontamination. Design and construction of decontamination shower facilities can accommodate placement of warm water lines and shower nozzles on the building exterior. Controls for dirty water run-off may be installed using exterior collection drains. Access fittings for medical gases on the building exterior also would facilitate use by emergency responders when utilizing supplied-air respirators. Design of hospital ventilation systems should consider the potential need to isolate the internal hospital environment from a contaminated outdoor plume or toxic cloud. Hospitals also could design emergency departments to better serve the surge in demand common to mass-casualty incidents.[45]

4. Economic Incentives

Hospitals currently have few incentives for maintaining a complete system for safe treatment of chemical casualties. For example, there is no code in the International Statistical Classification of Diseases and Related Health Problems (ICD-9) that allows a hospital to bill for the decontamination of a patient with HazMat exposure. This lack of reimbursement exists in spite of the highly technical equipment and procedures needed to detect and treat HazMat exposures. This appears inconsistent when compared to other highly technical procedures performed at the hospital (i.e., surgery) For example, both surgical and HazMat procedures require a highly trained and coordinated group of health professionals that must work as a team to perform time-critical, life-saving interventions; both procedures require specialized facilities and PPE for worker safety; and both may be associated with significant medico-legal and occupational liability.

Even though chemical releases may be relatively common throughout the US as a whole, the probability of a mass-casualty event occurring at any one hospital is low. However, this low probability event also may have an enormous societal impact. Federal assistance should promote hospital preparedness for the sake of national public health, especially in consideration of the individual institutional burden of preparing for these low-probability, high-impact events. Federal environmental legislation (SARA Title III) has been reported to improve planning by the healthcare sector for emergencies caused by environmental chemical exposures.[51] One may expect that federal legislation relative to hospital preparedness for chemical emergencies and terrorism also could have a positive impact.

Federal legislation also should address compensation for hospitals that experience mass-casualty incident. The Stafford Act, which provides the authorization and framework for federal assistance by the Federal Emergency Management Agency, has proven to be an unreliable source for hospitals in communities experiencing disasters.[52] The Stafford Act is more attuned to providing funds for property damage than for the added costs or lost revenues, accompanying the delivery of disaster-related health services. Federal and state governments may consider providing economic incentives for hospitals that implement engineering controls, as described above, that would be effective during chemical emergencies.

5. Enhancement of Community-based Coordination

Some authors suggest that it is not necessary for every hospital in a community to have the ability to treat contaminated patients.[43,53] In their opinions, one hospital with tertiary-care resources should be designated as a decontamination facility. Unfortunately, this concept may be based on the following false assumptions:

1. All (or even a majority) of the contaminated patients will be decontaminated at the scene of exposure;
2. All of the patients involved in a HazMat incident only will go to certain designated hospitals (and not the closest one);
3. Contaminated victims presenting to non-designated hospitals can be transferred safely to appropriate institutions without endangering patients or ambulance staff; and/or
4. The non-designated hospitals would not incur a violation of the COBRA laws for not offering medical screening of contaminated victims.

Instead, all hospitals in a community should plan together for mass casualty contingencies. "Hospital preparedness should expand from planning within the context of a single hospital organization to planning by the hospital to become part of a community-wide initiative to address mass casualties."[52] Every hospital should have the capability at the minimum to treat at least one or two contaminated patients, which is the number of victims in the majority of HazMat incidents.[38-40] Large-scale, multicasualty incidents would make HazMat preparedness difficult for most hospitals.[54] In this event, it would be in the best interest of the community to coordinate the varying levels of hospital HazMat capabilities in a manner similar to current trauma-care systems.

Study Limitations

The study design of comparing data from two cross-sectional surveys has one important, inherent limitation; namely, it was not possible to measure variations in antidote stock during the calendar year, which may or may not have been significant. However, since successful terrorist attacks by definition are unpredictable, one could argue that it is just as important to be prepared on any given day as it is in a given month. Thus, a cross-sectional design, as employed in the present study, may provide valuable insight.

With regard to HazMat infrastructure and staff training, it is unlikely that this study design would have made similar assumptions, since these factors require substantial financial investment from the hospital, and thus, may not be as subject to monthly variations.

Another potential limitation of this study is that the results may not be able to be generalized to the entire US population, since this study involved only one metropolitan area. However, descriptive studies of antidote and HazMat preparedness also have reported similar findings in numerous cities throughout the US during the same time period under investigation.[14,31–37]

Conclusions

The hospitals surveyed in this study were poorly prepared to manage chemical, mass-casualty events, including terrorism. This lack of hospital preparedness for chemical emergencies did not appear to change significantly between 1996 and 2000 in spite of an increasing threat for chemical terrorism and increased funding for bioterrorism preparedness at the local level. A coordinated national strategy for development of community-based hospital capabilities is suggested to meet the challenges of modern chemical emergencies. This strategy would include: (1) education of hospital administrators and care providers; (2) enforcement of existing HazMat laws and regulations; (3) engineering controls that facilitate safe and effective hospital-based HazMat response; (4) economic incentives for development of hospital preparedness; and (5) enhancement of community coordination, planning and communication.

In 2001, after the terrorist events in the US in which hijacked aircrafts and aerosolized anthrax were used as weapons of mass destruction, the US Congress allocated US$1.1 billion to state public health departments for bioterrorism preparedness in fiscal year 2002. It is hoped that, in light of the heightened awareness and real threat generated by these events, hospital preparedness would have improved since then. The authors currently are preparing a follow-up study to measure any changes in preparedness that may have occurred since then.

Contributors

M. Keim planned this study and was responsible for manuscript preparation and data interpretation. N. Pesik was responsible for data collection. N. Twum-Danso was responsible for data analysis and data interpretation.

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References

1. Institute of Medicine & National Research Council: *Chemical and Biological Terrorism: Research and Development to Improve Civilian Medical Response.* Washington, DC: National Academy Press, 1999, pp 15–29.
2. Kadivar H, Adams SC: Treatment of chemical and biological warfare injuries: Insights derived from the 1984 Iraqi attack on Majnoon island. *Military Medicine* 1991;156:171–177.
3. Mehta PS, Mehta AS, Mehta SJ, *et al*: Bhopal tragedy's health effects. *JAMA* 1990;264:2781–2787.
4. Hurst CG: Decontamination. In: Sidell FR *et al* (eds), Medical Aspects of Chemical and Biological Warfare. Washington, DC: Office of the Surgeon General at TMM Publications, 1997, pp 351–359.
5. Gum R: Healthcare and the Chemical Surety Mission. In: Sidell FR *et al* (eds) *Medical Aspects of Chemical and Biological Warfare.* Washington, DC: Office of the Surgeon General at TMM Publications, 1997, pp 397–413.
6. Okumura T, Takasu N, Ishimatsu S, *et al*: Report on 640 victims of the Tokyo subway sarin attack. *Ann Emerg Med* 1996;28:129–135.
7. Sharp TW, Brennan RJ, Keim ME, *et al*: Medical preparedness for a terrorist incident involving chemical or biological agents during the 1996 Atlanta Olympic Games. *Ann Emerg Med* 1998;32:214–223.
8. Anonymous: Averted New Year's attack included use of poison gas bombs. *PRNewswire*, 30 January 1999.
9. U.S. Centers for Disease Control and Prevention: Update: Investigation of bioterrorism-related anthrax. Connecticut, 2001. *MMWR* 2001;48: 1077–1079.
10. U.S. Coast Guard. National Response Center, Incident Types. Available at http://www.nrc.uscg.mil/incident.htm. Accessed 05 March 04.
11. Parachini J: Combating Terrorism: *Assessing Threats, Risk Management, and Establishing Priorities.* Testimony before House Subcommittee on National Security, Veteran Affairs and International Relations, on behalf of the Center for Nonproliferation Studies, 26 July 2000, Washington, DC USA.
12. U.S. General Accounting Office: *Combating Terrorism: Spending on Government-wide Programs Requires Better Management and Coordination.* Washington, DC: U.S. General Accounting Office, 1997, Publication No. GAO/NSIAD-98-39.
13. Sidel VW, Cohen HW, Gould RM: Good intentions and the road to bioterrorism preparedness. *Am J Public Health* 2001;91:716–718.
14. Cone DC, Davidson SJ: HAZMAT preparedness: Sufficient or so-so? *Prehosp Disast Med* 1995;10:S62. Abstract.
15. Leonard M: Community planning for hazardous materials disasters. In: *Topics in Emergency Medicine.* Aspen Systems Inc., 1986, pp 55–64.
16. Anonymous: Hundreds flee deliberate poison cloud in Missouri. *Reuters.* 28 February 2000.
17. Anonymous: Minnesota protesters left poison. *Associated Press/Washington Post.* 25 July 2000.
18. Matthews M, Bowman T: Apparent plan to gas Disneyland during Easter foiled: Japan cult suspected in sarin plot. *The Baltimore Sun.* 22 April 1995: p 1A,9A.
19. Eckstein M: The medical response to modern terrorism: Why the "rules of engagement" have changed. *Ann Emerg Med* 1999;34:219–221.
20. Spaid E, Bowers F: Atlanta bombings usher in a new form of terrorism. *The Christian Science Monitor.* 26 February 1997;89:4.
21. Thomas P: Atlanta authorities convinced blasts most likely aimed at officers. *The Washington Post.* 23 March 1997;120:A3.
22. Nordberg M: Terrorism's bloody trail: Learning tragic lessons in scene safety from the Israelis. *Emergency Medical Services* 1996;25:70–74.
23. Laurent JF, Richter F, Michel A: Management of victims of urban chemical attack: The French approach. *Resuscitation* 1999;42:141–149.
24. Nakajama T, Sato S, Morita H, *et al*: Sarin poisoning of a rescue team in the Matsumoto sarin incident in Japan. *Occupational and Environmental Medicine* 1997;54:697–701.
25. Nozaki H, Hori S, Shinosawa Y, *et al*: Secondary exposure of medical staff to sarin vapor in the emergency room. *Intensive Care Medicine* 1995;21: 1032–1035.
26. Simon JT: Biological terrorism: Preparing to meet the threat. *JAMA* 1997;278:428–430.
27. Joint Commission on Accreditation of Healthcare Organizations: *Comprehensive Accreditation Manual for Hospitals.* Oakbrook Terrace: Joint Commission on Accreditation of Healthcare Organizations, 2000.

28. 29 CFR Part 1910.120. Washington, DC: U.S. Government Printing Office, 1995.
29. Kai T, Ukai T, Ohta M, Pretto E: Hospital disaster preparedness in Osaka, Japan. *Prehosp Disast Med* 1994;9:29–34.
30. Cone DC, Davidson SJ: Hazardous materials preparedness in the emergency department. *Prehospital Emergency Care* 1997;1:85–90.
31. Burgess JL, Blackmun GM, Bodkin CA: Hospital preparedness for hazardous materials incidents and treatment of contaminated patients. *West J Med* 1997;167:387–391.
32. Ghilarducci DP, Pirrallo RG, Hegmann KT: Hazardous materials readiness of United States Level 1 trauma centers. *Journal of Occupational & Environmental Medicine* 2000;42:683–692.
33. Wetter DC, Daniell WE, Treser CD: Hospital preparedness for victims of chemical or biological terrorism. *Am J Public Health* 2001;91:710–716.
34. Chyka, PA, Conner HG: Availability of antidotes in rural and urban hospitals in Tennessee. *Am J Hosp Pharm* 1994;51:1346–1348.
35. Dart RC, Stark Y, Fulton B: Insufficient stocking of poisoning antidotes in hospital pharmacies. *JAMA* 1996;276:1508–1510.
36. Woolf AD, Chrisanthus K: On-site availability of selected antidotes: Results of a survey of Massachusetts hospitals. *American Journal of Emergency Medicine* 1997;15:62–66.
37. Teresi WM, King WD: Survey of the stocking of poison antidotes in Alabama hospitals. *Southern Medical Journal* 1999;92:1151–1156.
38. U.S. Centers for Disease Control and Prevention: *CDC recommendations for civilian communities near chemical weapons depots: Guidelines for medical preparedness.* Federal Regulation 1995;60:33308.
39. Hall HI, Dhara VR, Green PP: Surveillance for emergency events involving hazardous substances—United States, 1990-1992. *MMWR* 1994;43:SS-2.
40. Department of Health and Human Services, Public Health Service: *Hazardous Substances Emergency Event Surveillance,* Annual Report 1993. Atlanta: U.S. Agency for Toxic Substances and Disease Registry, 1993.
41. Holly, D: Experts: States unprepared for bioterrorism. *Associated Press,* 11 July 2001.
42. Sidell FR: Civil Emergencies Involving Chemical Warfare Agents: Medical Considerations. In: Somani SM (ed), *Chemical Warfare Agents.* San Diego: Academic Press, Inc. 1992.
43. Kirk MA, Cisek J, Rose SR: Emergency department response to hazardous materials incidents. *Emerg Med Clin N Amer* 1994;12:461-481.
44. Milsten A: Hospital responses to acute-onset disasters: A review. *Prehosp Disast Med* 2000;15:32–45.
45. Adler J: The protection and sheltering policy in hospitals. *Prehosp Disast Med* 1990;5:265–267.
46. Burgess JL: Hospital evacuations due to hazardous materials incidents. Am *J Emerg Med* 1999;17:50–52.
47. Brennan RJ, Waeckerle JF, Sharp TW, Lillibridge SR: Chemical warfare agents: Emergency medical and emergency public health issues. *Ann Emerg Med* 1999;34:191–204.
48. U.S. Army Medical Research Institute of Chemical Defense (USAMRICD): *Medical Management of Chemical Casualties.* Aberdeen Proving Ground: USAMRICD, 2000, pp 51–54,118–126.
49. Haz/Mat DQE, Inc.: All hospitals must be HazMat prepared. *HazMat News.* 1995;3:1
50. Gough AR, Markus K: Hazardous materials protections in ED practice: Laws and logistics. *J Emerg Nurs* 1989;15:477–480.
51. Landesmann LY, Markowitz SB, Rosenberg SN: Hospital preparedness for chemical accidents: The effect of environmental legislation on health care services. *Prehosp Disast Med* 1994;9:154–159.
52. American Hospital Association: *Hospital Preparedness for Mass Casualties: Summary of an Invitational Forum, Final Report.* Washington, DC: American Hospital Association, 2000.
53. Agency for Toxic Substances and Disease Registry: *Hospital Emergency Departments: A Planning Guide for Management of Contaminated Patients.* In: Managing Hazardous Materials Accidents, Volume 2. Atlanta: US Department of Health and Human Services, Public Health Service, 1991.
54. Auf der Heide E: Community Medical Disaster Planning and Evaluation Guide: An Interrogatory Format. *American College of Emergency Physicians Publication,* 1995.