RESEARCH

# Hospital Response to a Major Freeway Bridge Collapse

John L. Hick, MD, Jeffery Chipman, MD, Gregory Loppnow, MD, Marc Conterato, MD, David Roberts, MD, William G. Heegaard, MD, MPH, Greg Beilman, MD, Michael Clark, MD, Jonathan Pohland, MD, Jeffrey D. Ho, MD, Douglas D. Brunette, MD, and Joseph E. Clinton, MD

## ABSTRACT

**Background:** We describe the hospital system response to the Interstate 35W bridge collapse in Minneapolis into the Mississippi River on August 1, 2007, which resulted in 13 deaths and 127 injuries. Comparative analysis of response activities at the 3 hospitals that received critical or serious casualties is provided.

**Methods:** First-hand experiences of hospital physicians, issues identified in after-action reports, injury severity scores, and other relevant patient data were collected from the 3 hospitals that received seriously injured patients, including the closest hospitals to the collapse on each side of the river.

**Results/Discussion:** Injuries were consistent with major acceleration/deceleration force injuries. The most critical patients arrived first at each hospital, suggesting appropriate prehospital triage. Capacity of the health care system was not overwhelmed and the involved hospitals generally reported an overresponse by staff. Communication and patient tracking problems occurred at all of the hospitals. Situational awareness was limited due to the scope of structural collapse and incomplete information from the scene.

**Conclusions:** Hospitals were generally satisfied with their surge capacity and incident management plan activation. Issues such as communications, patient tracking, and staff overreporting that have been identified in past incidents also were problematic in this event. Hospitals will need to address deficiencies and build on successful actions to cope with future, potentially larger incidents. (*Disaster Med Public Health Preparedness.* 2008;2(Suppl 1):S11–S16)

**Key Words:** surge capacity, mass casualty incident, hospital preparedness

On August 1, 2007, the Interstate 35W (I-35W) bridge in Minneapolis collapsed into the Mississippi River, killing 13 people and injuring 127. This article describes the regional hospital system response to this incident with an emphasis on emergency department (ED) activities at Hennepin County Medical Center (HCMC), University of Minnesota Medical Center-Fairview (UMMC), and North Memorial Medical Center (NMMC).

The Minneapolis/St. Paul metropolitan area comprises 2.6 million residents in 7 counties. There are 29 hospitals in the metropolitan area, which maintain approximately 6000 hospital beds. They are partners in a hospital compact under which HCMC acts as the Regional Hospital Resource Center (RHRC)—a clearinghouse for hospital resource requests and policy and information issues during an incident. One hospital in each of 8 regions of the state is so designated, and is the primary point of contact with the Minnesota Department of Health during emergencies, forming a tiered system of response.[1] This hospital also coordinates regional planning efforts under the Hospital Preparedness Program grants from Health and Human Services. In a disaster, an "Alert Orange" is declared at affected hospitals, resulting in notifications to staff, activation of the hospital command center and incident command system, and other actions that increase hospital capacity for casualty care.[2,3]

Close working relationships have been established among emergency medical services (EMS), public safety agencies, hospitals, public health services, and emergency management. This has occurred through committee work, the Metropolitan Medical Response System, and multiday, multijurisdiction functional exercises, which have included establishment of a Multi-Agency Coordination Group.[4,5]

HCMC is a 422-bed (all bed numbers reflect operating, not licensed, beds) level 1 trauma center located 12 blocks (1 mile) from the south end of the bridge collapse site (Table 1). The ED and urgent care areas



Copyright © Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.

https://doi.org/10.1097/DMP.0b013e3181790bf7 Published online by Cambridge University Press

TABLE 1

**Hospital Locations and Patient Distribution**

| | Distance From Scene, mi | Patients via EMS | Self-Referred August 1 | Disposition |
|---|---|---|---|---|
| Hennepin County Medical Center* | 1 | 25 | 0 | 1 death (in ED); 16 admitted (60%) |
| University of Minnesota Hospital | 1.4 | 10 | 15 | 12 admitted (48%) |
| Abbott Northwestern Hospital | 3.6 | 6 | 2 | 1 admitted (12%) |
| North Memorial Medical Center* | 5.7 | 9 | 1 | 4 admitted (40%) |
| Unity Hospital | 9.7 | | 6 | No admissions |
| St. John's Hospital | 12.8 | | 4 | No admissions |
| Methodist Hospital | 10.3 | | 2 | No admissions |
| Fairview Ridges Hospital | 18.8 | | 2 | No admissions |
| St. Joseph's Hospital | 9.1 | | 1 | No admissions |
| Total, August 1 | | 50 | 33 | |

*Level 1 trauma center.

have a combined 60 beds plus an acute psychiatric services area. In 2006, the ED had 98,838 visits. The HCMC EMS dispatch center and the West Metro Medical Resource Control Center (MRCC) are located within the hospital complex.

NMMC in Robbinsdale, MN, is the next closest level 1 trauma center to the scene. NMMC has 425 hospital beds and 47 ED beds, and it had 80,138 ED visits in 2007.

UMMC is a 550-bed tertiary care hospital with a 21-bed ED and 19,443 ED visits in 2007. UMMC does not receive critical trauma but has a full spectrum of surgical and subspecialty services available and is developing a trauma program. It is the closest hospital to the north side of the collapse site.

## METHODS

Emergency physicians in a leadership position on the day of the bridge collapse were identified at the 3 hospitals that received the majority of the EMS-transported casualties, as were all serious (yellow) and critical (red) patients. Information was obtained regarding their hospital response and their injury severity scores for patients presenting to each facility, including data from retrospective medical chart and after-action reviews. The institutional review board at each facility approved the use of information and chart reviews as presented. Additional delayed patient data were obtained from RHRC staff. Descriptive statistics were used.

### Emergency Response

The I-35W bridge connecting portions of Minneapolis was built in 1967 and was the busiest bridge in Minnesota, carrying more than 140,000 vehicles per day on 8 lanes of traffic 116 ft above the Mississippi River. The bridge was unique at the time of construction for its extended arch of 458 ft (total span >2000 ft) over the Mississippi River, avoiding the need for river pilings below the nearby lock and dam. The arch design, although stable, lacked redundancy. The bridge was categorized in recent inspections as "structurally deficient" but not imminently in danger of failing.

On August 1, 2007, traffic was confined to 4 of the 8 lanes because of resurfacing work. At 1805 hours, bumper-to-bumper traffic moved slowly in both directions; 114 vehicles and 18 construction workers were on the bridge when the center span dropped directly into the river, causing the north and south ends to buckle toward the banks, collapsing the entire bridge.

Multiple EMS and fire department units responded to the scene. Initial information suggested a major structural collapse, and an alert was sent via the Web-based MN-Trac alerting and resource tracking system to all hospitals and EMS services in the area from the MRCC at 1809 hours, advising a multiple casualty incident. A total of 25 updates were sent from MRCC between 1809 and 2359 hours to provide additional information to the hospitals and EMS services.

### Hospital Response

Of the bridge collapse victims, 79 were evaluated in area hospitals on August 1 (Tables 1 and 2). All red patients were transported to HCMC, arriving between 1840 and 1900 hours (Table 3). Subsequent patients had injury severity scores <10, suggesting that critical patients were appropriately prioritized and transported to the closest trauma center. The 2 other hospitals that received yellow casualties also observed declining injury severity scores in their EMS-transported patients. Self-referred casualties were seen in many area hospitals. Only 1 self-referred patient, a spinal column

TABLE 2

**Injury Severity Scores (ISSs)**

| | Admit ISS Range | Admit ISS Average | ISS 1–8 | ISS 9–14 | ISS ≥15 |
|---|---|---|---|---|---|
| HCMC | 1–50 | 17 | 5 | 4 | 6 |
| UMMC | 3–14 | 6 | 10 | 2 | 0 |
| NMMC | 4–14 | 9.5 | 2 | 2 | 0 |

HCMC, Hennepin County Medical Center; UMMC, University of Minnesota Medical Center-Fairview; NMMC, North Memorial Medical Center.



Copyright © Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.

https://doi.org/10.1097/DMP.0b013e3181790e6f Published online by Cambridge University Press

TABLE 3

**First 7 Patients Arriving at HCMC (Over a 20-min Period)**

| Patient No. | Key injuries | ISS | Disposition |
|---|---|---|---|
| 1 | Cardiac arrest | 34 | Pronounced dead after brief evaluation |
| 2 | Head and abdominal injury | 30 | OR |
| 3 | Abdominal injury | 34 | OR |
| 4 | Head and spinal injury | 50 | CT-OR |
| 5 | Head and spinal injury | 17 | CT-ICU |
| 6 | Abdominal injuries | 12 | CT-ICU |
| 7 | Abdominal injuries | 22 | OR |

ISS, injury severity score; OR, operating room; CT, computed tomography; ICU, intensive care unit.

fracture (presenting on August 2), required admission. A total of 44 patients presented for delayed evaluation of symptoms August 2 to 10.

Casualties were distributed via EMS to area hospitals according to usual trauma triage criteria. Had the event involved many more patients, the MRCC would have recommended destinations to EMS units based upon hospital capacity information and predetermined "first wave" allocation numbers for each hospital based upon their trauma-receiving capability.

MRCC coordinated initial event information and patient lists, with the RHRC assuming this responsibility later in the evening of August 1 and during the subsequent days as delayed patient presentations occurred. Requests for patient information came from multiple agencies, and some patient information was subpoenaed by a federal agency. The RHRC coordinated a legal response to the subpoena for all of the hospitals involved.

No cardiac arrests occurred after hospital arrival (ie, critical mortality was 0). No water-related or submersion injuries were seen in surviving patients. Occupants of many vehicles that dropped the full 116 ft into the river walked away with minor injuries and several presented the following day for evaluation. This relative lack of critical injury may be attributed to the protective effects of "riding" the debris down, lack of significant forward speed of the vehicles, the vehicle protective cage and shock absorbers, use of passenger restraint systems, and airbag deployment. Injuries were consistent with vertical force–compression trauma and resembled those usually associated with vehicular trauma with a high prevalence of spinal column injuries, as shown below:

- Spinal compression and burst fractures—14 patients (none with spinal cord injury)
- Extremity fractures—including open fractures
- Closed head injury
- Diaphragm disruption—2 patients
- Pregnancy complications—2 patients (one emergent c-section for fetal distress)
- Liver laceration with hemoperitoneum
- Intestinal perforation, splenic rupture, traumatic abdominal hernia
- Open chest wound

Area hospitals generally had lead time to prepare for incoming casualties. Some had significant self-referred casualties and others none. Most experienced staff reporting in excess. There were no shortages of staff or equipment that required coordination between hospitals. All of the hospitals experienced problems with internal communications and communication with external staff. Key response activities and issues for the 3 hospitals receiving yellow and red category patients are summarized in Table 4.

## RESULTS/DISCUSSION

The I-35W bridge collapse produced a moderate challenge to the hospital system, requiring activation of mass casualty plans at multiple hospitals and a minor degree of regional coordination. Although this event was not a disaster in the sense that capacity was not exceeded (no hospitals used nontraditional areas for patient care and none experienced staff or supply shortages that could not be rapidly addressed within the facility), the incident highlights several key issues for hospital disaster response.

Hospitals undertook both rapid "hot wash" analysis of their responses as well as more detailed, structured after-action reviews to identify issues for corrective action plans. Improvements in staff notification (including consideration of a shared staff notification system backed up by multiple hospitals, so that when 1 switchboard is overwhelmed, another hospital can activate messaging and callbacks for the affected institutions), supply response, staff staging, communications, and incident management were common themes in this as well as historical incidents.[6,7] As usual, most difficulties were experienced when usual processes could not be expanded or followed.[8]

### Incident Management

Several hospitals near the bridge activated their disaster plans but did not receive patients. In discussions, 2 key points emerged: The hospitals were not usually processing/monitoring the information available on MN-Trac and that information was often scant, especially early in the incident. Unfortunately, hospitals often must make a judgment call as to whether to activate plans before knowing the full extent of the incident. In those cases, especially when the hospital is not the closest to the site and is not a major trauma center, a "stand-by" or partial activation is advisable to avoid overcommitting resources. Many hospital plans focus on making multiple operating rooms available despite the fact that few nontrauma hospitals would be expected to receive any, or at worst a few, patients requiring operative intervention in anything short of a catastrophic emergency. One hospital



Copyright © Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.
https://doi.org/10.1097/DMP.0b013e3181776f6f Published online by Cambridge University Press

TABLE 4

**Key Hospital Responses and Issues**

| | HCMC | UMMC | NMMC |
|---|---|---|---|
| Alert Orange declared | Yes | Yes | No |
| Time from collapse to first patient arrival, min | 35 | 24 | 66 |
| Staff recruitment | Paged from home and voluntary staff reporting | Paged from home and voluntary self-reporting | Shift held at 1900 h |
| ED response coordination | ED staff physician | ED staff physician | ED staff physician |
| ED space changes | 31 of 50 beds cleared | Interventional radiology area used, carts in halls, 15 of 21 ED beds cleared | No clearing done |
| Inpatient space changes | 10 OR, 3 CT opened (vs 2 OR and 1 CT usual), 25 ICU beds opened (3 available before collapse) | 4 total CT scanners available; adequate inpatient space | Surgical cases held, PACU space prepared for patient care; adequate inpatient space |
| Patient tracking | Temporary numbers | Temporary numbers | Usual registration |
| Documentation | Retrospective entry into electronic system, reverted to paper charts initially | Paper charting (usual) | Electronic/paper order entry with dictation (usual) |
| Issues faced | | | |
| Command | Situational awareness and information from field about scope and pending casualties were poor (reported across facilities) | Situational awareness | Situational awareness<br>No command assigned; in retrospect would have partially activated to ensure incident command, PIO, etc in place |
| Communications | Telephone switchboard failure<br>Internal telephone lines did not function as planned because of staff educational issues<br>Radios sometimes set to wrong channel or did not hold charge<br>Runners used when needed<br>Paging groups not set up for surgery department | Telephone switchboard failure | ED telephone lines jammed (mainly by staff inquiring about possible need to come in)<br>Charge nurse unable to function because of volume of telephone calls |
| Staff | Excess staff reporting—crowded resuscitation area, adequate ED staff available | Excess staff reported, including inpatient staff that were not familiar with ED charting/procedures | Excess staff calling |
| Supplies | IV fluids, succinylcholine, barrier gowns in short supply and requested/delivered<br>Supplies not needed were delivered to the ED and placed in congested areas; needed supplies often delivered to wrong area of ED | C-collars in short supply | No shortages |
| Treatment | Patients prioritized for CT, 2 experienced minor delays (10–15 min) awaiting CT<br>Surgical management technique (definitive repair vs damage control) depends on ORs being aware of how many more cases are pending/likely | Patients often received several primary assessments but no definitive assessment until care organized and accountability to surgery staff<br>Nonincident patients experienced delays in care (noncritical) | Patients prioritized by ED physician with case management assistance from 2 trauma surgeons |
| Tracking | Temporary numbers (blood bank/Hollister numbers) did not integrate with location in electronic health record, making it more difficult to locate patients; tracking sheet helpful for this<br>Patients registered and tracked accurately in electronic health record within 60 min<br>Temporary numbers do not allow labs/radiographic ordering | Temporary numbers started as single integers, which were confused with cubicle numbers<br>Temporary numbers did not integrate into electronic records system, making patient tracking and results delivery difficult | Tracking patients difficult even with few patients, electronic health record does not locate patient well (if out of ED for studies, etc) |
| PIO | PIO overwhelmed initially with family information requests, media requests, attempting to monitor media | | ED staff overwhelmed by family calls—needed to designate contact point for family reunification and PIO |

HCMC, Hennepin County Medical Center; UMMC, University of Minnesota Medical Center-Fairview; NMMC, North Memorial Medical Center; OR, operating room; CT, computed tomography; ICU, intensive care unit; PACU, postanesthesia care unit; PIO, public information officer; IV, intravenous; C, cervical.



Copyright © Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.
https://doi.org/10.1097/DMP.0b013e3181790bf7 Published online by Cambridge University Press

that received casualties (NMMC) elected not to activate its emergency plan but recognized in retrospect that a partial activation to provide increased accountability for decisions and to manage the public information, liaison, and patient tracking functions may have been helpful.

## Communications

Communications problems were common across hospitals and response agencies, as is typical in most disasters.[6,7,9] All 3 hospitals receiving multiple casualties reported that telephone call volume had a significant impact on response activities. These calls usually came from families calling to locate loved ones and staff calling to determine whether they should come in to work. The setup of the Family Support Center and a family reunification hotline was delayed because of the American Red Cross building and staff's proximity to the event. It is likely that even when this can be done expediently, there will be a period of 30 minutes when the hospital will have inadequate telephone operators and telephone lines to manage call volume. Methods of alerting staff that they are not needed may be as important as alerting staff that are needed to prevent excess self-reporting and calling. Internal telephone systems often continue to function, but may require additional staff education (eg, at HCMC staff must depress the internal line button before picking up the handset or else they will pick up an incoming call). Regional hospital Web-based and 800-mHz radio systems worked throughout the event.

## Surge Capacity: Space, Staff, and Stuff

Surge capacity plans that allowed accommodation of patient loads were implemented.[2,7,9,10] Intensive care unit (ICU) capacity was successfully expanded according to plan at HCMC (eg, use of postanesthesia care, clearing of cardiac short stay, moving selected patients to floor beds), which generated a 30% increase in ICU capacity. When these beds were not needed, no patients that had been moved (reverse triage) required transfer back to the ICU.[11] Hospitals experienced a surplus of staff voluntarily reporting, usually to patient care areas rather than the labor pool/staff staging area, which is a normal phenomenon and requires unneeded staff be redirected to an appropriate area.[12] At HCMC a new supply officer position in the ED has been developed and a single location for supply delivery identified.

## Patient Triage and Tracking

Triage officers (physicians) were assigned at all 3 hospitals to quickly assess incoming EMS patients. Triage nurses assessed self-referred patients per usual routine. Triage tags were not used because patients could be directed to usual locations for care within the emergency departments. Disaster numbers were placed on patients at HCMC and UMMC. The triage officer at HCMC did not need to change the assigned EMS triage category based on the injuries observed (no evidence of overtriage of red casualties but based on a limited number of critical patients).

Patient tracking presented a problem both in the prehospital and hospital environment. Use of numbering systems that do not conflict with room numbers is important, as is a system that can be readily integrated with an electronic health record, radiology, and ordering interface. However, a standard, brief paper sheet that remains with the patient is still necessary to prevent loss of data and ensure continuity of information when care location or caregivers change. All of the hospitals experienced problems with patient tracking regardless of the number of victims received. These were often related to inability to locate a patient within the hospital on the electronic health record system, either because registration was incomplete or the system could not recognize temporary beds or locations for patients. Several hospitals are creating "dummy beds" in their system for disaster use and are refining their use of disaster numbering systems.

## Patient Treatment

Patient care issues were few. Hospitals felt that they were able to prioritize patients for computed tomography, which was the only bottleneck identified at 2 facilities (HCMC and UMMC) and was temporary. Computed tomography has been identified as a potential bottleneck in other experiences.[13] Surgical staff at HCMC have asked for better communication to the operating room in future events regarding the number of victims still arriving so that they can make decisions about "damage control" surgery versus definitive management.

HCMC had no self-referred casualties during the night of the collapse. This is unusual given the proximity to the site[9,14–16] and may reflect the rapid availability of transport resources or self-triage of ambulatory casualties away from the trauma center, assuming that it would be extremely busy. Both of these are hypothetical explanations, however.

## Exercise and Planning Issues

Multiple personnel at many institutions stressed the value of prior exercises and familiarity with their emergency operations plans as contributors to successful response. In some institutions, surgery staff recognized that notification, communication, and patient flow system issues generated by the event could have been resolved with more realistic exercises of surgical services. At HCMC a recent evening shift exercise (criticized by many staff at the time because it occurred on an extremely busy shift) was cited by the incident commander and critical care staff as key to their successful actions during the event.

Although psychologically injured casualties did not overwhelm crisis center or inpatient psychiatry beds, hospitals felt that their emergency operations plans were inadequate to coordinate staff support, patient psychological screening and support, family reunification, and spiritual support. Because of this, the compact hospitals are including a behavioral health branch director under the Hospital Incident Com-



Copyright © Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.
https://doi.org/10.1097/DMP.0b013e3181a1960f Published online by Cambridge University Press

mand Operations Section to manage these diverse activities. Job action sheets and supporting tools are being developed and behavioral health teams will augment staffing at affected hospitals in future events.

At a regional level, prior cooperation and agreements between hospitals and agencies such as the American Red Cross were critical to aid information sharing and overcome initial objections about patient list sharing by administrators not familiar with the compact. A Family Support Center full-scale exercise in spring 2007 proved valuable in defining operations and staff needs during the event, but line of authority, responsibilities of the jurisdictions and agencies, and mission of the centers require additional preplanning to avoid confusion and potential conflicts in future events. The RHRC had limited function in this particular event, but it was still a valuable construct in the coordination of information between hospitals and from hospitals to other agencies, and would have been the conduit for patient transfer and resource request activities in a larger incident.

## CONCLUSIONS

The collapse of the I-35W bridge required activation of disaster plans at several hospitals and implementation of surge capacity plans. System capacity was never exceeded, but valuable lessons were learned that may be applicable to larger events. Hospitals were generally satisfied with their surge capacity and incident management responses. Challenges included poor situational awareness of the entire scene early in the event, communication issues, specific equipment and supply needs, and information management. Corrective action plans will seek to avoid these issues in future events.

### About the Authors

*Drs Hick, Loppnow, Conterato, Roberts, Heegaard, Ho, and Brunette are Associate Professors of Emergency Medicine, Dr Chipman is Assistant Professor of Surgery, Dr Beilman is Professor of Surgery and Anesthesia, Drs Clark and Pohland are Resident Physicians, and Dr Clinton is Professor and Chair, Department of Emergency Medicine, University of Minnesota Medical School.*

*Address correspondence to John L. Hick, MD, Emergency Medicine 825, Hennepin County Medical Center, 701 Park Ave S, Minneapolis, MN 55415 (e-mail: john.hick@hcmed.org).*

*Received for publication October 29, 2007; accepted February 28, 2008.*

### Authors' Disclosures

The authors report no conflicts of interest.

### Acknowledgments

The authors wish to acknowledge the citizens of Minneapolis, who came to each other's aid, providing invaluable early assistance. We also would like to recognize Minneapolis's public safety and EMS agencies for their collaboration and dedication to community service, as well as Mary Burfeind, Mark Lappe, the hospital compact, the MRCC, and the dedicated personnel of HCMC, HCMC EMS, NMMC, and University of Minnesota hospitals for their exemplary efforts and teamwork.

ISSN: 1935-7893 © 2008 by the American Medical Association and Lippincott Williams & Wilkins.

DOI: 10.1097/DMP.0b013e31817196bf

## REFERENCES

1. Barbera J, McIntyre A. Medical Surge Capacity and Capability: A Management System for Integrating Medical and Health Resources During Large-Scale Emergencies. CNA Corporation Web site. August 2004. *http://www.cna.org/documents/mscc_aug2004.pdf*. Accessed May 22, 2006.
2. Hick JL, Hanfling D, Burstein JL, et al. Healthcare facility and community strategies for patient care surge capacity. *Ann Emerg Med*. 2004;44:253–261.
3. Hospital Incident Command System. California Emergency Medical Services Authority Web site. *http://www.emsa.ca.gov/HICS/default.asp*. Accessed January 21, 2008.
4. IS 701—Multi-Agency Coordination Systems. National Incident Management System (NIMS). Federal Emergency Management Agency Emergency Management Institute Web site. 2007. *http://emilms.fema.gov/IS701/index.htm* . Accessed January 21, 2008.
5. Multi-Agency Coordination Systems in Health Events. Minnesota Department of Health Web site. 2006. *http://www.health.state.mn.us/oep/plans/multiagency.ppt*. Accessed January 21, 2008.
6. Auf der Heide E. The importance of evidence-based disaster planning, *Ann Emerg Med*. 2006;47:34–49.
7. Milsten A. Hospital responses to acute-onset disasters: a review. *Prehosp Disaster Med*. 2000;15:32–45.
8. Burstein JL. The myths of disaster education. *Ann Emerg Med*. 2006;47:50–52.
9. Roccaforte JD. The World Trade Center attack. Observations from New York's Bellevue Hospital. *Crit Care*. 2001;5:307–309.
10. AHA Hospital Preparedness for Mass Casualties. Health Connect Web site. 2000. *http://www.hospitalconnect.com/ahapolicyforum/resources/disaster.html*. Accessed January 21, 2008.
11. Kelen GD, Kraus CK, McCarthy ML, et al. Inpatient disposition classification for the creation of hospital surge capacity: a multiphase study. *Lancet*. 2006;368:1984–1990.
12. Cone DC, Weir SD, Bogucki S. Convergent volunteerism. *Ann Emerg Med*. 2003;41:457–462.
13. Einav S, Aharonson-Daniel L, Weissman C, et al. In-hospital resource utilization during multiple casualty incidents. *Ann Surg* 2006;243:533–540.
14. Hogan DE, Waeckerle JF, Dire DJ, et al. Emergency department impact of the Oklahoma City terrorist bombing. *Ann Emerg Med*. 1999;34:160–166.
15. Dacey MJ. Tragedy and response—the Rhode Island nightclub disaster. *New Engl J Med*. 2003;349:1990–1991.
16. Gutierrez de Ceballos JP, Turegano Fuentes F, Perez Diaz D, et al. Casualties treated at the closest hospital in the Madrid, March 11, terrorist bombings. *Crit Care Med*. 2005;33(Suppl 1):S107–S112.



Copyright © Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.
https://doi.org/10.1097/DMP.0b013e31817196bf Published online by Cambridge University Press