Chapter 3. Results

Literature Search and Abstract Review

The literature search process identified 243 unique, potentially relevant citations. Appendix F provides a summary of the results of the literature search and review process.

Two hundred eight articles (86 percent) were excluded from further consideration during the abstract review process. The following were grounds for exclusion: did not include hospital staff; no training or education; no original data; no evaluation; did not include a response to an MCI or a disaster; abstract only; or did not apply to any of the key questions.

Article Review

Of the 35 articles deemed eligible through abstract review, 21 (58 percent) were eligible for data abstraction. The remaining 14 articles were excluded for the following reasons: did not include hospital staff; no original data; no training or education; or did not apply to any of the key questions (see Appendix G). We were unable to locate one article (which was identified through hand searching) because of an incorrect or incomplete citation. All articles reviewed and referenced are listed in Appendix H.

Focus and Design of the Reviewed Studies

The 21 studies that met the inclusion criteria were a heterogeneous group. Most drills occurred in the United States,[16-27] although the Middle East,[28-31] Europe,[32-34] and Asia[35] were represented. In one study the location was not stated.[36] All included studies were published between 1968 and 2002, and were clustered between 1985 and 1990 and between 1995 and 2000 (see Appendix E, Evidence Table 1).

Sixteen of these studies addressed the effectiveness of hospital disaster drills in training hospital staff to respond to an MCI (key question 1);[16-26,28,29,32,33,35] one study addressed the effectiveness of computer simulations in training hospital staff to respond to an MCI (key question 2);[31] and four studies addressed the effectiveness of tabletop or other exercises in training hospital staff to respond to an MCI (key question 3).[27,30,34,36] Nineteen studies described methods or tools that have been used to evaluate the effectiveness of hospital disaster drills, computer simulations, and tabletop or other exercises in training hospital staff (key question 4).[18-36]

Note: Appendixes cited in this report are provided electronically at http://www.ahrq.gov/clinic/epcindex.htm

Type of MCI Addressed and Number of Hospitals Studied

The studies addressed a variety of MCIs. Six were focused on a fire or explosion,[18-20,32,33,36] one of which was a burn nursing practice simulation game[36] and the other five of which were simulated hospital disaster drills. Seven described transportation accidents (e.g., a plane crash at a local airport).[22-26,30,35] Three studies were focused on a chemical event,[16,17,28] two studies described a radiation event,[21,34] and one study focused on a biological event.[27] The event type was not stated in two studies.[29,31]

Although most studies took place in a single hospital,[16-19,21-23,25,30-33,35,36] five studies provided evidence from multiple hospital settings, ranging from three to 21.[20,24,27-29] Two studies did not specify the number of hospitals involved.[26,34]

Target of the Training

In all but one study, the educational intervention targeted multiple types of hospital staff (see Appendix E, Evidence Table 1). Thirteen studies included physicians in the target group,[16-21,23-25,29,32,33,35] and eleven studies included nurses.[16,18,19,21,24,29,30,32,33,35,36] Other groups targeted included administrators in five studies,[16,31-33,35] first responders in nine studies,[16,17,20,23-25,29,30,32] and security and transportation personnel in two studies.[16,35] Four of the studies did not specify a targeted hospital staff group.[22,26-28]

Quality Scores

Evidence Table 2 summarizes the study quality scores based on strict criteria for evaluating reports of the effectiveness of educational interventions (see Appendix E). There was substantial variation in overall study quality. Among the 16 studies that evaluated hospital disaster drills, the *total quality score* ranged from 21 to 75 percent on a scale from zero (none of criteria met) to one hundred percent (all criteria met). The *representativeness score* for these studies ranged from 0 to 100 percent, with a mean of 52 percent, median of 50 percent, and interquartile range of 25 to 75 percent. The *bias score* was not applicable, as no study had a control group. The *description of the study score* ranged from 25 to 75 percent, with a mean of 45 percent, median of 38 percent, and interquartile range of 25 to 63 percent. The *outcome score* ranged from 13 to 63 percent, with a mean score of 32 percent, median score of 38 percent, and interquartile range of 25 to 50 percent. Most studies did not assess their educational intervention with quantitative methods and of the two studies that did, one received a score of zero in the statistics category[32] whereas the other received a score of 100 percent.[25]

The one study on computer simulations had a low total quality score of 17 percent.[31] This study had a low score in all five study quality categories (see Appendix E, Evidence Table 2).

The single study that assessed a tabletop exercise[36] scored 56 percent on overall study

quality. As shown in Evidence Table 2 (Appendix E), the Burns study also had a moderately high study quality score in all categories.

The three studies reporting on other types of drills scored between 61 percent[30] and 38 percent[27,34] overall (see Appendix E, Evidence Table 2). The Gray study had a score of 50 percent or greater in four of the five study quality categories, while the Levy and Inglesby studies had a score of at least 50 percent in only one study quality category.

Results of Key Questions

Each key question is individually addressed in this section. The evidence is reported for each question according to the type of event studied (see Appendix E, Evidence Table 3)

Question 1: What is the effectiveness of hospital disaster drills in training hospital staff to respond to an MCI?

The majority of studies we identified addressed the key question regarding hospital disaster drills.[16-26,28,29,32,33,35] The learning objectives of these exercises included various knowledge objectives (i.e., to test coordination of response and evacuation procedures),[32] skill objectives (e.g., to assess knowledge of use of fire extinguishers),[19] and behavioral objectives (e.g., timely contact of appropriate safety personnel)[19] (see Appendix E, Evidence Table 1). This group of studies also used a number of training evaluation methods, most typically group debriefings. "Smart" (i.e., medically trained) observers, other observers, and triage and/or victim tracking cards were often used to evaluate the outcomes. The outcomes of these studies provided many lessons having an impact on command and control, communications and patient flow, and other areas (see Tables 1 to 4). All studies reported important lessons learned.

The six hospital disaster studies that addressed transportation accidents took different approaches, resulting in a variety of conclusions.[22-26,35] Cook et al. took a "game" approach that allowed employees to study the disaster plan prior to the drill. The author believed this approach was useful in increasing understanding of the disaster plan, identifying plan flaws, and improving coordination.[22] Eisner, in a study focused on the emergency department and targeted to first responders and the triage teams, simulated an airplane crash at a nearby airfield. The study found that more than half of the notional victims experienced a serious delay in care that would result in excess deaths.[23] Paris also studied a simulated airport disaster and used "smart" casualties and triage cards to analyze the care provided to victims.[26] Lau, simulating an undescribed transportation accident designed to test knowledge, skills, and behaviors, found that although the disaster plan was successfully activated, there were difficulties in the areas of triage and charting.[35] However, Lau also found that practice drills provided clinicians with the opportunity to anticipate possible operational difficulties and find remedies to track them. Fishel and Maxwell reported difficulties in triage in their studies.[24,25] In addition, Maxwell reported problems with patient tracking, and Fishel reported problems in communications.

Five studies reported on a fire disaster or explosion, four of these placing the event within the

hospital[18,19,32,33] and one setting the mock event at a college.[20] All studies targeted several groups, including physicians,[18-20,32,33] nurses,[18,19,32,33] administrators,[32,33] and first responders.[20,32] Training objectives varied from evacuation assessment[32,33] to assessing first aid at the scene of the fire[20] and knowing the location of and how to use fire extinguishers.[19] Similar to other hospital drills, these studies were evaluated by group interviews and de-briefings, and "smart" and other observers.

Chobin, Saxena, and Tur-Kaspa studied chemical spills.[16,17,28] Chobin et al. tested the Occupational Safety and Health Administration (OSHA) requirements in responding to a chemical spill.[16] This study used simulated patients and involved external and internal response and multiple departments. The authors found it very useful to test OSHA-required disaster plans before an emergency, and they concluded that the hospital may not be able to meet some OSHA regulations. Saxena evaluated the ability of a hospital to make a coordinated response to a hazardous materials incident and found that the list of chemicals involved was not correctly reported and that communication ranged from ineffective to nonexistent.[17] Tur-Kaspa evaluated a hospital drill with "smart" casualties—army physicians with experience in managing chemical casualties.[28] This study identified lessons learned that were incorporated into the hospital deployment plan. The authors felt their study had wide implications for disaster mitigation worldwide.

The EPC team concluded that enough studies were available to suggest that hospital disaster drills were effective in training hospital staff to respond to an MCI; however, the study designs were weak, and overall the evidence was insufficient to draw firm conclusions, leading to an evidence grade of C (weak) (see Chapter 2, Methods, Evidence Grades). The published literature lacked studies addressing either bioterrorism directly or other prolonged MCIs. These incidents have a different presentation, with sporadic presentation of cases and perhaps continuing over days or weeks with a high casualty toll and large numbers of concerned and potentially exposed as well.

Question 2: What is the effectiveness of computer simulations in training hospital staff to respond to an MCI?

One study used computer simulation in training hospital staff to respond to a basic disaster.[31] This study was targeted to senior administration and had both a behavioral objective of training decision makers and a clinical outcome objective of identifying bottlenecks and solutions. The computer simulation also identified electromechanical failures, crowd control issues and other security problems, and specific medical equipment and medication needs. The study was evaluated by observations of the staff while problem-solving and by post-exercise group discussion. Computer animation was used to describe the bottlenecks that arose in the emergency department, the diagnostic departments, and the operating rooms. Levi found that simulation techniques used in a limited scale preparatory drill improved preparedness of hospitals prior to implementation of a full-scale disaster drill.

Although this study provided valuable information, this question received an evidence grade of I (Insufficient) due to the limited amount of evidence.

Question 3: What is the effectiveness of tabletop or other exercises in training hospital staff to respond to an MCI?

One study addressed a tabletop exercise[36] and three studies addressed other types of exercises.[27,30,34] Burns studied a tabletop exercise designed specifically to educate nurses on the treatment of patients injured by an incendiary device.[36] The authors found the simulation exercise motivated participants and allowed them to use new concepts prior to an actual disaster. They also found it helpful to use the content material in a way that simulates the practice setting and provides an opportunity for immediate feedback.

The TOPOFF exercise, funded by the Department of Defense, was developed to test readiness of *top* government *off*icials and others to respond to multiple simultaneous terrorist attacks.[27] This exercise incorporated a regional response across hospitals and state and federal infrastructure. The authors concluded that public health resources now in place would not be sufficient to respond to the demand created by a bioterrorist attack. This study provided future directions for planning and preparedness at all levels of government.

Levy et al. took a novel approach and conducted an audio-graphic teleconferencing drill.[34] The authors concluded that this technology-based training activity was an effective means to familiarize emergency responders with policies and procedures regarding radiation accidents. Gray et al. developed a video simulating a disaster and designed to educate hospital staff on how the disaster plan worked.[30] The authors outlined the advantages of videos, which they found to be 1) allowing staff to see emergency equipment and demonstration of its use; 2) developing further staff insight into facing mass casualties; and 3) increasing the exposure of staff to the material, with over 500 hospital employees viewing the video within a two-week period.

Given the few studies available and their heterogeneity, the EPC team graded the evidence addressing this question as I (Insufficient).

Question 4: What methods or tools have been used to evaluate the effectiveness of hospital disaster drills, computer simulations, and tabletop or other exercises in training hospital staff to respond to an MCI?

Nineteen studies included specific evaluation methods (see Appendix E, Evidence Table 1). Thirteen of the studies used more than one type of evaluation method.[19,20,22,24-29,31-33,36] Group or individual debriefings were the most common,[19,21,22,24,25,27,29,31-35] followed by “smart” observers (medical personnel).[19,22,24,28,32,33] Other observers[18,28,31-33,36] and trained “smart” casualties[26,28,29] were also used in several studies. Four studies used a written exam.[20,29,30,36] Other methods of evaluating the educational intervention included individual interviews,[27] inspection of review by chemical spill specialists,[28] self-assessment,[36] a computer-generated detailed picture of the situation,[31] observer checklists,[22] mock disaster patient charts,[23] victim tracking cards,[26] and videotaping.[20]

As shown in Evidence Table 2 (Appendix E), the studies had scores ranging from 13 percent to 75 percent in the study quality category for assessing the outcomes of the educational intervention. Only three of the studies received full credit for describing the evaluation methods

in sufficient detail to permit replication,[19,22,25] and only five of the studies received full credit for using objective methods to evaluate outcomes of the educational intervention.[22,23,25,30,32] One of these studies noted improvement in understanding of the hospital disaster plan, as measured by a multiple choice questionnaire.[30] Two studies focused on evaluating the timeliness of initiating patient care by assessing how the severity of injuries related to the arrival time at treatment.[23,25] The drill Gretenkort reported was focused on comparing two methods of evacuating patients, using point-to-point time measurements.[32] Cook used observer checklists to identify notification (start and stop of drill), available facilities and equipment (area opened and prepared for drill; wheelchairs and stretchers available), and personnel and procedures followed (whether security and transport personnel were present; whether a disaster log was started). Cook also reported that a de-briefing conference was held immediately post-exercise, followed by a written report.[22] However, none of the studies was specifically designed to demonstrate the validity and reproducibility of the evaluation methods.

Because of the heterogeneity of the evaluation methods and the lack of evidence on the validity and reproducibility of the methods, the EPC team concluded that the evidence on the utility of reported evaluation methods merited an evidence grade of I (Insufficient).

Outcomes of the Studies

Hospital disaster drills, computer simulations, and tabletop and other exercises are designed to test the hospital's disaster plan and to allow employees to become familiar with disaster procedures, leading to reduced chaos and improved institutional response at the onset of an actual disaster. These training exercises address many aspects of disaster response. On the basis of this review of the literature, discussion with experts, and analysis of the HEICS job action sheets,[10] the EPC team identified several important aspects of hospital disaster response that include outcomes that may be useful to evaluate.

Most of the lessons learned from the studies relate to one or more of the following categories: the incident command system; communications (both internal and external); clinical care, including triage, patient care, patient flow, and patient tracking; security; materials and resources; and decontamination (see Appendix E, Evidence Table 3).

Each of the three identified types of training exercises (hospital drills, computer simulations, and tabletops and others) addressed multiple aspects of a hospital's ability to respond to a disaster. A substantial overlap existed between the disaster drills and tabletop exercises in the outcomes addressed (see Figure 2). However, despite this overlap, two outcomes—*patient tracking* and *decontamination*—were unique to disaster drills in the current literature. Only three outcomes were addressed in the computer simulation study (patient flow, security, and materials/resources), and none of them were unique to this method of disaster response training.

Incident Command System

Seven studies reported findings related to the incident command system (see Table 1), all of which advocated the concept of strong leadership during a crisis. Gretenkort and Lau reported that the incident command system worked well,[32,35] and Cook reported that the incident command system decreased confusion in the drill.[22] Four studies reported that flaws in the incident command system led to a lack of communication and confusion.[18,20,27,33]

Communications

Thirteen studies dealt with the issue of communications (see Table 2). Nine of the studies reported findings related to internal communications,[16,18,19,21,22,24,27,33,35] and nine studies addressed external communications.[16,17,21,24,27,28,32,34,35]

Internal Communications. Among the studies addressing internal communications, only one, Chobin et al., found that communication occurred smoothly.[16] Eight studies illustrated breakdown of communications.[18,19,21,22,24,27,33,35] Studies cited the inadequacy of overhead intercom systems,[19,21,22,33] delay in communication because the emergency department was immobilized and unable to receive messages,[18] lack of training in the use of radios,[35] and significant time delays spent identifying correct contact numbers.[24,27]

External Communications. The results of the studies reporting on external communications were mixed. Chobin and Gretenkort reported smooth and successful interfaces with outside agencies.[16,32] In the Levy study, participants were able to successfully carry out notification of proper authorities and extensive live communication among sites in five time zones.[34] Tur-Kaspa emphasized that an effective communication system between different sites and the control center is essential.[28] Five studies noted shortcomings including incomplete messages,[21] ineffective activation of emergency operations centers,[17] language difficulties when the operator was under pressure,[35] technical and operational radio communication problems,[24] and a highly inefficient process of decision making by conference call leading to indecision and significant delays in taking action.[27]

Clinical Care

Nineteen studies cited results related to clinical care of patients (see Table 3). Eleven studies described outcomes on triage,[18,20,21,23-27,29,34,35] twelve studies described the impact of the drill on patient care,[18-21,25-29,33,35,36] fourteen studies described patient flow issues,[16,18-22,24,25,27,29,31-33,35] and six studies described patient tracking issues.[16,25,28,29,33,35]

Triage. Levy reported success in triage based on correlation of clinical signs with radiation exposure.[34] All other studies in this category reported triage problems, including confusion due to unavailability of the usual triage area;[18] incorrect use of physical zones for different categories of patients;[21] inadequate updating of patient demographics;[35] slow arrival at triage;[23] inexperienced staff in triage;[18,24] inadequate selection of victims for removal from the incident scene;[20] patients who were either never assigned to a triage category[25,26] or were assigned to an incorrect triage category.[29] Inglesby identified concern over the ability to distinguish between the concerned and potentially exposed and those with early signs of infection.[27] This point is significant because Inglesby was the only study that looked at a bioterrorism event.

Patient Care. Paris, Lau, and Maxwell found that patient care drills proceeded according to plan,[25,26,35] and Classic found that a plan to use building exits as a "choke point" for screening worked well.[21] Burns found a knowledge increase in nurses' capacity to treat victims of an incendiary device.[36] Other studies identified a range of deficiencies. Tur-Kaspa reported that clinicians must be able to access information on dosages and side effects of antidotes to be effective when responding to a chemical event.[28] Baughman reported that treatment began in triage area, before patients were sent to the treatment area.[18] Menczer reported a need for more thorough first aid after removal from the disaster site.[20] Paris reported that significant delays in patient care were noted for patients under the drill procedures, and Weston, Paris, and Halstead reported on events leading to adverse outcomes for patients, the latter due to inability to maneuver heavy operating room beds.[19,26,33] Gofrit reported that simulated casualties received incomplete medical evaluations,[29] and Lau found a conflict for busy clinicians between documentation and giving effective patient care.[35] The comprehensive exercise by Inglesby found that hospitals were beyond capacity for patients in less than twenty-four hours.[27]

Patient Flow. Several patient flow issues were identified by the studies. For example, Gretenkort studied the use of the *Jaerven Rescue Drag Sheet*, which greatly facilitated removal of patients from the area of the simulated hospital fire.[32] Cook found that personnel reporting to assigned areas lessened congestion in the emergency department.[22] Halstead and Inglesby identified needed improvements, the former finding that corridors and marked evacuation routes were blocked by equipment,[19] and the latter finding inadequate plans for patient disposition, including disposition of the deceased.[27] Gofrit, Menczer, and Weston identified issues in transporting patients,[20,29,33] and Fishel found that the ambulance crews became overwhelmed and exhausted in a planned drill.[24]

Patient Tracking. Weston reported that all patients were accounted for within the planned time limit of the drill.[33] Other investigators found that clear labeling, identification, and record keeping were vital for efficient reception and treatment of casualties.[28,35] Gofrit reported medical documentation was inadequate,[29] and Maxwell identified patients who had arrived in treatment areas without completing triage.[25] Chobin identified the importance of patient identification and charting.[16]

Security

Two studies described security issues in some detail. Security of the building and perimeter was described as exceptional in one study,[21] while another study raised concerns about the concept of a *security lockdown*, wherein all entrances would be locked and guarded as a measure to handle notional massive crowds.[27] Two other studies simply reported security as being present.[18,31]

Materials and Resources

Chobin reported on success with the prompt arrival of the fire department and proper use of breathing equipment.[16] Menczer found that first aid equipment and supples must be transported to the scene as soon as the disaster is identified.[20] Six of the studies identified deficiencies including difficulty accessing disaster charts;[18] a shortage of ventilators and other trauma care equipment;[29] inadequate numbers of wheelchairs, chairs, poles, and ropes to maintain order;[35] other equipment deficiencies and electro-mechanical failures;[31] gas levers that needed closing but were hard to find;[19] and inadequate antibiotic supplies with logistical difficulties in distribution.[27]

Decontamination

Two studies focused on decontamination. One study emphasized that full protective equipment must be worn in the contaminated area and that decontamination must be directed by personnel with loudspeakers.[28] Classic reported that after radiation exposure, the deceased must not be released to funeral homes until after the corpses are decontaminated.[21]