The Effectiveness of Disaster Training for Healthcare Workers:
A Systematic Review

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ABSTRACT

OBJECTIVES: Disaster training for health care workers is an important focus for medical and public service institutions. Knowledge from evidence-based medical literature is lacking regarding the best methods to train health care providers in disaster response. The authors systematically reviewed the literature to report whether training interventions in disaster preparedness improve knowledge and skills in disaster response. **METHODS:** The authors searched MEDLINE, ISI Web of Science, BIOSIS, Cumulative Index to Nursing and Allied Health (CINAHL), *The Cochrane Library*, ClinicalTrials.gov, the Public Affairs Information Service, and Education Full Text. Selected journals, articles, and other comprehensive reports were also reviewed for relevant citations. Subjects of eligible articles were hospital based and prehospital healthcare providers. Inclusion Criteria for the literature were: articles published in English between January 2000 and December 2005, described a training exercise undertaken to further knowledge and/or skills in disaster response, measured a quantitative and objective outcome, and used a control or comparison group. Included studies were independently reviewed by two researchers and study quality was assessed using criteria adapted from the US Preventive Services Task Force and the Centre for Reviews and Dissemination. **RESULTS:** The literature search identified 258 studies, and ten studies met inclusion criteria. Subjects of included studies consisted of emergency medical services personnel, public health nurses, medical students, emergency department physicians and nurses, and long-term care facility staff. Evidence exists that both supports and questions the effectiveness of computer and web-based training interventions. Fair to poor evidence supports the effectiveness of lecture-based training. **CONCLUSIONS:** The evidence is mixed regarding whether training interventions for health care providers

in disaster preparedness improve objective measures of knowledge and skills in disaster response. Standardized and rigorous methodology should be used in the future to examine the effectiveness of disaster training, as this area of medical education is likely to remain a national and professional priority.

INTRODUCTION

Disasters are increasing in incidence and severity worldwide. Consequences of disasters in terms of human morbidity and mortality as well as economic cost are growing at an astounding rate.¹ Whether a disaster is caused by a natural or man-made force, it may be defined by its capacity to overwhelm a community's ability to provide basic needs, including healthcare.^{2,3} Any disaster, due to a geologic or weather event, or created by acts of terrorism or large-scale industrial accidents, may cause significant human suffering. By taking a considerable toll on human life and health, disasters often create "mass-casualty incidents" (MCIs) that require special effort and large-scale coordinated response of healthcare professionals both in and out of hospitals and healthcare facilities.

Along with the increase in incidence of disasters themselves, recent years have seen the healthcare and public service communities give increased attention to disaster preparedness and response. High-profile natural and man-made disasters such as Hurricane Katrina and the terrorist attacks of September 11th 2001 have forced healthcare leaders to take a fresh look at disaster planning. Regardless of the devastating effects on healthcare infrastructure and the mentally overwhelming nature of these events, health care professionals and public service leaders must prepare and train their organizations and personnel to respond and mitigate disasters when they occur.

For example, the Association of American Medical Colleges (AAMC) has recommended that bioterrorism education be incorporated into all four years of medical school.⁴ Furthermore, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) has mandated that hospitals must practice disaster management with disaster drills for their organizations and the communities which

they serve.⁵ These drills must occur twice a year and intend to assess the communication, coordination, and effectiveness of the hospital's and community's ability to respond to a disaster. The drills are "critiqued to identify deficiencies and opportunities for improvement."⁵ However, JCAHO does not specify measures to be used to assess the effectiveness of disaster response. In addition, it is unclear whether these drills are effective in improving the response of healthcare providers in the event of an actual mass casualty event.

Much of the literature on disaster training and response reports "lessons learned" and other subjective measures that create a conventional wisdom that is "at variance with empirical field disaster research."⁶ Despite efforts to suggest standardized and objective tools and methods to assess and execute disaster training^{1, 7-9} the literature in disaster training lacks scientific rigor. Sadly, the same "lessons" seem to be "learned" over and over again during responses to real disasters!⁶ The movement towards evidence-based disaster planning and training has had to begin with debunking the assumptions and myths of a false conventional wisdom that may limit the effectiveness of healthcare providers' response to disasters.^{6, 10}

The medical and public health communities have embraced the scientific method and the practice of evidence-based medicine to answer a broad range of questions of effectiveness, from counseling on prevention of disease to the best method of teaching CPR to laypersons. In recent years, clinicians and researchers have attempted to employ similar methods to assess the effectiveness of training in disaster response. However, support for evidence based medicine in disaster training is in its infancy. Many methods and measures to teach disaster response and assess the effectiveness of disaster training interventions have been proposed. For example, researchers have suggested following standard guidelines for assessing disaster

response, including disaster training in basic medical education for students in healthcare professions, and following systematic protocols such as the Incident Command System to manage disasters.^{1, 7, 11, 12} However, evaluating these and other methods of disaster training and response is difficult mainly due to the paucity of published data on disasters and disaster training. The question remains: How do we know if disaster training is effective in improving disaster response?

A limited number of review articles written in the last five years have approached this question.^{2, 3, 13-15} The most systematic is an evidence report completed by Hsu, et al,² for the Agency for Healthcare Research and Quality (AHRQ) and also published in the peer-reviewed literature.¹⁵ This report assessed the effectiveness of training methods for hospital staff in mass-casualty incident management. The literature search for this report was conducted through February 2003, with no search restrictions based on publication date. The report was unable to draw firm conclusions on training effectiveness due to insufficient strength of the evidence. Additionally, the report excluded out-of-hospital healthcare workers such as EMTs, firefighters, and public health personnel, who play a critical role in disaster response and complement the efforts of hospital-based staff. Another review for the AHRQ assessed training relevant to bioterrorism preparedness via literature available before June 2001.¹³ However, the vast majority of the evidence in that review dealt with infectious disease outbreaks that may not have been directly related to acute disaster response.

The purpose of this review is to expand the systematic review literature evaluating the effectiveness of disaster and mass-casualty training to include all healthcare providers and to critically appraise the more current literature using national and international standards. The recent increase in funding for disaster

planning and research, coupled with calls for more scientifically rigorous studies of disaster training, has increased the available evidence regarding disaster training in the past five years. A potentially larger and more rigorous evidence base may allow us to draw new and stronger conclusions about the effectiveness of disaster and mass-casualty training interventions. The disaster training literature demands a fresh look, as we continue to face the growing challenges of disaster management and response.

METHODS

A. Focused Question:

This systematic review seeks to answer the question: “Do training interventions for healthcare providers in disaster preparedness, such as didactic and hands-on courses, disaster drills and simulations, and other forms of continuing education, improve objective measures of knowledge and skills in disaster response?”

B. Target Population:

For the purposes of this review, “health care providers” includes all potential providers of health care services in a disaster or mass-casualty situation. This definition includes health care facility staff such as physicians, nurses, and physician extenders; “first responders” such as paramedics, emergency medical technicians and fire fighters; and other prehospital personnel such as public health nurses and county or municipal emergency management staff.

C. Literature Search

We searched eight electronic databases, included MEDLINE via PubMed, ISI Web of Science, BIOSIS, Cumulative Index to Nursing and Allied Health (CINAHL), *The Cochrane Library*, ClinicalTrials.gov, the Public Affairs Information Service, and Education Full Text. These databases were selected by recommendation of a health sciences librarian in combination with databases cited in published disaster preparedness literature reviews. We used Medical Subject Headings (MeSH) terms when possible or key word searches when otherwise appropriate, and included: Health Personnel, Hospital Staff, Emergency Medical Technicians, Emergency Medical Services, First Responders, Disasters, Terrorism, Mass Casualty, Training,

Evaluation Studies, Outcome Assessment, and Effectiveness. These terms were combined in various ways with Boolean operators (Appendix I). We limited the electronic searches to “human” studies and “English Language.” Since the majority of relevant literature has been published post 9/11/01, we concentrated our search on this era. However, we also included the year prior to 9/11 to obtain a sample of this earlier literature. Therefore, we searched the databases from January 2000 to December 2005.

The reference lists of systematic reviews and comprehensive reports on disasters not part of the inclusion criteria for this review were manually searched for other relevant citations. A prior search strategy by the UNC Injury Prevention Research Center (IPRC) for a previously completed bibliography¹⁶ was also hand-searched for relevant citations (Appendix II). To be thorough, researchers performed a targeted hand-search of pertinent journals for potentially eligible articles (Appendix III). We also searched the reference lists of articles deemed eligible for inclusion in this review.

All citations were imported into the electronic database management program EndNote 9.0 (Thomson Corporation, Stamford, CT, USA). Within the EndNote Libraries (ENLs), citations were compiled and duplicate articles found by the various searching methods were discarded.

D. Study Screening and Inclusion Criteria

One researcher screened potentially relevant abstracts by inclusion criteria agreed upon by the research team. To meet inclusion criteria, articles must have been published between January 2000 and December 2005. In addition, included articles had to describe an experiment, drill, course, or other training exercise undertaken for

the purpose of furthering knowledge and/or skills in disaster response. The subjects of included articles had to be health care providers, either hospital or pre-hospital, including but not limited to nurses, doctors, paramedics, emergency medical technicians, and fire department, public health, and emergency management personnel. Included articles had to have a quantitative outcome such as time, test score, or other objective measures of changes in knowledge or skill. Studies that only reported perceptions or attitudes regarding the potential benefits of training were not included. Articles that solely described qualitative outcomes such as “lessons learned” or subjective preferences for a training method (i.e. the exercise was “enjoyable” or “beneficial”) were also not included. Outcomes must have been compared to a control group or comparison group (at minimum, pre/post testing of the same group) for the article to be included. Lastly, to be included, a purpose of the article must have been to evaluate the effectiveness of a training program at achieving a level of competence relating to disaster response. Studies that only described “how” to evaluate disaster planning or training, drills, and exercises were not included.

E. Study Selection and Data Abstraction

Articles with abstracts that met inclusion criteria underwent full text review. Two researchers independently evaluated the full text of articles deemed eligible by screening using a standardized worksheet. If both reviewers agreed that the study met inclusion criteria, it was included in the review. Any disagreements were adjudicated by consensus discussion of the whole research team.

All included studies underwent data abstraction. We created and employed a standardized data abstraction form using an Excel (Microsoft, Redmond, WA, USA)

spreadsheet to ensure completeness and consistency in reviewing quality assessment and synthesizing results. Two reviewers independently abstracted data from each included article and graded the quality of the study. Researchers abstracted the following data from eligible studies: Type, date, location and description of training; type and number of healthcare providers; study design; sampling method; type of comparison group; measured outcome and method of measurement; type of analysis and study findings. In addition, the researchers made comments on the appropriateness of the analyses conducted, internal and external validity, and potential study biases.

F. Quality Assessment

We graded the quality of the evidence in the articles based on criteria adapted from the US Preventive Services Task Force (USPSTF) of the Agency for Healthcare Research and Quality (AHRQ) and the Canadian Centre for Reviews and Dissemination (CRD).¹⁷⁻¹⁹ These criteria are based on the work of leading experts in the independent evaluation of the scientific evidence for effectiveness on a broad range of clinical topics. After critically appraising each study, two authors independently rated the quality of the evidence in each included study as good, fair, or poor using a standardized worksheet (Appendix V).

Good studies were well designed and well conducted experimental (e.g. randomized controlled trial- RCT) or observational (e.g. cohort) studies. Specifically, they included ample data from a representative study population (i.e. sampling methods were sound) to assess the effectiveness of the training intervention. Appropriate controls were used to measure effectiveness, and subject groups were comparable on confounding factors. The training intervention and measured

outcomes were clearly described and appropriately analyzed (e.g. intention to treat for RCTs and adjustment for potential confounders for cohort studies). Study findings were generalizable to other healthcare provider populations.

Fair studies were experimental, quasi-experimental (e.g. before-after design) or observational studies that reported adequate data to statistically assess the effectiveness of a training intervention. Adequate controls were used to measure effectiveness. The training intervention and measured outcomes were adequately described. Strength of evidence was limited by questions about the internal validity of the study, generalizability of the findings, or the size or sampling method of the study population.

Poor studies had important methodological or design flaws that question the validity of the reported results of the study. Objective outcome measures and control groups were present, but evidence was insufficient to assess the effectiveness of the training intervention. Specifically, measured outcomes or the training intervention may have been poorly described or inadequately reported. Selection bias, measurement bias, or confounding may have been sufficiently present to challenge the validity of reported results.

These criteria were not used as rigid rules, but as guidelines for assessment of the quality of the evidence presented in each study. Disagreements in quality grade between researchers were adjudicated by consensus of the research team. In general, a good study met all criteria for its category, a fair study may not have met all criteria but was judged to have no flaw which would invalidate the results of the study, and a poor study contained at least one flaw which may have invalidated the results of the study.

G. Analysis

We created evidence tables to describe the included studies and answer the research question. Findings were synthesized descriptively rather than by meta-analysis due to the small number of studies that met inclusion criteria and the methodological heterogeneity of the studies. Meta analysis was also inappropriate due to the different outcome measures across studies.

RESULTS

A. Literature Search

The literature search identified 258 potentially relevant citations. Electronic databases yielded 160 articles, 31 were found via targeted hand-searching, and 67 were included from the IPRC bibliography search (Figure One). We reviewed and excluded nine abstracts not imported into the ENL because of problems with electronic import filters. Sixty-three duplicate articles across all three search strategies were discarded, yielding 186 unique and potentially relevant citations.

We further excluded 160 articles (86%) based on abstract analysis in accordance with the inclusion criteria. Two reviewers independently assessed the full text of the remaining 26 articles. Upon full text review, 16 of the articles were excluded. Four of the excluded articles²⁰⁻²³ had inadequate data (outcomes were self-report surveys or assessed opinions) or did not specifically evaluate training in disaster response. Twelve^{8, 9, 24-33} of the articles had no comparison group, and most of these had inadequate data as well. The remaining ten articles³⁴⁻⁴³ were deemed eligible for data abstraction and inclusion in this review (Figure One). Characteristics and quality of each included study are summarized in Tables I and II.

B. Description of the Included Studies

Eight of the ten included studies^{34, 36-41, 43} were published in the latter part of our search period (2003-2005). All but two of the studies evaluated training conducted in the United States. One study³⁹ reported on training in the US and seven foreign countries, and the other study³⁴ described training Latin-American EMS providers of various countries of origin.

The number of subjects in each study ranged from 50 to 764. In three^{35, 41, 42} articles, subjects were out-of-hospital healthcare providers: different types of EMS system personnel, firefighters, and public health nurses. Subjects in one study³⁸ were nursing facility staff. An additional four^{36, 37, 40, 43} articles described training subjects who were hospital-based healthcare providers (only Emergency Department providers were represented) or medical students. Subjects in the remaining two studies were both hospital-based and out-of-hospital providers: Latin American emergency care providers of several types,³⁴ and multi-national physicians and “other health care professionals.”³⁹

The training intervention in four articles^{34, 36, 37, 43} was computer or internet-based and had no face-to-face education component. Five of the articles^{35, 39-42} evaluated training methods that included didactic lectures given by on-site instructors, presentations, and interactive discussions about disaster scenarios. The remaining study³⁸ compared computer-based to lecture-based training.

The outcome measure in all ten articles was some type of test of knowledge. A statistically significant change in knowledge, measured by an increased test score, was used to demonstrate effectiveness of the training intervention. In general, studies with computer or website interventions used computers to conduct the test, while studies with lecture interventions used written multiple choice tests.

C. Design, Quality, and Results of the Included Studies

One randomized controlled trial was included,³⁶ and may represent the first prospective trial to focus specifically on evaluating bioterrorism training provided to emergency physicians. The training intervention in the study was access to an educational website dealing with bioterrorism. However, 30% of the physicians

randomized to the website intervention did not access the site. Nonetheless, intention-to-treat analysis as well as per-protocol analysis that grouped physicians by actual website usage found no difference in bioterrorism knowledge due to the intervention. Although the study was conducted during late 2001 during the highly publicized anthrax incidents, both the intervention and control groups had the same exposure to media and other forms of information. Neither group appeared to increase knowledge of bioterrorism. This study was the only included article to receive a “good” quality rating.

One cohort study³⁵ was included in the review. In this study, authors evaluated Department of Defense “Domestic Preparedness” (DP) training. Firefighters and paramedics who attended 40 hours of didactic lecture education increased their mean scores on a validated “Domestic Preparedness Questionnaire,” while firefighters and paramedics who did not attend this training did not increase their scores. However, meaningful selection bias may have been present, as personnel who received DP training were hand-selected by their department. In addition, DP-trained personnel were different than non-DP trained personnel with regard to potentially confounding variables. Firefighters and paramedics selected to attend the DP training were significantly older, more experienced, were more likely to be officers, and had received a greater amount of hazardous materials training. This study received a “fair” quality rating.

The remaining eight studies^{34, 37-43} were “quasi-experimental” with a before-after design. Authors attempted to assess effectiveness by giving a pre-test to a group of subjects, all of whom received a training intervention, and then giving a post-test to the same group of subjects. This design is generally weaker than designs with a separate control group, notably due to possible “secular trends” or outside influences

on the subjects that may have nothing to do with the intervention.¹⁸ Without consideration and measurement of potential outside influences over the study period, adequate follow-up assessment, one cannot evaluate whether any improvements in training are attributable to the training intervention or some other competing factor.

For example, two studies, one a pilot study³⁷ for the second,⁴³ attempted to assess whether a screensaver and linked website was an effective intervention to increase bioterrorism knowledge. The authors could not conclude that improvements in knowledge were due to their intervention. One likely reason for the inconclusive results is that data were collected during late 2001 and early 2002, shortly after the September 11th, 2001 terrorist attacks and fall 2001 anthrax incidents. The “secular trend” of dramatically increasing media coverage and public and healthcare provider awareness of bioterrorism during this time could provide a reasonable explanation for the subjects’ increase in bioterrorism knowledge. To their credit, the authors did not overstate the ability of these studies to assess the effectiveness of their interventions. These two studies were given a quality rating of “fair.”

Three of the other quasi-experimental studies^{34, 38, 42} were also given a quality rating of “fair.” These studies concluded that the training intervention was effective in improving knowledge. However, these three studies did not clearly describe the data collection instrument, outcome measures or timing of measurement. For example, in two of the studies^{34, 42} it was unclear if subjects took short and similar tests after relatively short training interventions, i.e. test improvement could have been due to memory and not the training intervention. Along with similar measurement concerns, the third study in this group³⁸ had less external validity than the other studies. In this study, authors compared methods of fire safety training for

long-term care staff. In the specialized setting of a nursing home, the content of disaster training may be less applicable to other providers in disaster response.

The final three included studies³⁹⁻⁴¹ were given a quality rating of poor. These studies did not adequately report information on the data collection instruments used to measure potential change in knowledge. In one study of public health nurses in New York City,⁴¹ it was unclear whether change in knowledge was measured objectively. The authors stated that test scores “revealed participants’ knowledge” but then presented a table (Table 2⁴¹) that suggested change in knowledge may have been self-assessed (i.e. the participants may have been asked “Do you know the answer to this question” rather than “what is the answer to this question”). A study³⁹ examining the needs of children in disasters stated that an “objective multiple choice questionnaire” was used for a pretest and posttest, but did not further describe the test items or state what the test purported to measure. The last study⁴⁰ thoroughly described a medical school course on bioterrorism and disaster response, but presented no information on the test instrument used to assess pre- and post-training knowledge. All three of these studies concluded that their training interventions were associated with improved knowledge. However, we felt that these conclusions were not supported by what is (and is not) reported in these studies and the studies received a grade of “poor.” The interventions described may or may not be effective in disaster training.

D. Principal Findings of this Review

In summary, seven^{34, 35, 38-42} of the ten studies concluded that their training intervention in disaster preparedness improved knowledge related to disaster response. However, three³⁹⁻⁴¹ of those studies were deemed of poor quality by the

research team. Additionally, the only study of good quality,³⁶ which was a randomized controlled trial, concluded that its training intervention did not increase participants' knowledge of bioterrorism.

Fair evidence exists in support of the effectiveness of computer and web-based training interventions,^{34, 38} while both good³⁶ and fair^{37, 43} evidence also exists that questions the effectiveness of these types of trainings. Fair^{35, 38, 42} to poor³⁹⁻⁴¹ evidence exists in support of the effectiveness of didactic lecture-based training in disaster preparedness. Overall, the evidence is mixed regarding whether training interventions for health care providers in disaster preparedness improve objective measures of knowledge and skills in disaster response.

DISCUSSION

A. Synthesis of Results

Little additional good evidence regarding the effectiveness of disaster training has become available in the five years since domestic terrorism focused the attention of health care providers on disaster preparedness. The large majority of studies published during our search period of January 2001 to December 2005 that have attempted to evaluate disaster training interventions are not scientifically rigorous enough to adequately assess the effectiveness of described interventions. While the quality of studies in this area of the literature may have improved somewhat since prior systematic reviews^{2, 13} were conducted, the body of evidence remains unable to offer definitive conclusions regarding the most effective methods of training healthcare providers in disaster response.

Despite the shortcomings of the evidence, this review does offer four important contributions to the disaster preparedness literature. We rigorously analyzed the quality of the evidence for disaster training methods, and included studies of all types of health care providers. In addition, our review illustrates the need for researchers to use a common method of training evaluation and highlights the important differences between studies of efficacy and studies of effectiveness.

First, we sought to contribute to the “Evidence-Based Disaster Planning”⁶ effort by conducting a more rigorous examination of studies of disaster training. Instead of relying solely on “lessons learned,” this effort intends to improve disaster planning based on systematically collected data from scientifically rigorous disaster research studies. To that end, our inclusion criteria included study quality measures and our system of evidence grading was modeled after established methods used in other evidence-based systematic reviews.¹⁷ The previous review conducted by Hsu, et

al² included four studies^{31, 32, 44, 45} published within the time frame of our search (2000-2005). While our search strategy identified all four studies, none were included in our review because they did not have a control group. Indeed, Hsu, et al note that in their review, “no study had a control group.”²

Secondly, we reviewed studies that assessed the training of pre-hospital health care providers, not just hospital staff. Six^{34, 35, 38, 39, 41, 42} of the ten included studies evaluated the training of health care providers who practice in out-of-hospital settings or nursing facilities where advanced care may not be immediately available. Experience with many types of disasters shows us that pre-hospital personnel such as EMS workers, both on-duty professionals and self-dispatched volunteers,⁴⁶ are a part of disaster response. These personnel should be considered in any evaluation of disaster training. The Centers for Disease Control and Prevention (CDC) and others^{6, 37, 47} have noted that public health workers and many other types of public service personnel are important potential primary contacts in disaster detection and response.

In addition, our review confirms that a common method of training evaluation is still not in use by researchers evaluating disaster response. The various outcome measurements and methods described in the included studies show that independent researchers do not subscribe to a particular set of evaluation criteria. Diverse data reporting also precludes conducting meta-analysis that may provide further insight into the changes in knowledge or skill in disaster response due to training. Recent years have not only seen an increase in publications on disaster training, but also an increase in studies on how to evaluate disaster training. However, few of these evaluation methods have been applied in widespread practice. Other areas of the medical literature have adopted common reporting guidelines for research. For example, the “Utstein Guidelines” are the accepted method of reporting cardiac arrest

data.⁴⁸ An “Utstein Style” has also been proposed for disaster research,¹ which endorses a similar style of uniform reporting that would allow for comparison across studies as well as more valid and reliable methods of combining study results. Hopefully, published endorsements for these or other broad-based evaluation methods for disaster training^{8, 49} will encourage researchers to subscribe to a common ground. Universally accepted criteria that are used to evaluate both disaster response and disaster training would greatly improve the strength of evidence regarding the most effective methods of disaster response and could potentially lead to the ability to conduct meta-analyses.

Lastly, we remind that conducting studies that truly assess the effectiveness of disaster training interventions is inherently difficult. It is unclear whether knowledge gained via a short multiple-choice test would represent better performance in a real disaster situation. It seems likely that improvement on objective measures under ideal conditions would be a poor proxy for improvement in a true disaster response. For example, just as a cardiac arrest training simulation⁵⁰ cannot mimic the stress of performing real-life cardiopulmonary resuscitation, short triage scenarios^{34, 42} cannot reproduce the emotions and pressures of a true disaster scene. One article was titled as a study of efficacy³⁶ and we argue that the other included studies measured the efficacy of their training interventions as well. The ideal study would be able to measure a group of participants’ response to a real disaster, randomize the group to receive disaster training or not, then measure the group’s response during another real disaster. The unfortunate circumstance of more real disasters may provide the only way to truly measure effectiveness. It remains unclear whether an objective test of knowledge or skills under ideal conditions reflects the effectiveness of a training intervention under “real-world” disaster conditions.

Furthermore, “the question of whether various preparedness and response measures actually affect morbidity and mortality remains to be addressed.”⁶

Appropriate patient-centered research outcomes such as “lives saved” due to a given training intervention would provide evidence of effectiveness. However, such outcomes are difficult to measure. Each disaster situation has unique challenges that make standard evaluation of disaster response a complex task.

B. Limitations

This review has several limitations. First, we limited our search to only include English-language articles. Efforts to improve education in disaster preparedness and response are most certainly international. The European Master in Disaster Medicine⁵¹ program is one example of a multi-national collaboration (including partners in the United States at Harvard University, Yale University⁵² and Vanderbilt University⁵³) that aims to formalize and improve education in disaster medicine. However, a repeated PubMed search that was not limited by language did not return any additional articles. Therefore, this may be a minor limitation.

Additionally, we limited the review to the published literature and there is likely unpublished or unavailable data on disaster training that is not included in this review. As described above, JCAHO requires accredited hospitals to conduct disaster training,⁵ yet this training is either not reported in the peer-reviewed literature or was not evaluated such that it would be included in this review. In addition, state offices of emergency management conduct drills that may or may not be evaluated but which do not appear in the published literature. Also, the military may engage in disaster training that is either classified or not reported in a manner captured by our search strategy.

Furthermore, we excluded studies that evaluated knowledge and skills that may be related to disaster response in some cases. We determined that a broad set of medical knowledge and skills is relevant in some way to disaster response. Nonetheless, our review only included studies conducted for the explicit purpose of evaluating disaster training. For example, the review by Catlett, et al¹³ assessed studies that may be related to training in bioterrorism preparedness. However, the vast majority of included studies in that review dealt with identifying infectious disease outbreaks such as HIV/AIDS and other sexually transmitted diseases. We excluded studies such as these. We also excluded studies that evaluated training of trauma surgery teams²¹ via patient simulators because the studies were not conducted expressly for the purpose of disaster training. Detecting infectious disease outbreaks and trauma surgery may be necessary components of some responses to disasters, as many fields of medicine may be. However, including the many areas of medicine that are components of a disaster response would have been an overwhelming task that would have further hindered our ability to draw conclusions regarding the effectiveness of disaster training. We focused on training interventions most specifically related to acute disaster response. In an attempt to decrease the number of extraneous studies in our review, we may have excluded studies that some readers would consider relevant to training in disaster response.

C. Recommendations for future research

Conducting scientifically rigorous research on disaster training methods is feasible. Randomized trials and appropriately controlled cohort studies may not require any greater time and effort than lower-quality quasi-experimental studies. To appropriately judge the effect of a training intervention, researchers should compare

subjects receiving the intervention to subjects not receiving the intervention. This may be an unappealing requirement in disaster training, as healthcare agencies would likely prefer that all personnel receive training. However, which types of training are effective remains unclear. Certainly in most situations the “control group” in a given training evaluation (i.e. those not receiving training) could undergo the training intervention once it is shown to be effective, or at least efficacious.

Additionally, future research should work to incorporate multiple types of healthcare providers into regular training scenarios. Regularly occurring JCAHO-mandated drills and curricula encouraged by the AAMC provide ample opportunity to conduct disaster training research with multiple types of healthcare providers. Researchers recently presented an abstract of an evaluation of such an interdisciplinary training.⁵⁴ Further similar efforts are encouraged.

Perhaps most importantly, future evaluations of disaster training efforts should be presented and published. We agree with Auf der Heide that “more emphasis needs to be placed on reporting the findings of field research through peer-reviewed scientific journals.”⁶

D. Conclusions

We conclude that the available evidence is insufficient to determine whether a given training intervention in disaster preparedness for healthcare providers is effective in improving knowledge and skills in disaster response.

Based on the available evidence, the effectiveness of computer-based or didactic lecture training in disaster response for healthcare providers remains unclear.

Nonetheless, both disaster preparedness and appropriate disaster training for healthcare providers remain important national and professional priorities. The principles

of evidence-based medicine should be rigorously applied to this area of medical education in order to improve knowledge and skills in disaster medicine.

Table I - Characteristics of Included Studies

Ref	First Author	Year Published	Year Conducted	Study Location	Study Design	Number of Participants (n)	Type of Provider	Description of Training Intervention	Outcome Measures*
34	Baez	2005	unclear	Internet prehospital care forums	Before-After	55	Latin American First Responders, EMTs, nurses, physicians	2 15-minute internet education modules	Number of scenarios correctly triaged
35	Beaton	2002	September 2000	Urban fire department, northwest US	Cohort	baseline = 206 trained = 80 DP trained = 78	Pre-Hospital: Firefighters and paramedics	Dept of Defense Domestic Preparedness training. 40 hours onsite education by experts: lectures, multimedia, demonstrations, handbook. Interactive screen saver and linked web site	DPQ scores: test of knowledge of domestic preparedness
37	Filoromo	2003	Late 2001	UAB ED	Before-After	50	In-Hospital: Med Student ED rotators	Interactive screen saver and linked web site	General test on bioterrorism knowledge from website
43	Terndrup	2005	Late 2001, early 2002	UAB ED	Before-After	157	In-Hospital: Med Student and Intern ED rotators	Interactive screen saver and linked web site	Bioterrorism-specific questions in an Emergency Medicine rotation test
38	Harrington	2003	unclear	Not Stated	Before-After	289	Long Term Care Facility Staff	Comparison of Computer vs. Instructor led- workshop-style training in fire safety and emergency procedures	Test of knowledge
39	Olness	2005	2001-2004	Cleveland, Thailand, Pakistan, Ethiopia, Nicaragua, Panama, Syria, India	Before-After	280	Non-specific Physicians and Health Care Professionals	5 day course- didactic lectures, case discussion, eval and feedback	Objective multiple choice questionnaire
40	Parrish	2005	03-04 and 04-05 medical school years	Texas A&M college of medicine	Before-After	72	In-Hospital: 2nd year Medical Students	4 day block of instruction including lecture and hands-on experience with scenarios	Test of knowledge of disaster preparedness
41	Qureshi	2004	August 2001	New York City (NYC)	Before-After	764	Pre-Hospital: Public health nurses in public schools in NYC	4 hour didactic training conducted by Columbia professors	Knowledge regarding emergency preparedness
42	Risavi	2001	unclear, but before 9-11-01	Pennsylvania	Before-After	109	Pre-Hospital: paramedics, RNs, EMTs, first responders	Two-hour didactic lecture with slides and video, given by principle investigator.	Written 20 question Mass Casualty Incident scenario
36	Chung	2004	November 2001 to October 2002	Boston	Prospective, Multicenter Randomized Controlled Trial	63	In-Hospital: EM and Peds EM attendings, fellows, and 4th year EM residents	Training intervention group randomized to access to an educational web site, also weekly scenarios emailed. Duration 1 month.	Multiple choice questions on knowledge, diagnosis, treatment of bioterrorism

* Several studies also measured other outcomes such as attitudes or opinions. Only outcomes relevant to our question are reported here.

Abbreviations: UAB: University of Alabama at Birmingham; ED: Emergency Department; EMT: Emergency Medical Technician; RN: Registered Nurse;

DP: Domestic Preparedness; DPQ: Domestic Preparedness Questionnaire; EM: Emergency Medicine

Table II - Quality of Included Studies

Ref	First Author	Study Design	Recruitment and Sampling Method	Description of Control Group	Type of analysis	Did the study conclude that training was effective?	Quality Grade
34	Baez	Before-After	Convenience. Volunteers recruited through 3 Spanish-language internet prehospital care forums.	before/after	Descriptive measures (mean scores), bivariate (t-test, chi-square, analysis of variance)	Yes. Higher test scores immediately following intervention compared to pre-test scores ($p < 0.001$)	Fair
35	Beaton	Cohort	One urban fire department participated. Firefighters to receive training were chosen by department; were different (Older, more experienced, officers, More Haz-Mat) than controls	controls were non-Domestic Preparedness trained firefighters	Descriptive measures (mean scores), bivariate (t-test, pearson's correlation)	Yes. Higher mean scores following intervention ($p = 0.001$) in trained group and no change in scores in control (non-trained) group	Fair
37	Filoromo	Before-After	Convenience. Testing was part of medical student EM rotation at one hospital; unclear if required	before/after	Descriptive measures (mean scores), bivariate (paired t-test)	No. Statistically insignificant change in pre-post scores	Fair
43	Terndrup	Before-After	Convenience. Testing was part of medical student and intern EM rotation at one hospital; unclear if testing was required.	before/after	Descriptive (mean scores) bivariate (chi square)	No. "Cannot conclude that improvements in performance are related solely to screensavers linking website" due to lack of available website usage data. Higher scores ($p < 0.01$) were achieved in post-tests vs. pre-tests in 2 of 3 trial periods	Fair
38	Harrington	Before-After	Convenience. Staff from a long term care facility were "randomly assigned to two groups." Unclear whether training was required for employment.	before/after testing for separate instructor-led and computer-led training groups; "instructor" group previously validated	Descriptive measures (mean scores), multivariate (analysis of covariance)	Yes-Higher mean scores ($p < .001$) following intervention in both computer-led and instructor-led groups	Fair

Abbreviations: EMS: Emergency Medical Services; EM: Emergency Medicine

Table II - Quality of Included Studies (con't)

Ref	First Author	Study Design	Recruitment and Sampling Method	Description of Control Group	Type of analysis	Did the study conclude that training was effective?	Quality Grade
39	Olness	Before-After	Convenience. Motivated volunteers from chose to attend offered training in various countries around the world	before/after	Descriptive (mean scores). P values presented, no analysis discussed.	Yes. Higher test scores immediately following intervention compared with pre-intervention scores ($p<0.001$)	Poor- inadequate description of assessment instrument and outcome measure
40	Parrish	Before-After	Convenience. Participants were medical students taking a required medical school course.	before/after	Descriptive measures (mean scores), bivariate (t-test)	Yes. Higher test scores immediately following intervention compared with pre-intervention scores ($p<0.001$)	Poor- inadequate description of assessment instrument
41	Qureshi	Before-After	Convenience. Public Health Nurses assigned to New York City schools; unclear how they were recruited, sampling not well described	before/after	Descriptive measures (mean scores), bivariate (paired t-test)	Yes. Higher test scores immediately following intervention ($p<0.05$) and at one to six month follow-up ($p<0.001$)	Poor- unclear if knowledge was se reported
42	Risavi	Before-After	Convenience. Pre-hospital providers in two Pennsylvania EMS systems were recruited by an unclear method.	before/after	Descriptive measures (mean scores), bivariate (paired t-tests), multivariate (repeated measures analysis of variance)	Yes. Higher test scores immediately following the intervention ($p<0.001$) for prehospital providers. Decrease ($p<.01$) in mean score at 1 month follow-up for basic-level providers.	Fair
36	Chung	Prospective, Multicenter Randomized Controlled Trial	Participating physicians at 3 academic medical centers were block-randomized by hospital. Unclear how eligible physicians were recruited.	Physicians randomized to no educational intervention	Descriptive measures (mean scores), bivariate (t-test). Intention to treat as well as per-protocol analysis completed.	No. No significant difference between pre- and post-test scores between groups at one and six month follow-up points.	Good

Abbreviations: EMS: Emergency Medical Services; EM: Emergency Medicine

Appendix I

Literature Search Strategies and Key Words

1. PubMed Search using MeSH headings and keywords:

("education"[Subheading] OR "preparedness") AND ("Health Personnel"[MeSH] OR "Emergency Medical Technicians"[MeSH] OR "Emergency Medical Services"[MeSH] OR "First Responders") AND ("Disasters"[MeSH] OR "Terrorism"[MeSH] OR "Mass Casualty") AND ("Evaluation Studies"[MeSH] OR "Outcome Assessment (Health Care)"[MeSH])

2. ISI Web of Science Search and BIOSIS Search

TS=(Health Personnel OR Hospital Staff OR Emergency Medical Technicians OR Emergency Medical Services OR First Responders) AND TS=(Disasters OR Terrorism OR Mass Casualty) AND TS=(Training OR Evaluation Studies OR Outcome Assessment OR Effectiveness)

DocType=All document types; Language=English; Databases=SCI-EXPANDED, SSCI; Timespan=2000-2005

3. CINAHL via EBSCO host

(Health Personnel OR Hospital Staff OR Emergency Medical Technicians OR Emergency Medical Services OR First Responders) AND (Disasters OR Terrorism OR Mass Casualty) AND (Training OR Evaluation Studies OR Outcome Assessment OR Effectiveness)

*** The keyword search used for CINAHL was also used for the databases ClinicalTrials.gov, PAIS, Education Full Text, and the Cochrane Library, Including The Cochrane Database of Systematic Reviews (Cochrane Reviews), Database of Abstracts of Reviews of Effects (DARE), The Cochrane Central Register of Controlled Trials (CENTRAL), The Cochrane Database of Methodology Reviews (Methodology Reviews), The Cochrane Methodology Register (CMR), Health Technology Assessment Database (HTA), and the NHS Economic Evaluation Database (NHS EED).

Appendix II

IPRC Capacity and Preparedness Search Methodology

The UNC IPRC conducted a prior search similar to the one conducted for this review for a previously completed annotated bibliography¹⁶ on capacity and preparedness to respond to disasters. The UNC IPRC search was limited to PubMed, and the search parameters were set to identify documents published in English between January 2000 and December 2005 using the keyword phrase: (disaster OR mass casualty OR terrorism) AND (preparedness OR planning OR capacity) AND (hospital OR EMS or emergency medical services OR rescue OR healthcare OR recovery). In addition, a targeted search through journals and documents from state and federal agencies was conducted. Articles that did not meet inclusion criteria for the annotated bibliography on capacity were separated into EndNote Libraries (ENLs) based on topic (i.e. “training” or “case report” or “evaluation of effectiveness”). These ENLs were hand-searched and cross-referenced to the ENL created for the current review. Relevant citations were added to the ENL for this review and duplicates were discarded.

Appendix III

Journals Manually Searched for Relevant Reviews and Articles

The search was conducted in April 2006 for articles published between January 2000 and December 2005. The following is a list of targeted journals searched:

Academic Emergency Medicine

American Journal of Emergency Medicine

Annals of Emergency Medicine

Disasters

Emergency Medicine Clinics of North America

Journal of Emergency Nursing

Journal of Trauma, Injury, Infection, and Critical Care

Prehospital and Disaster Medicine

Prehospital Emergency Care

Appendix IV

Disaster Training Review- Inclusion Criteria Worksheet

Article

Author:

Year:

Title:

Inclusion Criteria

- _____ Published between Jan 2000 and December 2005
- _____ Experiment, Drill Course, Training exercise furthering knowledge/Skills in Disaster management or response.
- _____ Subjects are healthcare providers, either hospital or pre-hospital
- _____ Quantitative outcome such as time, test score was measured
- _____ Data presented are objective measures (i.e. not self-report surveys)
- _____ Data presented are compared to a control group (minimum pre/post)
- _____ Purpose is to evaluate effectiveness of training (i.e. not to describe “how” to evaluate, or standardize evaluation.

Comments:

Appendix V

Disaster Training Review- Quality Assessment of Included Studies Worksheet

Article

Author:

Year:

Title:

Criteria (Circle number if criterion is present)

1. The study is a well designed and well conducted experimental (e.g. randomized controlled trial- RCT) or observational (e.g. cohort) study.
2. The study includes consistent and ample data to assess the effectiveness of the training intervention.
3. Appropriate controls were used to measure effectiveness,
4. Subject groups were comparable on any important confounding factors.
5. The training intervention and measured outcomes were clearly described and appropriately analyzed (e.g. intention to treat for RCTs and adjustment for potential confounders for cohort studies).
6. Subjects and study findings were generalizable to other populations involved in disaster response.
7. The study is experimental, quasi-experimental (e.g. before-after design) or an observational study.
8. The study has adequate, not ample, data to assess the effectiveness of a training intervention.
9. Data on measured outcomes are reasonably consistent

10. Adequate controls were used to measure effectiveness.
11. The training intervention and measured outcomes were adequately described.
12. Strength of evidence is limited by questions about the internal validity of the study, generalizability of the findings, or size and nature of the study population.
13. Objective data and control groups are present, but evidence is insufficient to assess the effectiveness of the training intervention.
14. Measured outcomes or the training intervention are poorly described or inadequately reported.
15. Selection bias, measurement bias, or confounding is sufficiently present to challenge the validity of reported results.

INSTRUCTIONS

1. If criteria 1-6 are all present, the study should be rated GOOD.
2. If the majority of criteria 7-12 are present, including criterion 12, the study should be rated FAIR.
3. If ANY of criteria 13-15 are present, the study should be rated POOR. Please comment on and describe any POOR rating.

OVERALL STUDY RATING (CIRCLE): **GOOD FAIR POOR**

COMMENTS:

Figure One- QUOROM⁵⁵ Tree for Literature Search Results

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