The Importance of Evidence-Based Disaster Planning

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The findings and conclusions in this report are those of the author and do not necessarily represent the views of the Agency for Toxic Substances and Disease Registry.

Disaster planning is only as good as the assumptions on which it is based. However, some of these assumptions are derived from a conventional wisdom that is at variance with empirical field disaster research studies. Knowledge of disaster research findings might help planners avoid common disaster management pitfalls, thereby improving disaster response planning. To illustrate the point, this article examines several common assumptions about disasters, compares them with research findings, and discusses the implications for planning. These assumptions are that:

1. Dispatchers will hear of the disaster and send emergency response units to the scene.
2. Trained emergency personnel will carry out field search and rescue.
3. Trained emergency medical services personnel will carry out triage, provide first aid or stabilizing medical care, and—if necessary—decontaminate casualties before patient transport.
4. Casualties will be transported to hospitals by ambulance.
5. Casualties will be transported to hospitals appropriate for their needs and in such a manner that no hospitals receive a disproportionate number.
6. Authorities at the scene will ensure that area hospitals are promptly notified of the disaster and the numbers, types, and severities of casualties to be transported to them.
7. The most serious casualties will be the first to be transported to hospitals.

The current status and limitations of disaster research are discussed, and potential interventions to response problems are offered that may be of help to planners and practitioners and that may serve as hypotheses for future research. [Ann Emerg Med. 2006;47:34-49.]

SEE RELATED EDITORIAL, P. 50.

INTRODUCTION

Numerous responders and planners who have been involved in disaster events have written articles reporting lessons learned in these events. A review of this literature, however, shows that many of the problems experienced in planning and responding to disasters seem to be “learned” over and over again in disaster after disaster. Although the reasons for this are complex, a significant contributing factor is that disaster planning is only as good as the assumptions on which it is based. Knowledge based on systematically collected data from field disaster research studies might help planners avoid common disaster management pitfalls, thereby improving disaster response planning. The focus of this article is on research dealing with operational and organizational emergency medical response issues in domestic, peacetime disasters.

Limitations of Disaster Research

Although there are many limitations on current research about disaster medical planning, many data have been gathered that can be used to improve emergency planning. The status and limitations of current research include the following:

- Most operational research on disaster medical planning has been conducted on sudden, single-impact disasters such as tornadoes, flash floods, or explosions. In these sudden-onset events, the researcher usually cannot select the location where the data collection will occur.
- The selection of variables that can be controlled is often limited. The unexpected nature of disasters also means that data collection on emergency medical responses generally has to be retrospective. This, in turn, creates difficulties with before-and-after comparisons of the event. For example, persons in the locality before the disaster may have relocated because of destruction of their homes and workplaces. Others will have been in the area only temporarily because of the disaster (eg, assigned or volunteer responders). This makes probability sampling challenging.
- Data are often evanescent, which is the case for a number of reasons; for example, individuals and officials are often more willing to share information in the immediate aftermath of a disaster than later. Many of those affected will be in the
<table>
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<td>1</td>
<td>Dispatchers will hear of the disaster and send emergency response units to the scene.</td>
<td>Emergency response units, both local and distant, will often self-dispatch.</td>
<td>Effective disaster planning requires planning not only for the jurisdiction but also at the intercommunity level. Plans should anticipate the likelihood that more help than needed will arrive, whether requested or not.</td>
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<td>2</td>
<td>Trained emergency personnel will carry out field search and rescue.</td>
<td>Most initial search and rescue is carried out by the survivors themselves.</td>
<td>Planners may incorrectly assume that they will have control over disaster EMS responses. Disaster search and rescue is often ad hoc and uncoordinated. Even if not part of the planned response, law enforcement officers often become involved in search and rescue. Survivors involved in search and rescue may have the best information on the location of the missing.</td>
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<td>3</td>
<td>Trained EMS personnel will carry out triage, provide first aid or stabilizing medical care, and—if necessary—decontaminate casualties before patient transport.</td>
<td>Casualties are likely to bypass on-site triage, first-aid, and decontamination stations and go directly to hospitals.</td>
<td>Hospitals should not assume that casualties will be triaged, decontaminated, or given first aid in the field. Patients arriving in private cars may need to be carefully extricated so that injuries are not aggravated.</td>
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<td>Casualties will be transported to hospitals by ambulance.</td>
<td>Most casualties are not transported by ambulance. Rather, they arrive at hospitals by a variety of nonambulance vehicles (e.g., private cars, police vehicles, buses, taxis, or even on foot).</td>
<td>EMS authorities often have little control over time of transport or hospital destination for disaster casualties. Transport outside of the EMS system also poses challenges for patient tracking.</td>
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<td>5</td>
<td>Casualties will be transported to hospitals appropriate for their needs and in such a manner that no hospitals receive a disproportionate number.</td>
<td>Most casualties are transported to the closest or most familiar hospitals.</td>
<td>Although specific hospitals may be designated to receive contaminated casualties (e.g., as required by Superfund Amendments and Reauthorization Act Title III), it is the patients who will often choose their destination. Thus, all hospitals must be prepared to do decontamination. Although it may not be possible to prevent inefficient casualty distribution, it may be possible to influence or plan around it.</td>
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However, when more help arrives than requested or expected, they may not have set up effective processes for integrating them into the response.\[^{62}\]

**Potential Interventions for Self-Dispatched Responders**

As illustrated in the examples above, disaster planners and public safety agencies need to expect unsolicited responders and have a plan for coordinating or directing their activities.

Managing outside responders could be facilitated by the establishment of an intercommunity or statewide mutual aid plan (for example, one based on the Incident Command System) and intercommunity or statewide mutual aid radio frequencies and procedures. Inclusion of agreements on who is responsible for collecting specific types of information (such as estimates of casualties, damage assessments, resource needs assessments, and resource availability), who needs to receive the information, and the technical means for transmitting the information to those who need it might help address the problem.

- **Example:** Terrorist attack on the Pentagon in Washington, DC, September 11, 2001. “Effective inter-organizational coordination was a key factor in the successful response to the attack on the Pentagon.... Officials of the Metropolitan Washington Council of Governments, composed of 17 regional jurisdictions, and key Federal Government agencies were involved in hourly conversations and briefings about the situation at the Pentagon from the morning of September 11. The command centers of the local jurisdictions worked smoothly with each other since their emergency plans had been exercised during their preparation efforts for the Year 2000 computer concerns two years earlier. More importantly, the mutual aid agreements with the Fire and Rescue units from Arlington County, Fairfax County, Montgomery County, Alexandria, and Washington, DC following the Air Florida Flight 90 crash of January 13, 1982 had produced a common doctrine and a shared working experience. The other county responders recognized that Arlington County was in the lead position and were able to efficiently integrate their resources in the ACFD [Arlington County Fire Department] incident command system.... The basis for the on scene structure was the Incident Command System [ICS]. Arlington County uses ICS on a daily basis for all fire events, even for small fires. Personnel responding to the Pentagon attack were, therefore, integrated into a familiar operational structure.” This integration was further promoted by the establishment and maintenance of 2-way radio communications among the responding agencies.\[^{69}\]

Although mutual aid procedures have been suggested as an important tool for integrating outside responders, larger cities sometimes neglect to develop such procedures because city resources are so great that they do not anticipate the need for outside assistance.

- **Example:** Riots, Los Angeles, CA, 1992. “LAPD [Los Angeles Police Department] has, for many years, avoided mutual aid arrangements, whereby law enforcement from one jurisdiction agrees to assist law enforcement in another jurisdiction, believing that it was more likely that the Department would be called upon to help others than be in need of help itself.... The LAPD and the City had not engaged in effective inter-agency planning and training with other mutual aid providers so that the LAPD and the City would be prepared to utilize mutual aid resources quickly and effectively in the event of widespread civil disorders.”

The expeditious use of security perimeters and staging or check-in areas could help to improve coordination among local and outside responders (Figure 1). Establishing these perimeters requires the cooperation of law enforcement agencies to rapidly close off the area with roadblocks and portable barricades and fences. All incoming emergency responders are diverted to staging (“immediate availability”) or check-in (“standby”) areas outside the affected zone. At these areas are check-in or staging area managers in direct radio contact with the multiagency on-scene command post. This approach has several advantages. First, it may allow a rapid inventory of incoming assets, including those who have responded on an unsolicited basis. Second, incoming responders can be provided with a face-to-face briefing (which reduces radio traffic) and then provided with a radio frequency (or a radio) and a task assignment as directed by incident command. Third, this approach allows the scene to be restricted only to those currently needed there while keeping close at hand resources that might subsequently be needed. It should be noted that, although rapid establishment of security perimeters may be possible in smaller, localized disasters, this may not be possible in sudden-onset, large-scale, geographically dispersed events (e.g., earthquakes).

**ASSUMPTION 2: TRAINED EMERGENCY PERSONNEL WILL CARRY OUT FIELD TRIAGE.**

**RESEARCH OBSERVATION: THE SURVIVORS THEMSELVES CARRY OUT MOST OF THE INITIAL SEARCH AND RESCUE.**

Studies of search and rescue in disasters have shown that a substantial proportion of, if not most, search and rescue is carried out by untrained survivors.\[^{8,10,17,24,26,27,39,72-83}\]

- **Example:** Earthquake, San Francisco Bay Area, 1989. A random household survey of residents in 2 of the 6 counties impacted by the earthquake showed that 3% of the residents of San Francisco County and 5% of the residents of Santa Cruz County became involved in postimpact search and rescue, which adds up to more than 31,000 persons.\[^{84}\]

- **Example:** Earthquake, Mexico City, 1985. More than 2.8 million adults provided volunteer assistance in the aftermath of the earthquake, and more than 1.2 million participated in volunteer search and rescue activities.\[^{85}\]

Despite the best efforts and planning, it is hard to envision how anyone arriving in the affected area of one of these disasters could gain command and control over the massive search and rescue efforts carried out by the survivors, especially in the early hours after impact.
ASSUMPTION 3: TRAINED EMS PERSONNEL WILL CARRY OUT TRIAGE, PROVIDE FIRST AID OR STABILIZING MEDICAL CARE, AND—if necessary—DECONTAMINATE CASUALTIES BEFORE PATIENT TRANSPORT. RESEARCH OBSERVATION: CASUALTIES ARE LIKELY TO BYPASS ON-SITE TRIAGE, FIRST AID, AND DECONTAMINATION STATIONS AND GO DIRECTLY TO HOSPITALS.

Although disaster plans may call for casualties to be triaged and given lifesaving first aid in the field, survivors often bypass field first aid and triage efforts because they may not know that field first aid or triage stations exist, much less where they are. In addition, survivors may consider these stations as a lower level of care than that available at hospitals.

Although there are limited data on hazardous materials disasters, it is possible that decontamination stations set up in the field for hazardous materials disasters would also be bypassed. In a series of 12 case studies of non-disaster chemical and biologic incidents that Vogt and Sorensen carried out from 1999 to 2001, patients in 3 of the incidents were transported to hospitals without having been first decontaminated. A report by Berkowitz et al on multicasualty incidents involving hazardous materials spills between 1993 and 2000 stated that 33.1% of those decontaminated were not decontaminated in the field.

- Example: Sarin attack, Tokyo, Japan, 1995. At the time of the sarin attack, the Tokyo Metropolitan Fire Department had its own triage tags, but these were not used for the majority of the victims, who went to hospitals without the aid of fire department ambulances. Also, there was no field decontamination of victims at the disaster site.
- Example: Earthquake, Coalinga, CA, 1983. In accordance with the local disaster plan, a physician set up a triage area in the most devastated part of town. However, 31 of the 38 casualties arriving at the hospital in the first hour came by private car or on foot, the most serious in the back of a local neurosurgeon’s pickup truck. All of the casualties completely bypassed the triage area and went directly to the hospital.

Planning Implications of Lack of On-Site Triage, First Aid, and Decontamination

Hospital personnel should be prepared to carry out triage and decontamination at the ED entrance or redirect disaster victims from there to other areas at the hospital for such care. They should also not assume that contaminated casualties will be decontaminated in the field.

Injured victims may arrive in private cars and need to be provided with immediate first aid or medical care and stabilized (eg, on a spine board) before they are extricated from these vehicles. It is of interest to note that the likelihood may be that those with the most experience and training in extricating victims from vehicles may be those at the scene (eg, firefighters and emergency medical technicians).

Potential Interventions

Local health authorities may wish to consider developing simple instructions to give to members of the public who become involved in on-site search and rescue. These instructions could be conveyed by a number of means (eg, by local radio stations, Amber Alert systems, the Emergency Alert System (http://www.fcc.gov/cgb/consumerfacts/eam.html) or by the first arriving authorities on the scene). Instructions to these persons might include simple directions for protecting themselves, giving first aid, or dealing with contaminated casualties.

Efforts to educate the public about basic first aid, search and rescue, and disaster care (eg, through high school courses or Citizens Corps Programs, http://www.citizencorps.gov) might help improve the on-site care of those rescued by survivor-volunteers.

Disaster planners may want to consider dispatching some of the available extrication-trained personnel directly to hospitals, rather than to the scene, so they can assist in extricating casualties from private vehicles, and can interview survivors to obtain information on the location of other missing casualties.

ASSUMPTION 4: CASUALTIES WILL BE TRANSPORTED TO HOSPITALS BY AMBULANCE. RESEARCH OBSERVATION: MOST CASUALTIES ARE NOT TRANSPORTED BY AMBULANCE; RATHER, THEY ARRIVE AT HOSPITALS BY A VARIETY OF NON-AMBULANCE VEHICLES (EG, PRIVATE CARS, POLICE VEHICLES, BUSES, TAXIS, OR EVEN ON FOOT).

For many untrained persons who become involved in search and rescue at a disaster site, the “best emergency care” is seen as transport to the closest hospital as quickly as possible. If ambulances are not promptly available, survivors do not tend to wait for their arrival but will use the most expedient means to transport the casualties. The Disaster Research Center study ascertained that the initial means of casualty arrival at 75 hospitals for which data were available was as follows:

- ambulance, 54%
- private car, 16%
- police car, 6%
- helicopter, 5%
- bus or taxi, 5%
- on foot, 4%, and
- undetermined, 10%.

These figures describe only the initial means of casualty transport to hospitals: overall, most casualties were not transported by ambulance. Other reports also seem to indicate that many, if not most, disaster casualties are transported to hospitals by means other than ambulance.

- Example: Loma Prieta earthquake, San Francisco Bay Area, 1989. For 1,774 patients for whom data were available (out of 2,390 cases), 26% of earthquake-related emergency cases.
victims, regardless of legislative mandates and local planning arrangements. Although it is unlikely that any planning will prevent inefficient casualty distribution, there may be ways to influence it or plan around it.

**Potential Interventions**

Even though the majority of casualties are transported by private vehicle and completely outside the EMS system, an opportunity exists to balance casualty flow by controlling the destinations of the minority of casualties transported by ambulances under control of the local EMS system. For example, given the availability of multiple hospitals in an affected community, it might be best to have ambulances try to avoid the hospital closest to the disaster site. Control of ambulance destinations is difficult in the absence of a functioning 2-way radio system that can link all ambulances (regardless of jurisdiction) to a single dispatch center. This system functions best when it has the ability to contact local ambulances and those coming from outside the area. Finally, appropriate coordination of ambulance destination might be facilitated by an area-wide medical/hospital mutual aid radio communication system. Such a system might make it easier to determine which hospitals are able to receive casualties, which hospitals are damaged or being evacuated, and which hospitals are being overloaded with patients. Disaster plans that rely on telephones or cellular phones to carry out this coordination are likely destined for failure. Even if telephone and cellular circuits are undamaged, they tend to become rapidly overloaded, leading to circuit shutdown.\(^{50}\)

Another approach might be to predetermine how many casualties each hospital will initially be sent. Such a plan can be implemented even before hospitals can be contacted for information on their patient-receiving capacity. One such system, the "First-Wave Protocol," has been previously described.\(^{22}\) Each hospital determines in advance how many patients in each triage category it could take care of in a disaster when there is a minimum of staff available (for example, at 2 AM on a Saturday). This is called the First Wave Score. For a given triage category, each hospital divides its own First Wave Score by the sum of all the first waves scores for all the area hospitals for that triage category. This is expressed as a percentage and is called the First Wave Ratio. If, for example, Mercy Hospital determines that it could handle 4 patients in the "critical" triage category, and all of the area hospitals could handle together a total of 40 "critical" patients, then Mercy Hospital would have a "Critical" First Wave Ratio of 10% (4 of 40). In a disaster, the goal would be to send approximately 10% of the initial casualties triaged as "Critical" to Mercy Hospital. Similarly, each hospital would determine First Wave Ratios for each triage category. Subsequently, a hospital polling process could be used to determine more accurately each hospital's capacity on a moment-by-moment basis.

 Authorities might also be able to curtail overloading of the closest hospital by advising survivors at the scene that the wait times in more distant EDs are likely to be shorter and by providing preprinted maps with directions to local hospitals. Finally, it might be possible to set up triage areas on major roads leading to the closest hospitals so that patients could be redirected to the hospitals most appropriate for their needs.

**ASSUMPTION 6: AUTHORITIES AT THE FIELD WILL ENSURE THAT AREA HOSPITALS ARE PROMPTLY NOTIFIED OF THE DISASTER AND THE NUMBERS, TYPES, AND SEVERITIES OF CASUALTIES TO BE TRANSPORTED TO THEM.**

**RESEARCH OBSERVATION: HOSPITAL NOTIFICATION OF A DISASTER MAY BE FROM THE FIRST ARRIVING VICTIMS OR THE NEWS MEDIA, RATHER THAN FROM AUTHORITIES IN THE FIELD. OFTEN, INFORMATION AND UPDATES ABOUT INCOMING CASUALTIES ARE INSUFFICIENT OR LACKING.**

To the extent that hospitals can be forewarned before casualty arrival, they can better organize the resources necessary
ASSUMPTION 7: THE MOST SERIOUS CASUALTIES WILL BE THE FIRST TO BE TRANSPORTED TO HOSPITALS.
RESEARCH OBSERVATION: THE LEAST SERIOUS CASUALTIES OFTEN ARRIVE FIRST.

The Disaster Research Center Study observed what one might call "reverse-triage," with the least serious casualties tending to arrive first.9,11,12,14,113 Similar observations were reported in the 1989 San Francisco earthquake130 and the 1985 Mexico City earthquake.131 This could be because the more serious casualties were more likely to be trapped in the rubble, requiring more sophisticated search and rescue efforts to extricate them. Also, the least serious casualties are often more able to extricate and transport themselves.132

Implications of the Least Serious Arriving at Hospitals First

Unfortunately, because of the lack of timely information from the field, hospitals sometimes may be unaware that the more serious cases are yet to come, which has caused problems when the hospital's ED beds were already occupied by earlier arriving, less serious casualties.11

Potential Interventions

To the extent possible, authorities in the field should communicate with hospitals to advise them about casualty numbers and severities. This, of course, would seem more likely to occur if an existing EMS-hospital radio network is functioning and if EMS disaster planning makes it clear who at the site has overall responsibility for this task. Even then, hospital planners should realize that gathering and transmitting this information is often difficult and may not always occur.

At the same time, hospital staff might be advised as a general precaution to hold beds for serious casualties in reserve and not fill them with minor casualties until it is certain that those with more serious conditions have all been transported.

Suggestions for Future Research

Comparative systematic studies of EMS and emergency health care across multiple disasters, such as the Disaster Research Center Study,9,11-17 need to be repeated to see if the radical changes in EMS and health care have altered the patterns observed in the late 1970s.

A sustainable funding mechanism is needed to promote field studies of operational emergency health and medical care responses in disasters.

Field research in this area often involves rapidly evolving disasters. Furthermore, many of the relevant data become less accessible with time. Thus, it is important to establish standing field research teams that can be mobilized quickly after a disaster. Predisaster funding is important so these research teams can develop a standby capability and develop standardized data collection procedures and instruments that can be implemented in successive events.

More emphasis needs to be placed on reporting the findings of field research through peer-reviewed scientific journals.

Although this does occur, there are important findings published in non-peer-reviewed or unpublished reports that would be more credible if peer reviewed. Where available, the research instruments (eg, survey questionnaires) should also be reported, and efforts should be expended to develop standardized questionnaires for use by other researchers so that a uniform body of comparable data can evolve.

Methodology involved in quantitative estimates (eg, such as those for proportions of patients transported by ambulances) needs to be more consistently reported.

Research effort needs to be expended to study the effectiveness of various intervention strategies that hold promise for addressing some of the response problems identified in descriptive disaster studies. Some potential interventions have been identified in this article.

The question of whether various preparedness and response measures actually affect morbidity and mortality remains to be addressed. This is a challenging area that should be a greater focus of future research.

When such measures are identified, they could be used to assess the status of local disaster readiness through regular, national, random sample surveys. By comparing successive surveys, it could be determined whether preparedness is improving or deteriorating over time.

A national clearinghouse for disaster health and medical research is needed that can collect, collate, analyze, and disseminate research findings. Making these findings available in digital format at no cost to planners and practitioners would help to ensure that they are more often integrated into practice.

Summary

It is important for local communities to plan and train for disasters. However, planning and training are not enough: one must plan for the right things. Valuable lessons can be learned from formal disaster research studies. Often disaster plans fail to anticipate common response problems that have been identified during systematic field research studies:

- Emergency response units, both local and distant, will often self-dispatch.
- Most initial search and rescue is carried out by the survivors themselves.
- Casualties are likely to bypass on-site triage, first-aid, and decontamination stations and go directly to hospitals.
- Most casualties are not transported by ambulance. Rather, they arrive at hospitals by a variety of nonambulance vehicles (eg, private cars, police vehicles, buses, taxis, or even on foot).
- Most casualties are transported to the closest or most familiar hospitals.
- Hospital notification of a disaster may be from the first arriving victims or the news media, rather than from authorities from the scene. Often information and updates about incoming casualties are insufficient or lacking.
- The least serious casualties often arrive first.
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