The Importance of Evidence-Based Disaster Planning

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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.]

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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.[1] In these sudden-onset events, the researcher usually cannot select the location where the data collection will occur.[2]
- The selection of variables that can be controlled is often limited.[2] The unexpected nature of disasters also means that data collection on emergency medical responses generally has to be retrospective.[2] 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).[2] This makes probability sampling challenging.[1]
- 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.[3] Many of those affected will be in the

area only temporarily because of the disaster and may be difficult to identify and locate subsequently.[2] Over time, memories fade, and recall bias may become a problem.[1,4] For example, later interviews often tend to depict the response as less ad hoc than it actually was.[5]

- Recordkeeping may be abandoned in favor of patient care under the pressure to provide lifesaving care to a large number of victims.[1,6-9] Because of these limitations, research on disasters is not likely to meet with the expectations of those who think of research in terms of randomized, double-blind, clinical studies, or even the less rigorous observational case-control or cohort studies.
- Research on disaster medical responses has, for the most part, used qualitative methods and case or case series design. Typically, researchers have analyzed descriptive data and have derived empirical generalizations based on that material. Generally, this material came from interviews, sometimes supplemented by government documents, emergency department (ED) logs, after-action critiques, media accounts, and other sources of information.[10,11] This information may be coded for quantification and analysis. Examples of categories of information that might be coded are existence of a disaster plan, numbers or proportion of casualties transported by ambulance, hospital notification, number of casualties received or admitted, injury or illness severity, and damage to hospital systems.[12] Many of these studies are descriptive, rather than tests of hypotheses.[1]
- Some reports provide quantitative estimates but often without documentation of methodology. These statistics include such things as numbers of casualties, numbers of patients rescued by other survivors, and numbers transported by ambulance. Furthermore, although mean values are reported, measures of variation (eg, SD or 95% confidence intervals) are often lacking. Notably lacking are studies that examine mitigation, preparedness, response, and recovery variables with respect to their outcome in terms of morbidity and mortality. Another limitation of the existing literature is that many of the research reports are not published in peer-reviewed journals but rather appear in reports published by government agencies or academic institutions.
- Finally, some of the more useful case series are dated, and there have been significant changes in public health and emergency medical systems since their publication. Although these studies need to be validated with more recent data, some case studies and anecdotal reports suggest that problems identified by these earlier systematic studies may still be major obstacles to effective response.

Despite its methodologic limitations, empirical observation of disaster responses identifies a number of problems that appear to compromise effective provision of health and medical services in disasters. Many of these data have been collected systematically and objectively. In a number of studies, data have been collected from a broad range of individuals and organizations (eg, hospital administrators, physicians, nurses, dispatchers, emergency medical services [EMS] providers, police departments, fire departments involved in or affected by the disaster), thus allowing an analysis of how the various emergency response organizations interacted and giving a picture of the overall communitywide response.[11,12] This helps not only to assess the consistency of observations from multiple sources but also to develop a picture of the event from a "systems perspective," that is, to identify the interaction of various responders at a community level. This is important because what happens in one organization or locality can often influence what happens in another. For example, the actions or inactions of those in the field (eg, whether or not authorities in the field or their dispatchers promptly notify area hospitals of the event and the types, numbers, and severities of casualties they are likely to receive) will often affect subsequent operations at hospitals. The observations from these research studies reveal that what happens in disasters often differs from what the conventional wisdom would suggest. In at least 2 studies, observations have been carried out across multiple disasters in an effort to identify commonalities and patterns that may be difficult to discern in a collection of individual case studies. The first such study was the Disaster Research Center study, carried out in the late 1970s, during which data were systematically collected from 29 mass casualty events in the United States and its territories.[9,11-17] Tierney used this same approach to assess 8 US disasters in a 1993 unpublished report.[17]

The goals of this article are to:

- raise awareness of some key disaster preparedness planning and response problems identified in field research studies;
- propose and stimulate the development of some potential interventions for these problems;
- generate interest in learning more about disaster research findings; and
- make suggestions for future research.

Additional sources of information are provided at the end of the article. In the following section, a number of common planning assumptions[18-21] are listed and then contrasted with findings from field studies of disasters (see the Table). Implications of these findings are discussed, and some potential interventions are presented. These potential interventions may serve as hypotheses to be tested in future research studies.

ASSUMPTION 1: DISPATCHERS WILL HEAR OF THE DISASTER AND SEND EMERGENCY RESPONSE UNITS TO THE SCENE. RESEARCH OBSERVATION: EMERGENCY RESPONSE UNITS, BOTH LOCAL AND DISTANT, WILL OFTEN SELF-DISPATCH.

Early in a disaster, it is not always clear who at the scene is in charge and can be contacted about the need for assistance.[6,9,13,15,22-29] Emergency responders may first hear of a disaster from police scanners or the news media before they are informed by official sources. Frequently, initial reports are greatly dramatized and exaggerated.[9,30,31] For emergency

Table. Common disaster planning assumptions versus research observations.

Assumption Number	Research Observation	Planning Implications	Potential Interventions
1 Dispatchers will hear of the disaster and send emergency response units to the scene.	Emergency response units, both local and distant, will often self-dispatch.	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.	Expect unsolicited responders and develop a plan for coordinating them. Establish intercommunity or statewide mutual aid plans and training. Use staging or check-in areas outside of rapidly established security perimeters.
2 Trained emergency personnel will carry out field search and rescue.	Most initial search and rescue is carried out by the survivors themselves.	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.	Train first responders (including law enforcement officers) how to coordinate with survivors carrying out search and rescue. Designate personnel to obtain information from survivors about the location of the missing.
3 Trained EMS personnel will carry out triage, provide first aid or stabilizing medical care, and—if necessary—decontaminate casualties before patient transport.	Casualties are likely to bypass on-site triage, first-aid, and decontamination stations and go directly to hospitals.	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.	Develop real-time instructions that can be given to survivors (eg, by commercial radio) on how to: protect themselves; give first aid; deal with contaminated casualties. Provide courses on first aid, search and rescue, and disaster care for the public. Send first responders to hospitals to extricate casualties from private vehicles.
4 Casualties will be transported to hospitals by ambulance.	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).	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.	Educate the public about precautions to take when transporting casualties and about which should not be moved. Establish procedures for collecting information after the fact from hospitals about what casualties they have received.
5 Casualties will be transported to hospitals appropriate for their needs and in such a manner that no hospitals receive a disproportionate number.	Most casualties are transported to the closest or most familiar hospitals.	Although specific hospitals may be designated to receive contaminated casualties (eg, 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.	Consider having ambulances bypass hospitals closest to the disaster. Establish area and intercommunity EMS/hospital mutual aid plans and radio systems so that ambulances can be directed to hospitals best able to treat their patients. Use a ''First-Wave'' protocol to divide initial casualties among area hospitals.

Table (continued).

Assumption Number	Research Observation	Planning Implications	Potential Interventions
6 Authorities in 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.	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.	Initial hospital response may have to depend on the resources in house. Hospital procedures that require time-consuming activities before casualty arrival (eg, donning chemical-resistant suits, taping plastic on walls and floors, and erecting stand alone decontamination facilities for chemical casualties) may not be practical.	Base initial hospital response plans on in-house rather than on-call resources. Provide in-house staff with authority to activate and modify the plan. Develop plans for the expedient decontamination of unannounced casualties, which might include the use of fire hoses supplied with warm water, until more sophisticated decontaminated equipment can be set up.
7 The most serious casualties will the first to be transported to hospitals.	The least serious casualties often arrive first.	Because accurate and timely information from the field is often lacking, EDs may not know of the more serious patients yet to come. As a result, when they arrive, they may find all beds occupied.	Assign field responders to communicate casualty information to hospitals. Hold beds open at hospitals for the possibility of later-arriving more serious casualties.

responders, getting accurate, official information on the extent of the disaster and the need for help may be difficult at first.[6,8,9,24,27,28,30,32,33]

Several factors contribute to the hampering of information exchange after a disaster.

- Even if telephone lines and cellular systems are not damaged by the disaster, circuits quickly become overloaded and unusable.[8,10,24,28,29,34-53]
- Radio channels are frequently overloaded.[6,41,48,54-56]
- Many emergency response organizations do not have common radio frequencies on which to communicate with one other.[11,13,29,48,50,55,57-59]

Assuming that too much help is better than too little, emergency units, sometimes from many miles away and from surrounding states, often respond on an unsolicited basis. Local authorities may be unaware of their arrival (and thus have difficulty integrating them into the response).[6,9,11,13,22,45,47,50,52,59-62]

- Example: Coalinga, CA, 1983. Word went out by amateur radio that an earthquake that affected the town was ''the Big One.'' Although this disaster caused no deaths and resulted in only 16 serious injuries, 5 medevac helicopters and 30 ambulances came to Coalinga from as far as San Francisco, 100 miles away. None of the helicopters or ambulances had been officially requested, and some left their home areas without coverage when they responded to the incident.[63,64]
- Example: Aircrash, Sioux City, IA, 1989. United Airlines flight 232 was bound from Denver to Chicago with 296 passengers and crew on board.[65] While passing over Iowa at 37,000 feet, an explosion occurred in the rear engine, and all hydraulic controls were lost. The flight was diverted to the Sioux City Airport, where the plane crash-landed on the tarmac and cartwheeled into a surrounding corn field, resulting in 111 fatalities, with 185 survivors.[66] Thirty-five ambulances from 29 communities, 100 emergency medical technicians, 20 paramedics, and 40 outside fire departments came to Sioux City from Iowa, Nebraska, and South Dakota. Also responding to the crash were 80 Sioux City on-duty and off-duty firefighters, 4 civilian medical helicopters, 6 Army National Guard Helicopters dispatched from near Des Moines, and approximately 250 Air National Guard troops who were at the airport for a drill. More ambulances responded than were needed (and, contemporaneously, concern was raised that some ambulances had left their home counties without adequate protection in their absence).[7,65,67,68]

Self-dispatch of emergency units, especially those from outside jurisdictions, may require different processes for coordination than during daily emergencies.

Planning Implications of Self-Dispatch

Disaster plans that govern or take into consideration only normal, day-to-day responders are not always effective. E. L. Quarantelli, cofounder of the Disaster Research Center at the Ohio State University, now located at the University of Delaware, observed that those who respond to disasters are often not the same as those who respond to daily emergencies in a given locality.[9] For example, as we have seen, emergency response units will also come from outside jurisdictions, whether requested or not. Thus, effective disaster planning probably requires planning not only within the jurisdiction but also at an intercommunity level.

A common planning assumption is that disasters are characterized by resource deficiencies. (In fact, many define disasters as ''emergencies that exceed the available resources''); thus, their focus is on *mobilizing* resources (eg, personnel).

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 agences.[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 disorder."[70,71]

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 (eg, 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.[8,10,17,24,26,27,37,39,72-83]

- 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.

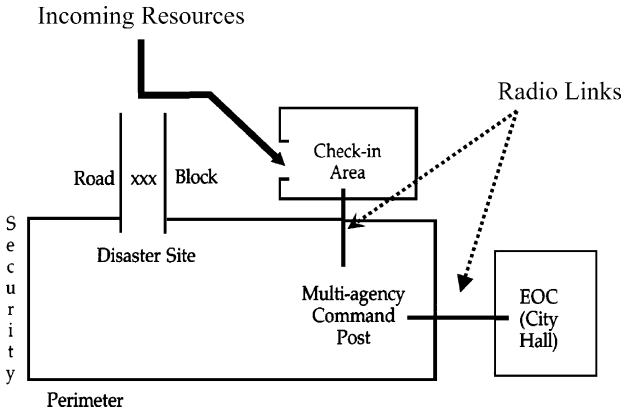

Figure 1. Use of staging or check-in areas to manage (unsolicited) outside responders and volunteers. Modified from[22].

Although the public carries out most initial disaster search and rescue, firefighters and other trained emergency and rescue personnel subsequently become involved as well. Sometimes, this includes a substantial number of law enforcement officers.[9,39,54,81,86-89]

Planning Implications of Search and Rescue by Survivors

Planners may assume that the community will have substantive control over the EMS and search and rescue response to a disaster. (We have already seen how this control may be hampered by the unexpected arrival of responders who have self-dispatched.) Actually, because most initial search and rescue is carried out by untrained survivors, it is often not well coordinated, nor is it under the control of local authorities.

As far back as the 1950s, observers characterized disaster search and rescue as an "informal mass assault."[90] Many unskilled people would tackle the first obvious problem, overcome it by sheer force of numbers, and then move on to the next problem to come into view. Little attention was paid to the big picture, and overall coordination was absent. Probably for this reason, explained later, this can compromise plans that assume that trained responders will have control over subsequent casualty-care activities, such as field first aid, medical care, decontamination, hospital notification, and casualty distribution among the available hospitals.

- Example: Tornado, Flint, MI, 1953. The tornado in Flint killed 115 and injured more than 800. Observers described successive groups of people who would walk up to a pile of debris, toss it aside looking for trapped victims, then move on to the next pile. Behind them, another group would search through the same debris, and then another group would come behind them and repeat the process. None of these groups were aware of what the others were doing.[27,91]

Although lack of coordination during search and rescue could negatively affect the outcome, there could be some advantages to search and rescue by the survivors. One is speed. The survivors are there when and where the search and rescue is needed. Another advantage is that the survivors, more than trained emergency responders, are likely to have knowledge about who is missing and about the last whereabouts of family members, neighbors, and coworkers.[81]

- Example: Gasoline leakage into underground water drainage system and subsequent explosion, Guadalajara, Mexico, 1992. Interviews were carried out with 43 victims and 22 persons who had volunteered during the search and rescue operations. During the first hour, most search and rescue was carried out by neighbors, associates, and relatives of the victims. Subsequently, they were joined by personnel from the army, Red Cross, Green Cross, police, and firefighters. Very few people were rescued alive after the first 2 hours, and chances of victim survival appeared to depend on the presence among the searchers of someone who knew the victim and his likely whereabouts.[81]

Although some law enforcement agencies may not perceive the need to prepare for direct involvement in postdisaster search and rescue activities, they often end up becoming involved. Their visibility as authority figures means that they can be a valuable asset in bringing some coordination to the site. Moreover, in many communities that have wilderness search and rescue teams, they often operate under the authority of local law enforcement agencies and may be a valuable disaster response asset.

Potential Interventions for Search and Rescue

One proposal for improving coordination of disaster search and rescue operations is to provide training to first responders in how to coordinate with survivors carrying out this task and how to link this activity with triage and EMS patient transportation.[92] Even relatively simple attempts at such coordination have been helpful. See the following examples.

- Example: Tornado, Waco, TX, 1953. Military personnel brought organization to the posttornado search and rescue efforts by incorporating civilian volunteers into their teams. Each team was composed of about 15 people under a leader and assistant leader. One member of each team had a walkie-talkie and kept in contact with the command post and other teams.[26]
- Example: Tornado, Wichita Falls, TX, 1979. Many people in the area went to the command post to offer assistance in the aftermath of the tornado. The police captain in charge assigned members of emergency response organizations to direct search parties; each search party was composed of 5 to 12 of these unofficial helpers.[76]

Survival of trapped victims might be improved if authorities would designate personnel to seek out survivors (either at the site or at local hospitals to which they have been transported) and interview them to obtain information on the likely location of other victims.

Because law enforcement personnel do become involved in postdisaster search and rescue operations, they too should receive training in how to coordinate the activities of survivors involved in this process.

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[9,80,93,94] because they may not know that field first aid or triage stations exist, much less where they are.[9,95] In addition, survivors may consider these stations as a lower level of care than that available at hospitals.[9]

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 nondisaster 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.[96] 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.[97]

- 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.[98]
- 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.[63,64]

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/eas.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 NONAMBULANCE 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.[11,13] 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.[9] Other reports also seem to indicate that many, if not most, disaster casualties are transported to hospitals by means other than ambulance.[14,17,26,27,43,51,54,61,63,64,76,78,80,81,88,93,99-108]

- 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

arriving on the night of the earthquake were transported by ambulance.[109]

- Example: Bombing, Murrah Federal Building, Oklahoma City, 1995. The means of transport to the hospital after the bombing of the Murrah building was known for 272 (70%) of the casualties. Of these casualties, 90 (33.0%) patients were transported by ambulance, 152 (55.8%) patients were transported by private vehicle, 27 (9.9%) patients walked or were carried, and 3 (1.1%) patients were transported by other means.[110]
- Example: Sarin attack, Tokyo, Japan, 1995. In this disaster, ambulances transported less than 11% of the more than 4,000 victims. St. Luke's International Hospital, one of the nearest medical facilities,[79] received the largest number of patients.[111] Of those, 35% of patients came on foot, 24% of patients by taxi, 13.5% of patients by private car, 13% of patients by nonambulance fire department vehicle, 7% of patients by ambulance, 1.4% of patients by police car, and 6% of patients by other means.[98]
- Example: Terrorist attack on the World Trade Center, New York City, 2001. Of the 7,364 patients treated at hospitals after the attack, only 504 (6.8%) patients were transported by ambulance.[112]

Nonambulance transport has several implications for other aspects of disaster planning, as discussed below.

Planning Implications of Nonambulance Transport

Because disaster casualties are most often transported by nonambulance vehicles, authorities have little control over time, rapidity, or destination of casualty transport. The lack of ambulance involvement in these cases also helps to explain the lack of appropriate field patient care.

Lack of transport by the EMS system also poses challenges for patient tracking; that is, determining what casualties have occurred and where these casualties are currently located.

In the following sections, we see that this may reduce the efficiency with which local hospital resources are used, and it may contribute to the fact that hospitals often do not receive advance notice of casualty arrival.

Potential Interventions

Nonambulance transport is unlikely to be prevented, probably because its cause is lack of sufficient ambulances precisely where and when they are needed. Evidence is lacking to show whether patients benefit or suffer from rapid, ad hoc, private vehicle transport compared with perhaps more-delayed ambulance care.

It might be possible to lessen the risks of private vehicle transport by educating the public about what precautions to take or about which patients should not be moved by those without proper training.

Patient tracking will likely have to rely on collection of patient information after casualties have arrived at hospitals, rather than depending on ambulance run records.

ASSUMPTION 5: CASUALTIES WILL BE TRANSPORTED TO HOSPITALS APPROPRIATE FOR THEIR NEEDS AND IN SUCH A MANNER THAT NO HOSPITALS RECEIVE A DISPROPORTIONATE NUMBER. RESEARCH OBSERVATION: MOST CASUALTIES ARE TRANSPORTED TO THE CLOSEST OR MOST FAMILIAR HOSPITALS.

The ideals for civilian disaster medical care are based on the military precepts of triage, that is, doing the greatest good for the greatest number of casualties, which implies making the best use of available medical resources. For example, casualties with sprained ankles and minor lacerations should not be sent to trauma centers or burn centers. Also, casualties should be distributed among the hospitals available so that no one hospital is disproportionately overloaded and so that patient needs are matched as best as possible with hospital capabilities. (In disasters, people do not tend to cease going into labor, having acute coronary ischemia, or suffering from acute exacerbations of asthma, chronic obstructive lung disease, hypertension, or diabetes. Thus, triage procedures may have to address not just injuries, but illnesses as well, whether these are due to the disaster or not.)

However, it is often challenging in disasters to make best use of the available medical resources. When survivors independently make what they perceive are rational decisions—to transport victims to the closest hospital—the decisions may result in hospitals near the scene receiving the bulk of the patients, whereas hospitals farther away await casualties who never arrive.[14,113] (A variation on this theme occurs when one hospital is better known in the community or is renowned for giving emergency care and therefore may receive a disproportionate share of the casualties.[9,45,80]) The Disaster Research Center study found that in 75% of the cases, more than half of the casualties were transported to the closest hospital, and in 46% of the cases, more than three quarters were transported to the closest hospital. This disproportionate distribution happened despite the fact that the unused hospitals had an average bed vacancy of 20%.[9] Other case study and anecdotal reports describe similar patterns[15,39,45,54,88,108,114-119] (Figures 2 to 4).

Planning Implications of Inefficient Casualty Distribution

Disaster planners may assume that the flow of casualties in a disaster will be under the control of the EMS system, especially given the current government emphasis on detailed planning. For example, under Title 3 of the Superfund Amendments and Reauthorization Act, local emergency planning committees must designate a local hospital that has agreed to accept and treat victims from hazardous materials incidents.[120] This designation of a decontamination hospital could lead to a false sense of security at other hospitals if hospital management believes that this relieves them of the need to plan for the arrival of contaminated casualties from a chemical disaster. As has been shown in studies of numerous disasters, victims and survivors determine the initial hospital destinations for most disaster

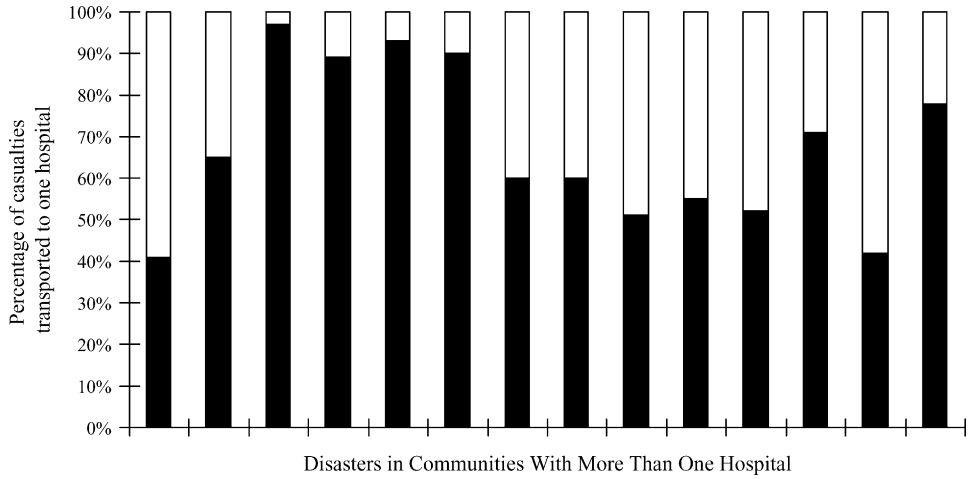

Figure 2. The Disaster Research Center Study: the percentage of casualties transported to one hospital. Of the 29 disasters in the study, 14 are included on this chart; the 15 communities with only 1 hospital were excluded.[14]

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

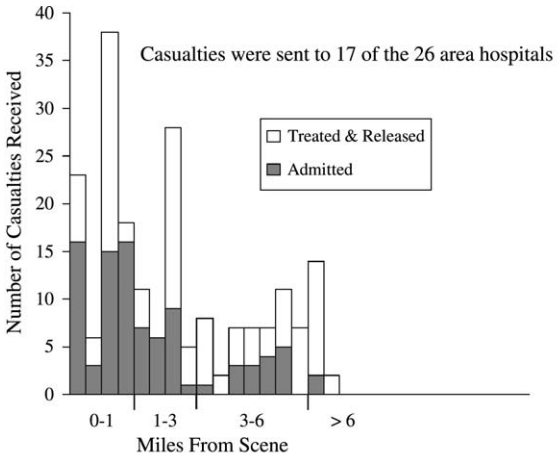

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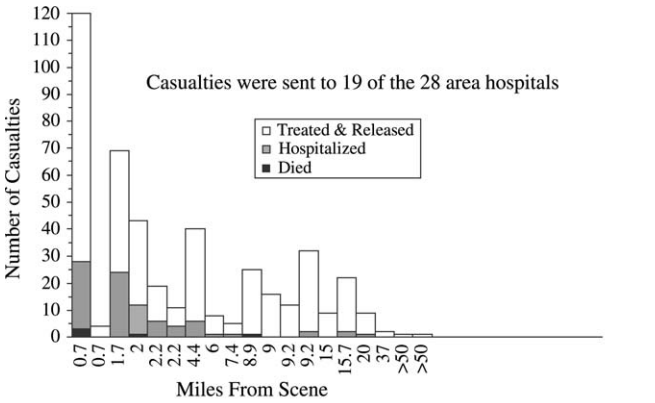
Figure 3. Distribution of casualties among area hospitals, Hyatt Hotel Skywalk Collapse, Kansas City, 1981.



Reprinted from Auf der Heide E. Common misconceptions in disasters: panic, the "disaster syndrome," and looting. In: O'Leary M, ed. *The First 72 Hours: A Community Approach to Disaster Preparedness*. Lincoln (Nebraska): iUniverse Publishing; 2004:340-380.

Figure 4. Distribution of casualties among area hospitals, bombing of the Murrah Federal Building, Oklahoma City, 1994.

to treat the casualties. The types of information needed by hospitals include the nature and scope of the disaster; the numbers, types, and severities of injuries or illnesses; and the estimated time of victim arrival. However, the Disaster Research Center Study showed that most often the first notification of hospitals was not from authorities at the scene but rather from the first arriving casualties or ambulances or the news media.[9,11,13] This pattern has also been noted in other disasters.[50,61,115,118,119]

- Example: Loma Prieta earthquake, San Francisco Bay Area, 1989. Forty-one of 49 hospitals received inadequate information related to the event from the field. The only sources of information for most hospitals were television broadcasts and reports from commercial radio stations.[30,121]

Planning Implications of Lack of Timely Hospital Notification

In developing preparedness and planning measures for hospitals, planners should recognize that often casualties will arrive with no advance warning. The lack of warning causes problems if, for example, hospital plans for chemical casualties call for time-consuming activities such as taping plastic sheeting to floors and walls, erecting stand-alone decontamination showers and tents, or donning chemical protective suits.

Furthermore, when timely notification is lacking, hospitals will need to be able to respond with the resources on hand. Plans that depend on the response of on-call or off-duty staff (eg, that require an off-site administrator to declare an emergency) may cause undue delays.

The Disaster Research Center Study also found that casualties began to arrive at hospitals within 30 minutes of impact and that most casualties are in hospitals within 1 to 1.5 hours. Thus, for resources to have an impact on the response, they would have to be present quickly. A similar pattern has been reported by others as well.[9,14,51,67,88,103,104,122-125] In some disasters, however, injuries continue to occur after the immediate postimpact period, often as a result of prolonged search, recovery, and cleanup activities.[125-129]

Potential Interventions

Disaster plans should assume that casualties will arrive with little or no warning. Thus, the initial response will have to depend on in-house resources. Early on, reliance should not be placed on staff who are not already in the facility. Even if they are on call, their rapid notification and response may be undependable because of overloaded and inoperable communications systems and blocked transportation routes. This means, among other things, that in-house staff should have full authority to activate disaster plans and modify them as needed to meet contingencies in the situation. However, some disasters (eg, earthquakes, large explosions) by their very nature become obvious to the entire community. In these cases, off-duty staff typically return to duty quite rapidly, even if not officially notified or requested. The same can be said when news of the disaster is immediately broadcast to the community during waking hours by the media.

One approach to the problem of unannounced chemical casualties might be for hospitals to have high-capacity hoses (eg, fire hoses) that can be supplied with warm water and fitted with appropriate spray nozzles so that victims can be decontaminated from a distance without injury to hospital staff. This initial decontamination could be carried out even before victims have disrobed, before hospital staff members have had time to don personal protective equipment, and before other preparations have been completed to deal with the victims. In this manner, initial decontamination could be carried out while standard decontamination procedures are being set up. This rapid use of warm water would also help to reduce the risk of casualties becoming hypothermic during inclement weather if they would otherwise have to wait outside for more traditional decontamination measures to be set up.

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 earthquake[130] 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.

Failure to anticipate or be aware of these response problems may be a major obstacle in overcoming them. Although command and control of disaster response is seen as an ideal, it is often not accomplished early in disasters, except perhaps in smaller, localized events occurring within a single jurisdiction. Despite this, it is possible to influence or plan around the patterns listed above, even if one cannot control them. This is embodied in Quarantelli's recommendation:

"Planning should take into consideration how people and organizations are likely to act, rather than expecting them to change their behavior to conform to the plan."[133]

Some strategies (listed as "Potential Interventions" above) that might be used to counter these problems have been suggested and may serve as hypotheses for future research on disaster medical responses:

- Developing plans and training for how to integrate outside and unsolicited responders into the response
- Developing intercommunity health and medical mutual aid plans
- Establishing local and intercommunity mutual aid radio communications systems
- Rapidly deploying security perimeters around disaster-affected areas and establishment of staging or check-in areas
- Establishing training programs for first responders on how to coordinate widespread postdisaster search and rescue operations
- Designating personnel to rapidly seek out survivors (either at the site or at local hospitals to which they have been transported) and interview them to obtain information on the likely location of other victims
- Issuing simple instructions to members of the public who become involved in on-site search and rescue
- Educating the public before the disaster about basic first aid, search and rescue, and disaster care (eg, through high school courses or Citizens Corps programs)
- Assigning first responders to assist area hospitals in safely extricating arriving victims from private vehicles
- Establishing procedures for collecting information after the fact from hospitals about where casualties have been transported when such data have not been collected during triage and patient transport
- Establishing EMS/hospital radio networks to rapidly collect hospital status information and direct the flow of those casualties who are transported by ambulance
- Pending hospital status information, having ambulances bypass the closest hospitals (those most likely to be crowded with casualties) unless there is a compelling reason not to do so
- Establishing a "First-Wave Protocol" to guide ambulance transport of casualties before hospital status information is available
- Planning for rapid, expedient, warm-water decontamination for unannounced casualties that arrive before more sophisticated procedures can be initiated
- Ensuring that hospital/EMS radio systems are established to facilitate early warning to hospitals from responders in the field
- Recommending that hospitals hold ED beds open for the more serious patients who may arrive after those patients with more minor conditions

Further Reading on Disaster Management and Research

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