Chapter 2:

Intensive Care Unit Microcosm Within Disaster Medical Response

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Objectives

- Explain the concept of all-hazard preparedness as it relates to critical care disaster response.
- Describe how hazard-vulnerability analysis can lead to effective contingency planning for a given problem.
- Identify the standard elements of an incident command system and how they inform critical care delivery.
- Compare and contrast internal and external communications processes employed during disaster response.
- Discuss how an individual hospital's response plan integrates with the larger community disaster response plan.

Case Study

A magnitude 6.5 earthquake strikes a large metropolitan area. A major tertiary referral center sustains direct damage to its infrastructure. Minimally injured patients begin showing up at the hospital on their own, and ambulances from the surrounding area have started to bring more seriously wounded patients to the emergency department. There are requests to board patients without life-threatening injuries in the postanesthesia care unit. The 2 remaining critical care beds in the intensive care unit (ICU) become filled with patients requiring mechanical ventilation. Several additional patients with fulminant respiratory failure are en route.

– Who will be in charge of bed allocation and triage in the ICU?

– Are there enough mechanical ventilators in the hospital inventory to meet the demand for resources?

– What means of communication are available between healthcare providers in different parts of the hospital?

– Who is going to convey developments about the hospital's disaster response to the media?

I. INTRODUCTION

During a large-scale mass casualty incident (MCI), the resources of local responding hospitals can be rapidly overwhelmed by the number of disaster victims who present for evaluation and treatment. Critical care resources must function well despite whatever injuries or illness affect the local populace during various natural and human-generated catastrophes. In a disaster setting, critical care medicine must continue to deliver resource-intensive, high-quality service at a time when, paradoxically, resources dwindle and demand escalates.

Preparing a response for unforeseen disasters is known as all-hazard preparedness. The Joint Commission has developed a set of standards for all-hazard preparedness in acute care hospitals. These standards address 4 disaster phases: mitigation, preparedness, response, and recovery (1). Because MCIs are impossible to predict, hospitals are obliged to have circumspect plans for dealing with each disaster phase, including the disaster's time, scope, type, and location. Some events, like the release of a nerve agent, demand a prompt response, and treatment cannot be delayed until outside assistance arrives. Hospitals should plan to be self-sufficient until support from governmental, community, and service organizations can be mobilized. ICU staff must understand how their efforts integrate with institutional, community, and governmental responses. The ICU staff should actively plan strategies to optimize the ICS, internal and external communications, surge capacity, and evacuation to ensure that they can provide high-quality care for incoming victims while continuing the care of current patients.

II. WHAT DOES IT MEAN TO BE PREPARED?

To achieve all-hazard preparedness, the ICU staff must plan to mobilize limited resources in the face of a daunting array of events. Disasters of large scope but limited duration, like the World Trade Center terrorist attack on September 11, 2001, might generate a significant influx of mostly trauma cases, requiring a high level of staff and equipment in a short time. Conversely, an infectious disease event like the severe acute respiratory syndrome outbreak in Toronto, Canada, in 2003 might persist for months and require resources over a longer period of time. Differences in hospital preparedness efforts between the 2 disaster types are highlighted in **Table 2-1**. Other causes of large-scale MCIs include the release of radiological, chemical, or bioterrorism agents; explosions; weather-related catastrophes; fires; and earthquakes. An ICU should also stand ready to deal with internal incidents, such as a fire or power outage within its own institution.

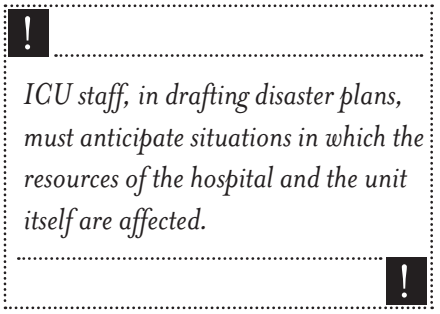

Table 2-1. Differing Characteristics of 2 Types of Disaster

Conventional Explosion	Disease or Pandemic Outbreak
Casualties usually as high as hundreds	Casualties may be in thousands
Mostly trauma patients	Mostly medical patients
Most patients present to the nearest hospital	Patients present to many hospitals
Emergency, surgical, and mental health services face greatest demand	Inpatient services (especially critical care) face greatest demand
Event recovery may begin within hours or days	Event recovery may take weeks to months

Given this complex array of challenges, critical care providers must forecast what constitutes readiness in their practice environment. One approach to such forecasting is a preparedness pyramid which emphasizes planning and policies, equipment and infrastructure, knowledge and capabilities of staff, and training and drills as domains in which to achieve a high level of preparedness (2). Such a framework identifies the areas that contribute to readiness, but the true key to uniformly effective MCI capacity is continued evaluation of competence within those areas. This approach to readiness normally involves a series of exercises that range from small, internal table-top exercises to fully integrated ICU-hospital-community drills (3). To optimize their results, readiness exercises should have specific objectives, maintain the highest degree of realism that is technically and fiscally possible, enroll a limited number of participants, and force decision making in real time. The intent of these exercises is to raise awareness of problems in the system and identify solutions to those problems (4). Because it is not feasible to develop detailed plans for every contingency, ICU management should analyze the fundamental nature of hazards and predict the ICU's vulnerability to their effects. Once the threats are assessed, the staff may address the planning details of personnel function and material allocation. Learning from past disasters should figure into this planning process. For example, the University of Texas Medical Branch at Galveston noted that during Hurricane Rita, having a single incident leader and command center was key to accomplishing the center's first-ever total evacuation, even when lacking a robust system of backup (redundant) communication to provide the desired seamless communications (5).

III. HOSPITAL DISASTER PLANNING AND THE INTENSIVE CARE UNIT

The first step that a hospital and its critical care venue must undertake to prepare for an MCI is to develop a hazard-vulnerability analysis (HVA) in order to prioritize response efforts given the impacts of a set of possible events. The hospital will examine which bad things might happen – for example: the nearby chemical tanks could burn, there could be a highway accident, or an ice storm could make the hospital lose power and cause staff difficulty in driving to work. Then, the HVA team will prioritize which accident is most likely to happen and determine what assets are required

for each accident via a needs-based assessment. Finally, they subprioritize what resources are needed (people, transportation, safety, power) in a complex equation designed to best cover all these hazards, with priority given to those most likely to happen. The HVA is a process that feeds back on itself: what we learn from current accidents can improve our plans for next time. Also, ironically, the planning process can both help and hurt: if we enhance our capacity for 1 type of disaster, we may reduce our capacity to respond to another disaster (6). For example, a computerized medical record system is extremely helpful during disaster response, but during a power outage it is rendered useless. Contingency planning might decrease this vulnerability by developing backup, paper-based charting options for use during outages.

> ! *In a disaster, a hospital's risk is directly proportional to its vulnerability and inversely proportional to its preparation for such an event.* !

In addition to completing the HVA, the ICU may wish to consider doing risk analysis to determine the probability of a specific outcome and the likelihood that it will have a certain impact during a disaster. For instance, imagine that 50 people with inhalational lung injury are en route to a hospital following a chlorine gas release. Data on the duration and extent of the toxic release, the number of victims requiring intubation and mechanical ventilatory support, and the number of ventilators available in the ICU for this purpose might help staff to perform at least a qualitative risk assessment. However, risk assessment may be undermined at a number of steps by incomplete or inaccurate information. Strategies aimed at optimizing the precision of healthcare risk assessment have been discussed elsewhere (7, 8, 9).

IV. INCIDENT COMMAND SYSTEM AND DISASTER MEDICAL RESPONSE

A. Characteristics of an Incident Command System

The medical incident command system (ICS) defines who is in command during a disaster. Both communities and hospitals should have an ICS in place before a disaster occurs. The ICS is based on the systems that firefighters, emergency medical services, and law enforcement use as they routinely work together at crisis scenes. The ICS should contain shared principles, including consolidated action plans, optimal ratios of leaders to employees, modular organization, shared terminology and modes of communication, and integrated resource management. Incident command systems are usually organized to have only 1 commander responsible for setting objectives and priorities. Section chiefs are assigned to the 4 standard sections reporting to the commander: operations, planning, logistics, and financial management, and form the remaining incident leadership. Action cards or job action sheets outline the

> ! *Large numbers of staff assigned to any supervisor can lead to inefficiency in disaster response.* !

fundamental duties of each section chief and other subordinate section members who should be prepared in advance to ensure that they will be available when needed. Smooth operation of all these staff and tools into a well-defined command system will avoid most problems, such as the distraction of ICS leadership which has been shown in simulations to rapidly curtail implementation of a given response plan (10).

Span of control refers to the number of people who report directly to a supervisor. Within a hospital ICS, the recommended ratio is 1 supervisor for every 3 to 7 workers, most commonly 5. Although no studies have identified the optimal span of control within a hospital ICS, studies in industry have shown that larger spans of control correlate with poor safety performance (11). This suggests that the efficiency of a hospital ICS can be maximized by limiting the number of people who report to each supervisor.

During a disaster, overall control will normally fall under the community's ICS (for example, directed by the chief of the fire department). Hospitals can enhance coordination by incorporating their own designated liaison to the community ICS within their own internal ICS structure, and by conducting training exercises with the community to jointly practice disaster response. A complex or prolonged incident may require a unified command system made up of representatives from multiple agencies in the community. In a unified command setting, there is greater opportunity to share specific information, which optimizes the responses of all participants. Hospitals that develop an ICS to optimize their organizational response will more effectively integrate their efforts with community or regional efforts. The Hospital Incident Command System, now in its fourth iteration, is an example of such an organizational construct (12).

Two essential parts of ICS leadership are maintaining real-time communication and monitoring the status and location of all responding staff. Recent integration of multichannel sensors into personal protective equipment might someday improve ICS leaders' capabilities for monitoring staff in real time (13). Personal protective equipment should clearly identify those in the ICS leadership to facilitate internal interactions, especially as the scope of response expands beyond the institution. Finally, though the ICS designates specific responsibilities for different types of responders, a general set of core competencies has been suggested for all responders/healthcare providers (14). These skills include recognizing a potential critical event, managing the immediate situation, comprehending safety principles, understanding an institutional emergency operations plan, showing effective communications, knowing one's role within the ICS, and demonstrating knowledge and skills needed to fulfill one's role during the event.

B. National Incident Management System

The US Federal Emergency Management Agency has established the National Incident Management System (NIMS) to provide a consistent, nationwide approach that federal, state, local, and tribal governments, the private sector, and nongovernmental organizations can use to work effectively and efficiently together, in a standardized and scalable manner. NIMS includes the ICS framework as well as multiagency coordination systems and public information systems. It outlines the processes, procedures, and systems needed to improve interoperability between disciplines and jurisdictions (15). Currently under review is guidance for implementing the NIMS,

including forms and templates for instituting ICS practices within an institution or on the local level. Any requests for funding require full NIMS compliance (16).

C. National Response Framework

The National Response Framework (NRF) is a guide to how the nation responds to all hazards. The NRF provides the structure and mechanisms to ensure federal support to state, tribal, and local communities. Of paramount importance in the design of both the NRF and NIMS is the basic premise that local jurisdictions maintain command, control, and authority over the response activities within their jurisdictions.

V. INTERNAL COMMUNICATIONS AND DISASTER MEDICAL RESPONSE

As noted in the sections on HVA and ICS, communication among members of a disaster response team is crucial to caring for casualties in a safe and efficient manner. The conventional ways in which day-to-day healthcare plans are conveyed, including landline and cellular telephones, pagers, and e-mail, cannot be relied upon when crisis strikes. Some of these services may be down for minutes to hours or even days, depending on the scope of a disaster and institutional readiness. Planning for redundant communication is vital in medical disaster management. Advantages and limitations of the forms of communication employed during disaster response are outlined in **Table 2-2**.

> ! *There are advantages and disadvantages to all communications modalities used during the healthcare response.* !

No details are insignificant in preserving communications during a disaster. In 2005, units of the Army National Guard responding to Hurricane Katrina in New Orleans, Louisiana, encountered problems when their radios were incompatible with those issued by the Air Force. Furthermore, due to a lack of power strips, they had difficulty keeping cellular telephones charged (17). Even a prearranged phone tree in which participants, starting with a small nucleus of people who sequentially contact more and more responders, can break down, and thus hamper resource mobilization. A communications drill at the Kings County Hospital Center in Brooklyn, New York, involving emergency medicine residents and their administrators showed that although 30 residents could be reached in 1 hour, the final branch on the tree could not be completed for 3 hours and 45 minutes (18).

Several technologies have been developed which enable real-time, cross-platform, multimedia data exchange for disaster response. These include the Advanced Health and Disaster Aid Network Web service architecture used by emergency response agencies in the Washington, DC, metropolitan area, and the Surveillance and Incident Reporting PDAs that capture and transmit both patient and environmental data from the field (19). Some lower-tech approaches

to institutional disaster communication are shown to work just fine, as evidenced by the daily hot sheets used by a healthcare system in Stuart, Florida, during consecutive hurricanes in 2004 (20). Although it is tempting to believe that making more information available to responders is necessarily better, excessive communication, especially random, multiagency communication, can generate confusion, paralyze available modes of communication with high volumes of calls, and ultimately cost patient lives.

Table 2-2. Modes of Communication During Disaster Response

Mode of Communication	Advantages	Disadvantages
"POTS" – Plain Old Telephone System, landline or cellular	One-on-one discussion and conference calls	Frequently unavailable in disasters
E-mail	Very rapid data exchange with multimedia Wide distribution	Requires Internet service
FAX transmission	Can FAX via computer or landline phone, depending on equipment; good way to send anything that is in hardcopy form that cannot be e-mailed	Will not work if computers and/or phones are down Requires 2 FAX machines or software on sending and receiving computers
Satellite telephone	Independent of landline phone system; still works when landline phones are down	Expensive and not widely available
Radio	Amateur radio networks can be mobilized Capable of reaching many listeners	Signal strength limits range Frequency availability limits range
Pagers	Small, portable, cheap Easy access to doctors and staff who wear them	Not all healthcare professionals wear pagers and they can be turned off Can only be used if telephone system is working Typically only 1-way (2-way is ideal but new technology)
Telemedicine	Detailed, real-time, interactive transmission Helpful for consultation between specialists	Requires expensive infrastructure Requires high-speed data transfer
Mail courier	Helpful when all else fails	Slow information dissemination

VI. EXTERNAL COMMUNICATIONS AND DISASTER MEDICINE RESPONSE

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Use of a public information officer can of streamline communications with the media during a disaster.

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In times of crisis, healthcare institutions invariably need to communicate with individuals and groups outside their walls. Among those who need to exchange information are governmental and private aid organizations, the media, families and friends of hospitalized patients, and the legal system.

A. Communicating with the Media

Dialogue between healthcare providers and the media must be anticipated. Dissonance during this process often results from the healthcare institution's failure to plan for the media presence. Strategies that contribute to effective media management include the designation of an official spokesperson, the use of prepared statements, the clearance of information through a command center, and the scheduling of periodic media briefings on developments. Two common barriers to effective communication are media personnel's lack of experience with healthcare crises and the reticence of healthcare institutions to release information that might jeopardize response efforts (21). Both barriers can be overcome through education: the media could be invited to participate in disaster training exercises, and hospital administrators and public information officers could be trained in the subtle differences between risk communication and crisis communication.

B. Communicating with Victims' Loved Ones

Though communication between healthcare institutions and the media may follow established guidelines, speaking with the loved ones of disaster victims requires a less formulaic approach. It is important to avoid speculative statements and collaborate with trained experts, such as clergy and social workers, who can convey information in a timely and tactful manner and provide regular updates to help these difficult interactions proceed more smoothly.

C. Communicating with Agents of the Legal System

Healthcare providers should anticipate the need to negotiate certain points with agents of the legal system during disaster response. The approach will vary depending on the nature of the disaster and local laws. For example, a 2004 review of quarantine powers in the 10 most populous US states showed significant variation in structure and function (22). Some public health analysts contend that leadership by clinicians is more beneficial to state health departments than leadership by appointed nonmedical officials, specifically because clinicians have experience in public health disease control (23). Furthermore, these analysts argue that health department leaders with clinical backgrounds are better positioned to implement quarantines in a manner that optimally preserves both individual rights and community safety. Given the diversity of local public health laws and leadership, it is easy to envision the jurisdictional friction that could be caused by a multistate infectious disease outbreak when the states have conflicting quarantine laws, mission statements, interpretations of civil liberty preservation, and mechanisms for law enforcement and public recourse.

VII. INTEGRATING HOSPITALS INTO COMMUNITY RESPONSE

This chapter has described institutional all-hazard preparedness, HVA, ICS, and internal and external communications. All of these elements need to come together within the larger framework of community emergency readiness and response (24). Hospitals should link to community response activities through 4 areas: comprehensive planning, thorough emergency operations plans, defined response capability, and ongoing surveillance and reporting. It is through these 4 domains that ICUs, via their hospital ICS structure, will reach out for assistance and coordinate with supporting groups and agencies, including local health providers, volunteer organizations, and others who may be able to assist (**Figure 2-1**).

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Disaster planning exercises should emphasize how the ICU microcosm fits within a broader response framework.

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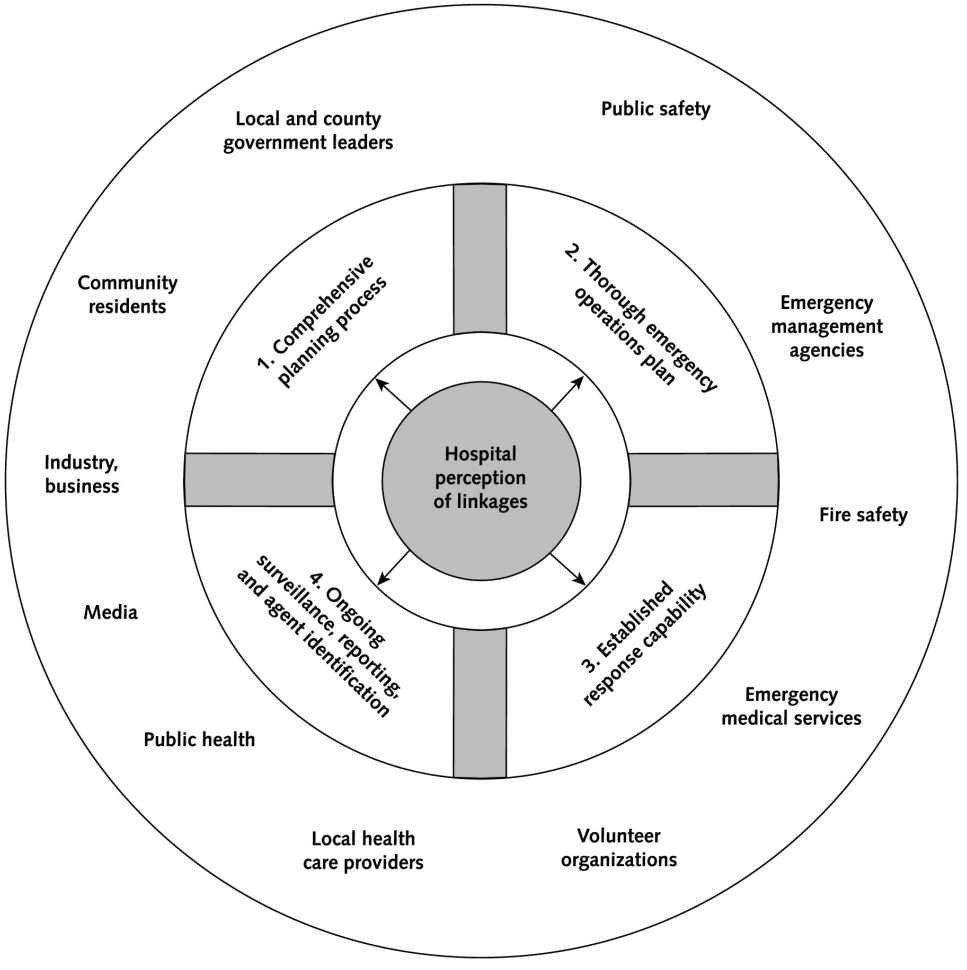
Figure 2-1. Hospital Links with Community Emergency Preparedness Activities [a]



[a] Adapted with permission from Braun BI, Wineman NV, Finn NL, Barbera J, Schmaltz SP, Loeb JM. Integrating hospitals into community emergency preparedness planning. *Ann Intern Med.* 2006;144(11):799-811.

Federal support may be available to supplement community resources when there are not enough local or regional resources to help. For example, the Strategic National Stockpile (SNS), administered by the US Centers for Disease Control and Prevention (CDC), was created to supply large quantities of essential medical material to states and communities within 12 hours of the federal decision to deploy. The SNS can provide treatment and prophylaxis for several infectious diseases, including tularemia, anthrax, plague, influenza, and smallpox. It can also supply a wide variety of antidotes, analgesics, sedatives, dressings, airway management tools, and mechanical ventilators. Oxygen and medical gases, however, are not included in the SNS and must be obtained locally. A standardized allotment of these items is provided in a push-package that can be mobilized from CDC warehouses and delivered to a given location within 12 hours. Some have proposed the creation of go-kits at SNS points of dispensing that would contain patient-routing supplies to help with triage, administrative supplies, along with key contact information, dispensing supplies to inform patients about the pharmaceuticals they might receive, and personal protective equipment and decontamination equipment (25).

Information outlining how local healthcare response elements might integrate with additional, interstate and regional resources is available within several documents (see Suggested Readings). In short, communities have a variety of resources they can draw from or develop in order to provide emergency care to sick or injured victims of disaster. Through collaborative planning, communities and healthcare institutions can develop systems for treating both new patients needing acute, noncritical care, along with stable patients (such as routine postoperative patients, patients on long-term intravenous antibiotics, etc) while maximizing the institutions' ability to care for an influx of critically ill victims of disaster via flexible reassignment of hospital inpatient resources to care for the maximal number of critically ill.

Key Points

INTENSIVE CARE UNIT MICROCOSM WITHIN DISASTER MEDICAL RESPONSE

- Disaster preparedness requires that ICUs and hospitals develop planning concepts (such as a written plan), and also that they train or rehearse the plan to develop operational insight into how an event might unfold.
- A hospital conducts HVA to examine which accidents are possible, which are most likely to occur, and what assets are required (people, transportation, safety, power) for each accident, finally using a needs-based assessment to prioritize resources to best cover all potential hazards.
- An ICS identifies, in advance, who is in charge during a disaster. In a local community this might be the chief of the fire department. Hospitals need to have their own ICS, which includes a liaison to the community ICS, and should conduct training exercises with the community to jointly practice disaster response.

Key Points

- Internal and external communications are crucial to patient care and should be emphasized in a disaster response plan. Typical communications, including landline and cellular telephones, pagers, and e-mail, cannot be relied upon when crisis strikes, so hospitals may employ newer high-technology communications, along with backup low-tech paper record keeping.

- Through collaborative planning, communities and healthcare institutions can develop systems for treating new patients needing acute, noncritical care and stable patients (such as routine postoperative patients) while maximizing the institutions' ability to care for an influx of critically ill disaster victims via flexible reassignment of hospital inpatient resources.

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