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Hospital Evacuation Decision Guide

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Executive Summary

This *Hospital Evacuation Decision Guide* is designed to:

- provide hospital evacuation decision teamsⁱ with organized and systematic guidance on how to consider the many factors that bear on the decision to order an evacuation, and
- assist decision teams in identifying some of the special situations, often overlooked, that may exist in their facility or geographic area that could affect the decision to evacuate.

No single formula or algorithm could possibly capture all of the nuances involved in the decision or the myriad different disaster scenarios that may lead to a hospital evacuation, and this *Guide* does not offer a formulaic approach to evacuation decisionmaking. Instead, the *Guide* is intended to supplement hospital emergency plans, which frequently lack specific guidance on how to make that critical decision, including what factors to consider and for how long the decision may be safely deferred. This *Guide* does not recommend or present best practices for carrying out an evacuation or for sheltering-in-place during and after a disaster other than to stress the critical need for comprehensive plans for both evacuating patients and for sheltering-in-place.

The *Guide* is based on an extensive literature search; discussions at an expert panel meeting; telephone interviews with experts having hospital evacuation experiences in different types of disasters; and a series of meetings with disaster planners, medical staff, and facilities experts from Partners Healthcare (Massachusetts General Hospital and Brigham and Women’s Hospital) in Boston. The technical expert panel (see Appendix A) also reviewed a draft version of the *Guide*.

The *Guide* includes a pre-disaster hospital self-assessment and discussions of both pre- and post-event evacuation decisionmaking.

Pre-Disaster Hospital Self-Assessment

The *Guide* contains two tools, which together comprise a Pre-Disaster Self-Assessment, for use as part of the planning process.

ⁱ The term “hospital evacuation decision team”—abbreviated in this *Guide* as “decision team”—is used in the *Guide* to denote the persons in charge of planning for an evacuation well in advance of an incident, as well as the persons who ultimately decide whether to evacuate a hospital during an incident. In reality, the Incident Commander, who is often a senior hospital administrator, would make this decision in conjunction with senior hospital staff and emergency management and response officials, if the hospital has activated its Emergency Operations Plan and is operating according to the Hospital Incident Command System (HICS). Developed by the California EMS Authority, HICS is a methodology for using the Incident Command System (ICS) in a hospital environment that is consistent with the National Incident Management System. Within the ICS management framework, the Incident Commander has overall responsibility for managing the incident, which for the purposes of this *Guide* refers to the event that precipitated a possible evacuation of the hospital.

- The first, a Pre-Disaster Assessment of Critical Infrastructure, focuses on critical infrastructure vulnerabilities that may affect the likelihood that a hospital would have to evacuate, either prior to or in the aftermath of a disaster. The assessment instrument in the *Guide* is divided into eight sections: municipal water, steam, electricity, natural gas, boilers chillers, powered life support equipment, information technology and telecommunications, and security. The focus is on environmental systems (HVAC), water, and electricity because they are critical for hospital operations, and their loss for an extended period invariably triggers a need for evacuation.
- The second, an Evacuation Time Self-Assessment Worksheet, is a framework for estimating the time required to safely evacuate all patients and focuses on a number of factors that affect evacuation time, including: the number of patients, mix of patient acuity, available staff, available exit routes within the hospital, patient transportation requirements, available transportation resources (vehicles and the necessary accompanying staff, equipment, and supplies), entry and egress points at the hospital, road and traffic conditions, and the location of receiving care sites.

Pre-Event Evacuations

Pre-event evacuations are undertaken in advance of an impending disaster, when the hospital structure and surrounding environment are not yet significantly compromised. As the event progresses and conditions deteriorate, the opportunity for a safe evacuation diminishes, and eventually decision teams must decide whether to evacuate the hospital or shelter-in-place. Deciding whether to preemptively evacuate or shelter-in-place requires consideration of two factors:

- the nature of the event, including its expected arrival time, magnitude, area of impact, and duration; and
- the anticipated effects on both the hospital and the community, given the nature of the event and the results of the Pre-Disaster Self-Assessment.

The *Guide* includes a two-part worksheet to help decision teams in this complex set of considerations. The first part focuses on implications of different characteristics of the impending disaster. The second part provides a framework for assessing the anticipated effects of the event on key resources needed to care for patients (water, heat, and electricity), the overall structural integrity of the building, and the surrounding community.

Post-Event Evacuations

Post-event evacuations are carried out after a disaster has caused substantial damage to a hospital or the surrounding community. As soon as possible after the event occurs, building integrity, critical infrastructure, and other environmental factors must be assessed in order to determine whether or not the hospital can continue to provide appropriate medical care to patients or should instead be evacuated. The *Guide* includes a worksheet to help with a careful assessment of damage to the

hospital's water, sewer, electricity, and heating systems, as well as the overall building integrity, to help decision teams decide whether an evacuation should be ordered.

Sequence of Patient Evacuation

After an evacuation is ordered, decision teams must decide the sequence in which patients should be evacuated. The most medically fragile and resource-intensive are usually evacuated first, as soon as appropriate transportation and staff are available. In cases where all patients are in immediate danger and evacuation must be conducted as quickly as possible, the evidence suggests that the most mobile patients should be evacuated first.

Chapter 1. Introduction

This document is designed to provide hospital evacuation decision teamsⁱⁱ—herein abbreviated as “decision teams”—with organized and systematic guidance on how to consider the different factors involved in hospital evacuation either in advance of an event, based on some degree of forewarning, or following a disaster, if needed. The *Hospital Evacuation Decision Guide* is intended to supplement hospital emergency plans, which focus on the specifics of how the hospital will shelter-in-place or carry out an evacuation once the decision to shelter-in-place or evacuate has been made. Many individual hospital evacuation emergency plans lack specific guidance on how to make that critical decision, including what factors to consider and for how long the decision may be safely deferred.

This *Hospital Evacuation Decision Guide* is not a “cookbook” and specifically does not offer a formulaic approach to evacuation decisionmaking. No single formula or algorithm could possibly capture all of the nuances involved in the decision or the myriad different event scenarios that may determine the need for evacuation. In some situations, the decision to evacuate is clear and obvious, such as a fire or major infrastructure damage that places patients and staff at risk. No decision guide is needed for these situations. This *Hospital Evacuation Decision Guide* is intended to provide assistance in those instances when the decision is not clear—when the uncertainty of the event and its aftermath may result in compelling arguments both for and against hospital evacuation.

This *Guide* does not recommend or present best practices for carrying out an evacuation or for sheltering-in-place during and after a disaster, other than to stress the importance of having comprehensive evacuation and shelter-in-place plans. The reader is referred to other publications for advice on developing and executing evacuation plansⁱⁱⁱ and shelter-in-place plans.^{iv}

ⁱⁱ The “hospital evacuation decision team”—abbreviated in this *Guide* as “decision team”—denotes the persons in charge of planning for an evacuation well in advance of an incident, as well as the persons who ultimately decide whether to evacuate a hospital during an incident. In reality, the Incident Commander—who is often a senior hospital administrator—would make this decision in conjunction with senior hospital staff and emergency management and response officials if the hospital has activated its Emergency Operations Plan and is operating according to the Hospital Incident Command System (HICS). Developed by the California EMS Authority, HICS is a methodology for using the Incident Command System (ICS) in a hospital environment that is consistent with the National Incident Management System. Within the ICS management framework, the Incident Commander has overall responsibility for managing the incident, which for the purposes of this *Guide* refers to the event that precipitated a possible evacuation of the hospital.

ⁱⁱⁱ See, for example, the California Emergency Medical Services Authority’s Evacuation Planning Scenario (http://www.emsa.ca.gov/HICS/files/Int_02.pdf), the New York City Hospital Evacuation Protocol (<http://www.nyc.gov/html/doh/downloads/pdf/bhpp/bhpp-hospital-nyctpevac-plan.pdf>), and the California Hospital Association’s hospital evacuation template (<http://www.calhospitalprepare.org/sites/epbackup.org/files/resources/HospitalEvacuationPlanChecklistCHAv07092008.doc>).

An additional role of this *Hospital Evacuation Decision Guide* is to assist decision teams in identifying some of the special situations, often overlooked, that may exist in their facility or geographic area and that could affect the decision to evacuate. Identifying these specific considerations, and planning in advance to take them into account during decisionmaking, may better prepare leadership to make an evacuation decision, should the need arise.

Methodology

An extensive literature search was conducted to identify all relevant material about hospital evacuations and decisionmaking during disasters affecting a single hospital or an entire region. Peer-reviewed journals and trade publications, as well as government reports, working papers, and other “gray” literature, were all included in the search.

An in-person meeting of an expert panel was convened in Washington, D.C., in January 2009. Panelists representing appropriate Federal agencies participated, as well as many hospital leaders who had experienced evacuations and researchers who have studied disaster evacuations. In the subsequent months, additional telephone interviews were conducted with experts having a wide array of hospital evacuation experiences (e.g., hurricanes, earthquakes, fires, floods). Finally, a series of meetings were held with disaster planners, as well as medical and facilities experts from Partners Healthcare (Massachusetts General Hospital and Brigham and Women’s Hospital) in Boston, Massachusetts. The expert panel also reviewed a draft version of the *Guide*. A list of panel members is in Appendix A.

Types of Disasters vs. Reasons for Evacuation

It is important to distinguish the *type of event* or disaster that could lead a decision team to consider evacuation (e.g., earthquake, flood), as distinct from the *ultimate reason* for the evacuation (e.g., structural damage, loss of municipal water).

In theory, any of the various types of disasters listed in Table 1 could lead a decision team to consider evacuating patients, either prior to an event or in the aftermath of the event. In this *Guide*, we distinguish between “Advanced Warning Events” and “No Advanced Warning Events.” With Advanced Warning Events, decision teams have time prior to the event to make evacuation decisions. Hurricanes are the most common example of an Advanced Warning Event. With earthquakes, tornadoes, and other instances of No Advanced Warning Events, decisions must often be made very quickly, either in the midst of the disaster or immediately afterward.^v

^{iv} See, for example, the California Hospital Association’s shelter-in-place checklist (<http://www.calhospitalprepare.org/sites/epbackup.org/files/resources/CHASIPChecklist030709.doc>).

^v Situations in which a decision team considered evacuating, but ultimately decided not to, are less likely to be documented in the literature; we therefore do not know the true breadth of disaster circumstances that led decision teams to consider evacuation but ultimately decide against it.

Table 1.
Types of Disasters¹

Natural Hazards	Technological Hazards	Terrorism
<ul style="list-style-type: none"> • Floods • Tornadoes • Hurricanes • Thunderstorms and Lightning • Winter Storms and Extreme Cold • Extreme Heat • Earthquakes • Volcanoes • Landslide and Debris Flow (Mudslide) • Tsunamis • Fires • Wildfires 	<ul style="list-style-type: none"> • Hazardous Materials Incidents • Nuclear Power Plants 	<ul style="list-style-type: none"> • Explosions • Biological Threats • Chemical Threats • Nuclear Blast • Radiological Dispersion Device (RDD)

The type of event precipitating an evacuation is typically well publicized. It is widely known, for example, that several hospitals evacuated their patients in the aftermath of Hurricane Katrina in 2005, and prior to Hurricane Gustav making landfall in 2008. What is less clear is the ultimate reason—or set of circumstances—that prompted many documented evacuations. In the case of the flooding following Hurricane Katrina, New Orleans hospitals evacuated when they lost city water, lost all power, or were unable to ensure the safety of patients and staff in the midst of civil unrest. After careful examination, it is clear that it was not the hurricane or the subsequent flood that caused decision teams to order hospital evacuations but the damage to hospitals and critical infrastructure, as well as problems in the surrounding community.

Table 2 lists some instances of hospital evacuations, the type of disaster that preceded the evacuation, whether (in the case of Advanced Warning Events) decision teams decided to evacuate prior to the event, whether the evacuation took place after the event, and the ultimate reason(s) for the evacuation. Table 2 is intended to be illustrative and not a comprehensive listing of all hospital evacuations. In particular, not shown are the many instances in which decision teams seriously considered evacuating but, in the end, decided not to. Table 2—and, more generally, this *Guide*—does not address operational aspects of how these evacuations were executed, such as which local, State, or Federal assets were used to evacuate patients.

Table 2 highlights the importance of critical infrastructure, in particular the water supply, in many evacuation decisions.

Table 2.
Illustrative Hospital Evacuations: Type of Disaster and Ultimate Reason for Evacuation

Event	Hospitals	Pre-Event Decision	Post-Event Decision	Ultimate Reasons for Evacuation
Nuclear Reactor Incident (1979)	Hershey Medical Center Community General Osteopathic Hospital Harrisburg Hospital Polyclinic Medical Center (Pennsylvania) ²	(No advanced warning)	Do not evacuate	N/A
Northridge (California) Earthquake (1994)	2 trauma centers, 2 general hospitals (private and county), a Veterans Affairs hospital, and a psychiatric hospital ³	(No advanced warning)	Evacuate (immediately after the earthquake)	Structural and nonstructural damage ³
Northridge (California) Earthquake (1994)	A general hospital (private) and a pediatric hospital ³	(No advanced warning)	Evacuate (3 to 14 days after the earthquake)	Structural damage ³
Chemical plant explosion (1997)	Helena Regional Medical Center (Arkansas)	(No advanced warning)	Evacuate	Anticipated air quality effects due to nearby explosion
Tropical Storm Allison (2001)	Memorial Hermann Hospital and Memorial Hermann Children's Hospital ⁴ (Texas)	Shelter-in-place	Evacuate	Loss of power
Bomb Threat (1999)	Galion Community Hospital ⁵ (Ohio)	Evacuate	Evacuated prior to the event	Anticipated effects of the bomb
Hurricane Katrina (2005)	Kindred Hospital New Orleans; ⁶ New Orleans Children's Hospital; ⁷ VA Medical Center of New Orleans; ⁸ Charity Hospital; ⁹ University Hospital (LSU Medical System) ¹⁰	Shelter-in-place	Evacuate	Loss of water, loss of power, or security breakdown
Hurricane Rita (2005)	University of Texas Medical Branch (Galveston, Texas); ¹¹ seven hospitals within one medical system ¹²	Evacuate	Evacuated prior to the event	Anticipated effects of the hurricane
Wildfire (2007)	Pomeroado Hospital (California) ¹³	Evacuate	Evacuated prior to the event	Anticipated effects of the wildfire
Rising rivers (2008)	Mercy Medical Center (Cedar Rapids, Iowa)	Evacuate	Evacuated prior to the event	Anticipated effects of flooding
Levy breach (2008)	Columbus Regional Hospital (Indiana)	(No advanced warning)	Evacuate	Flooding

Table 2.
Illustrative Hospital Evacuations: Type of Disaster and Ultimate Reason for Evacuation

Event	Hospitals	Pre-Event Decision	Post-Event Decision	Ultimate Reasons for Evacuation
Fire (2009)	Mt. Sinai (New York City) ¹⁴	(No advanced warning)	Evacuate	Fire
Rising river (2009)	MeritCare Hospital and MeritCare South University Hospital (North Dakota)	Evacuate	Evacuated prior to the event	Anticipated effects of flooding ¹⁵
Rising river (2009)	Innovis Health (North Dakota) ¹⁶	Shelter-in-place	Do not evacuate	N/A

Guide Organization

The remainder of this report is organized into three chapters:

- A **Pre-Disaster Hospital Self-Assessment** is discussed in Chapter 2. The self-assessment should be completed as part of a hospital’s disaster preparation and planning efforts. It focuses on critical infrastructure and assets that are of specific concern with respect to evacuation. It is intended to help decision teams identify vulnerabilities that affect the likelihood that a hospital would have to evacuate as well as specific challenges a hospital may face during evacuation, either prior to or in the aftermath of a disaster. The self-assessment and accompanying text also provide assistance in estimating the time required to evacuate patients from the hospital and relocate them to other facilities. Being able to form an accurate estimate of the time required to evacuate is a critical component of the decision to evacuate.
- **Pre-event evacuations**, an option in the case of Advanced Warning Events, are discussed in Chapter 3. For pre-event evacuations, the self-assessment of vulnerabilities and the scope/scale of the impending event are the key factors to consider. Chapter 3 includes guidance on whether—and when—to preemptively evacuate patients prior to an event, as well as on the accompanying decision regarding the sequence in which patients should be evacuated (i.e., who goes first).
- Chapter 4 addresses **post-event evacuations**, which could occur either 1) with an Advanced Warning Event in which decision teams decide to shelter-in-place during the event and subsequently realize the need to evacuate, or 2) following a No Advanced Warning Event.

Table 3.
Guide Terminology and Acronyms

Term	Definition
Advanced Warning Event	A disaster that decision teams and staff are tracking, as they consider whether it may warrant evacuating their facility.
AHRQ	Agency for Healthcare Research and Quality
ALS	Advanced Life Support (ambulance)
BLS	Basic Life Support (ambulance)
Closed Hospital	A hospital that has evacuated all patients and staff and is no longer providing inpatient, outpatient, or emergency services. Inspection and re-licensure will be required prior to reopening.
Critical Infrastructure	Assets, including physical systems, other support systems, and staff, that are essential to operate a hospital and provide a standard level of care to patients.
DoD	Department of Defense
EMAC	Emergency Management Assistance Compact
Evacuation	Moving most or all patients and staff out of a hospital and transporting them to other facilities where medical care will be provided.
Evacuation Sequence	The numerical order in which hospitalized patients are evacuated.
Evacuation Time	The length of time to move all hospitalized patients out of a hospital and safely transport them to receiving care sites.
Event	A disaster that causes enough damage to a hospital or the surrounding community so that decision teams consider evacuating the hospital.
FEMA	Federal Emergency Management Agency
HICS	Hospital Incident Command System
HVAC	Heating, ventilating, and air conditioning systems
Impending Event	A disaster that has the potential to cause enough damage to a hospital or the surrounding community that decision teams consider pre-event evacuation.
ICS	Incident Command System
ICU	Intensive Care Unit
IT	Information Technology
NDMS	National Disaster Medical System
NICU	Neonatal Intensive Care Unit
NIMS	National Incident Management System
NIPP	National Infrastructure Protection Plan
No Advanced Warning Event	A disaster that occurs without any warning.
PICU	Pediatric Intensive Care Unit
Pre-Event Decision	The decision whether, faced with an impending event, to 1) preemptively evacuate a hospital or 2) shelter-in-place.
Post-Event Decision	The decision whether or not, in the aftermath of an event, to evacuate a hospital.
Pre-Event Evacuation	An evacuation carried out prior to an impending event, when the hospital structure and surrounding environment are not yet significantly compromised; a pre-event evacuation is ordered when the anticipated

Table 3.
Guide Terminology and Acronyms

Term	Definition
	effects of an impending disaster would either place patients and staff at risk or make an evacuation extremely dangerous or impossible at a later time.
Post-Event Evacuation	An evacuation carried out after an event.
Shelter-in-Place	The decision not to evacuate a threatened hospital, either prior to a disaster or in its aftermath.

Chapter 2. Pre-Disaster Self-Assessment

Significant and detailed planning is required in order to support sound decisionmaking regarding hospital evacuation. Hospitals are required to have plans in place detailing evacuation, but those plans differ tremendously in their level of detail and often lack construct and context for decisionmaking. Two additional tasks, which together comprise a Pre-Disaster Self-Assessment, should be completed as part of the planning process.

The first task is completing a Pre-Disaster Assessment of Critical Infrastructure (see Table 4). As discussed in Chapter 3, a key consideration in deciding whether to issue a pre-event evacuation order is to assess vulnerabilities and determine the anticipated impact of the impending event on a hospital and its surrounding community. This impact on critical infrastructure is paramount, with water and power being most important.

The second Self-Assessment task involves estimating the time required to evacuate patients from the hospital. An Evacuation Time Self-Assessment Worksheet (Table 5) is included in this chapter to assist with this task. For Advanced Warning Events, it is critical to have estimated how long it will take to move patients out of the building and relocate them to other hospitals, ideally under a number of different sets of assumptions regarding patients, building conditions, and transportation resources.

Hospital staff should complete this self-assessment as part of their disaster and emergency preparation planning, update it when needed, and not wait until an actual event occurs that necessitates an evacuation decision.

Critical Infrastructure Self-Assessment Worksheet

The Pre-Disaster Assessment of Critical Infrastructure Worksheet (Table 4) is divided into eight sections: municipal water, steam, electricity, natural gas, boilers/chillers, powered life support equipment, information technology and telecommunications, and security. (Hospital staff, obviously critical resources, are considered in the Evacuation Time Self-Assessment Worksheet, later in this chapter.) The focus on environmental systems (HVAC), water, and electricity is appropriate, given that they are critical for hospital operations, and their loss for an extended period invariably triggers a need for evacuation. The Worksheet can be used in conjunction with the National Infrastructure Protection Plan (NIPP), which is a management guide for protecting critical infrastructure and key resources. A health care and public health sector-specific plan that details how the NIPP can be applied to health care settings is due to be released in 2010.¹⁷

Decision teams should know how long their hospital can shelter-in-place if critical infrastructure are damaged. For example, how long could the hospital maintain a safe temperature without city water during the summer months, and how long could essential power be maintained with only the current on-site fuel supply? The Pre-Disaster Assessment of Critical Infrastructure Worksheet (Table 4) is designed to help decision teams consider the vulnerabilities of their critical infrastructure and their hospital's ability to shelter-in-place, which in turn may guide investment decisions for mitigating vulnerabilities.

If critical infrastructure has not sustained damage, the hospital's ability to shelter-in-place will be affected by the extent to which staffing levels can be maintained, and whether the supply of critical consumable resources—such as food, blood, and medications—can meet the needs of patients and staff, drawing on existing caches within the hospital and regular and backup supply channels. Maintaining safe levels of staffing and consumable resources should be addressed in a hospital's plan for sheltering-in-place. If there is no such plan, the ability to shelter-in-place for more than a few days may be degraded.

Municipal Water

Considerable anecdotal evidence, as well as published reports, indicate that loss of water will lead to hospital evacuation if not promptly restored. Loss of the municipal water supply also jeopardizes hospital sprinkler systems and, in some hospitals, heating systems. A hospital pre-disaster self-assessment should recognize the presence/absence of backup water supply lines (in the event that the main line fails) and any on-site water reserves, such as a storage tanks or wells.

Steam

Some municipalities use large steam production plants to create steam and pipe it underground to buildings in local areas, including hospitals. For example, hospitals in Boston's Longwood Medical Area, which includes three tertiary care hospitals as well as a medical school, research labs, and ambulatory care areas, are heated with steam produced by the same off-site utility company.^{vi} These steam production plants are critical infrastructure, as are the pipes that deliver steam to area hospitals. Loss of water to the steam production plants, inability to generate steam, or inability to pipe it underground to hospitals would jeopardize heat and lead to hospital evacuation within 1-2 days during a typical northeastern winter.¹⁸ Some hospitals also use the incoming steam to generate electricity and for such hospitals, loss of steam would also mean loss of some of their electrical capacity.¹⁹ A hospital self-assessment should therefore include recognition of reliance on steam that is generated off-site and piped in for heating purposes, electricity generation, or both.

Natural Gas

For hospitals that use natural gas for heat and/or hot water, damage to gas mains lasting more than 1–2 days (especially in the winter) could lead to an evacuation. A hospital self-assessment should therefore recognize reliance on natural gas, whether there is more than one gas line feeding the

The Critical Role of Water

Children's Hospital of New Orleans withstood Hurricane Katrina and the resulting flood, and had sufficient potable water, generator fuel, staff, and supplies to shelter-in-place for many days. The hospital sits atop a levy, which floodwaters did not reach, and was essentially unscathed by the storm or the flood. When city water failed, however, it became impossible to fill the cooling tower, and the hospital lost air conditioning, forcing an evacuation in the heat of the Louisiana summer.⁷

Also in the aftermath of Hurricane Katrina, Kindred Hospital in New Orleans had power, but the hospital's water supply was cut off, which meant air conditioners could not operate. The loss of water necessitated evacuation of the hospital, including 50 ventilator-dependent patients.⁶

^{vi} Boston's steam utility is Trigen, owned by Veolia Energy. <http://www.veoliaenergyna.com/en/veolia-energy-north-america/locations/boston-cambridge.htm>. Accessed December 2009.

hospital, and whether gas from just one intact gas line could meet the most critical needs of the hospital.

Electricity

Electricity plays a large role in evacuation decisions. Prolonged loss of electricity can lead to HVAC loss, which can necessitate evacuation. In addition to controlling ambient temperature, electricity is essential for many medical technologies (e.g., monitors, CT scanners, dialysis machines, ventilators, incubators) as well as other critical functions. Patients dependent on electricity-driven life support equipment would require evacuation soon after power failure. Ventilator battery packs, for example, last only 2-3 hours, and the accompanying suction devices generally have no battery packs.²² The number of hours that a hospital can function without municipal electricity, or adequate fuel for backup generators, may be critical factors in an evacuation decision.

Most hospitals have backup generators, although the adequacy of these generators should be carefully assessed. For example, backup generators require fuel, and hospitals vary considerably in their on-site fuel storage capacity, whether there is a direct feed from the fuel tank to the generators, and whether it would be possible to refill the fuel storage tank—which is often underground—during a flood or after an earthquake.

A hospital pre-disaster self-assessment should include the number and size of backup generators and an estimate of the length of time these generators can sustain electrically powered life-support equipment and HVAC. A self-assessment should also consider the fuel storage capacity on site and any potential refueling issues.

Boilers/Chillers

Some hospitals use boilers to generate hot water; others use them for heating purposes, as well. Most hospitals also have chillers for air conditioning (with or without cooling towers). Redundancy in these types of critical infrastructure is rare, and their loss could necessitate an evacuation, depending on weather conditions. A hospital pre-disaster self-assessment should therefore recognize vulnerabilities due to the loss of boilers or chillers, irrespective of the loss of electricity, water, or steam.

Backup Generators

Although patients and most staff and family members were evacuated within 4 days of the Hurricane Katrina strike due to lack of city water and air conditioning, the Veterans Administration Medical Center in New Orleans was able to keep limited electrical power available, as its backup generators did not fail and remained several inches above the flood water. A coffer dam was erected around the fuel fill connection for the underground fuel storage tank to permit refueling a week later, and power was maintained to support the security and engineering staff that remained on duty until utility power was restored 3 weeks after the storm.²⁰

In the same post-hurricane flood, Charity Hospital's (Louisiana) backup generators failed, leaving them to rely on inadequate, portable generators (without direct fuel lines) to power life-support equipment such as ventilators.⁹

At Tulane University Hospital (Louisiana), backup generators failed, jeopardizing tissue and blood samples from patients enrolled in clinical trials of experimental cancer treatments.²¹

Boilers/Chillers

Mount Auburn Hospital in Cambridge, Massachusetts, began to evacuate patients within hours of boiler failure in December 2005.²³ An explosion that destroyed both the boiler and the chiller at a New Jersey also hospital prompted evacuation.²⁴

Powered Life Support Equipment

Some powered life support equipment (e.g., ventilators) may have backup battery packs in the event of an electricity failure. The life of these batteries is generally 2–3 hours; patients dependent on such equipment may therefore need to be evacuated more quickly than others. A self-assessment should include an inventory of the powered life-support equipment in use on an average day, how many of these have backup battery packs, and how many hours these batteries will last (the latter being a critical factor in deciding how quickly such patients must be evacuated).

Health Information Technology

Loss of key health information technology (IT) and telecommunications systems will, at a minimum, significantly reduce a hospital's ability to deliver health care services efficiently. For example, if a hospital's computerized provider order entry (CPOE) system suddenly goes offline, substantial delays in order completion can be expected, as well as increased risk of errors. In other instances, service delivery may cease altogether because automated systems cannot be quickly replaced by manual systems. For example, hospitals that rely on decentralized pharmacy and automated dispensing units may no longer have redundant systems for safely filling patient medication orders.²⁵

If patients must be evacuated, paper records are relatively easy to send with them, but many hospitals are moving away from paper records in favor of electronic medical records (EMRs). Some EMR systems can rapidly create and print a paper discharge summary to accompany each evacuated patient; other systems cannot, and the time required to create a useful discharge summary (current medications, allergies, orders, brief history) may substantially delay evacuation.

Telecommunications

Landline telephones in New Orleans failed when lines were damaged and when backup generators for phone switches were flooded or ran out of fuel following Hurricane Katrina. The local wireless cell phone networks failed as well because the data systems that exchange information for routing and billing calls also lost power. Because information for each account holder and cell phone device is generally stored on computers in the "home" market where the account is held, every customer with accounts originating in New Orleans lost wireless service. Individuals who had recently moved to New Orleans and still had a wireless service contract in another city, or who arrived from elsewhere to provide assistance, were able to use their cell phones (as long as the batteries lasted) for outgoing calls⁹ because their "home" accounts in other cities ran on computers that were unaffected by the storm.²⁶ Incoming calls, however, could not be completed because the local computers that identify and locate the intended recipient of an incoming call were offline. Satellite phone systems may work in circumstances like those in New Orleans, for calls placed to locations outside the city. Satellite phones obviously cannot reach landline or wireless phones that are out of service due to the disaster, and thus are of limited use for local communication.

Institutions and individuals with computers equipped for Voice Over Internet Protocol (VOIP), and who had power and Internet access after Hurricane Katrina, retained telephonic communication. In VOIP the audio (voice) signal is converted to digital packets of information that travel from one

Internet address to another on the same VOIP system. VOIP networks were deployed by FEMA, and by fire and other emergency responders, in the days and weeks following Hurricane Katrina.²⁷

Finally, lack of radio interoperability between hospitals and emergency responders, as well as between different teams of emergency responders (fire, military, police, EMS) may also jeopardize essential communication. (The Federal Government does not mandate how a State or local community organizes incident response activities or communications.²⁸) Some hospitals in New Orleans resorted to local HAM radio operators to relay essential messages within and beyond the city.²⁹ Two-way radio interoperability among emergency responders has improved more in some cities than in others since 2005.

The self-assessment focuses on the extent to which computer servers and essential data are backed up or managed offsite, whether redundant hardware and software systems exist, whether manual, paper-based systems can be quickly reintroduced, and whether the hospital has backup telephonic communication that does not rely on local service providers.

Security

During a disaster, additional security staff are often needed to: 1) keep unauthorized people out of the hospital, 2) guard transport vehicles as they move to and from the hospital evacuating patients, or 3) maintain order inside the hospital. While the hospital is empty, security staff may be needed to safeguard the property and the costly medical equipment and supplies left behind. Some hospitals rely on a contracted service for primary or backup security; others employ their own security staff and augment this force when needed.³⁰ Night and weekend shifts may have fewer security staff, making an evacuation at those times potentially less secure.

Security Concerns During Evacuation

One day after Hurricane Katrina made landfall, Kindred Hospital New Orleans lost its water supply, and the hospital administrator decided to evacuate the hospital. The evacuation was delayed because of civil unrest and looting in the neighboring area, as many of the ambulances sent to pick up patients were forced to turn back before reaching the hospital because of security concerns. Additional private security staff sent by Kindred corporate headquarters to protect the hospital were also delayed in their arrival.³⁰

Table 4.
Pre-Disaster Critical Infrastructure Self-Assessment

Evacuation-Relevant Resources	Implication
City Water	
<ul style="list-style-type: none"> • Is water used for heating the hospital? • Is water used for cooling? • Does the hospital have a well? • Is there one water line going into the hospital, or also a backup line? • Is there a water storage tower/tank on the roof? • If the water tower/tank collapsed, would the hospital then be without water (or sufficient pressure)? • How long can the hospital maintain a safe temperature without city water in summer heat? • How long can the hospital maintain a safe temperature without city water in winter cold? 	<p>Y= more vulnerable Y=more vulnerable N=more vulnerable Only 1=more vulnerable Y=more vulnerable to earthquakes (but good backup water source) Y=more vulnerable Hours = time until evacuation Hours = time until evacuation</p>
Steam	
<ul style="list-style-type: none"> • Does the hospital receive steam for heat from a separate steam-generation plant? • Is that steam plant on the hospital premises? • Is there one steam line into the hospital, or also a backup conduit? • How long can the hospital maintain a safe temperature if the steam-generation plant is off line? • Is steam also used to generate electricity? • If so, what % of electricity would be lost if the steam-generation plant went offline? 	<p>Y=more vulnerable N=more vulnerable Only 1=more vulnerable Hours = time until evacuation Y=more vulnerable >50%=vulnerable</p>
Electricity	
<ul style="list-style-type: none"> • Does the hospital have a central backup generator? • More than 1? • Is there a fuel storage tank on site with a direct line to the backup generator? • Is the fuel storage tank underground? • In a flood, would the intake be underwater? • How long can essential power be maintained using the current fuel supply? • Does the hospital have smaller or portable generators for floors/sections of the hospital? 	<p>N= more vulnerable N= more vulnerable N= more vulnerable N= more vulnerable Y= more vulnerable Hours = time until evacuation N=more vulnerable</p>

Table 4.
Pre-Disaster Critical Infrastructure Self-Assessment

Evacuation-Relevant Resources	Implication
<ul style="list-style-type: none"> • Can all essential areas of the hospital be powered with these smaller generators? • Is fuel stored on site for these smaller generators? • How long can essential power be maintained using the current fuel supply and these smaller generators? 	<p>N= more vulnerable</p> <p>N= more vulnerable</p> <p>Hours = time until evacuation</p>
Natural Gas	
<ul style="list-style-type: none"> • Is the boiler or other heating equipment fired by natural gas? • Is there one gas line into the hospital, or also a backup pipe? • How long can the hospital maintain a safe temperature if the gas stops? 	<p>Only 1= more vulnerable</p> <p>Hours = time until evacuation</p>
Boilers/Chillers	
<ul style="list-style-type: none"> • Does the hospital have backup/redundant boilers? • Does the hospital have backup/redundant chillers? • How long can the hospital maintain a safe temperature without the chiller in summer heat? • How long can the hospital maintain a safe temperature without the boiler in winter cold? 	<p>N= more vulnerable</p> <p>N= more vulnerable</p> <p>Hours = time until evacuation</p> <p>Hours = time until evacuation</p>
Powered Life Support Equipment	
<ul style="list-style-type: none"> • On a typical weekday, how many patients are on ventilators or other powered life-support equipment (including neonatal incubators and ventilators)? • Does each of these ventilators or other pieces of equipment have a battery pack? • What is the average battery life per ventilator/equip? 	<p><10 ____</p> <p>11-25 ____</p> <p>26-50 ____</p> <p>51-100 ____</p> <p>100+ ____</p> <p>N= more vulnerable</p> <p>Hours = time until evacuation</p>

Table 4.
Pre-Disaster Critical Infrastructure Self-Assessment

Evacuation-Relevant Resources	Implication
<ul style="list-style-type: none"> How many patients are otherwise oxygen dependent? 	<10 ____ 11-25 ____ 26-50 ____ 51-100 ____ 100+ ____
<ul style="list-style-type: none"> Does the medical gas system rely on electricity? If the medical gas system fails, how long can these patients be maintained using the current stock of portable/backup oxygen? 	Y= more vulnerable Hours = time until evacuation
Information Technology and Telecommunication	
<ul style="list-style-type: none"> Are servers and other telecommunication systems on the hospital premises or offsite? Are redundant hardware and software systems deployed offsite? Are critical databases (e.g. EMRs) managed or backed up offsite? Can the EMR quickly generate patient discharge summaries to accompany each evacuated patient? Can manual, paper-based backup systems and procedures be rapidly reconstituted (e.g. manual order entry, manual medication dispensing), and have staff been trained to safely use these systems? Does the hospital have VOIP capabilities or two-way radios that interoperate with local emergency responders? 	On premises = more vulnerable N = more vulnerable
Security	
<ul style="list-style-type: none"> Does the hospital employ its own security staff or contract with an outside security firm? Are sufficient security staff on site during every shift (including nights and weekends) so that two can be stationed at every entrance/exit? Can sufficient additional security staff be brought in to escort/guard transport vehicles? Does the hospital evacuation plan assume that municipal or State police will be available to assist? 	Own staff ____ Contracted ____ N= more vulnerable N= more vulnerable Y= more vulnerable

In some disaster situations, municipal and State police departments may be unable to deploy officers to hospitals because their officers, and the National Guard, are at capacity responding to other community needs. When civil unrest has been extreme, decision teams have occasionally resorted to hiring external security forces to escort evacuation vehicles. A pre-disaster self-assessment should address the availability of security staff (especially if the entire city is evacuating), backup plans if municipal/State law enforcement are insufficient, and how best to augment security staff around the clock, throughout an evacuation.

Estimating Evacuation Time

As part of pre-disaster planning, a decision team should estimate the time required to safely evacuate all patients. This is especially important for Advanced Warning Events, as will be discussed in Chapter 3.

More specifically, hospitals should estimate time requirements for two components of evacuation time. The first is the *time to empty the building*—that is, the time required to move patients from their location inside the hospital (e.g., their room) to a staging area from which they can be loaded into ambulances and other vehicles for transport to another hospital. The staging area might be the lobby of the hospital, the emergency department (which has ambulance bays), or a parking lot across the street from the hospital. Movement of patients from their hospital rooms to the staging area and beyond depends in part on factors internal to the hospital, such as whether hospital IT systems can generate a patient discharge summary, whether elevators are operational, whether staff have participated in evacuation drills, and how quickly additional staff can arrive to help with the evacuation.

It is important to distinguish between an orderly and planned evacuation, in which there is time to move patients in a manner that maximizes safety for all patients and staff, and a “drop everything and go” evacuation, in which patients and staff are in immediate danger and must exit the unit and/or hospital as quickly as possible. In the latter case, optimal procedures for safely moving patients may be abandoned in favor of the fastest possible egress.

The second component of evacuation time is the *time to transport patients*—that is, the time required to transport patients from the staging area to receiving hospitals or other care sites. The time required to transport patients from the staging area to receiving care sites depends primarily on factors external to the hospital, such as transportation resources availability, road conditions, and the locations of hospitals that can accept and properly care for patients.

Urgent Evacuation – No Advanced Notice

A fire in one tower of Mt. Sinai Hospital (New York) necessitated the rapid movement of patients to other parts of the hospital. There was no time for a central evacuation decision or order; staff on each unit moved patients horizontally and then vertically, as the tower filled with smoke. The evacuated tower included an ICU and operating rooms; surgical staff moved patients mid-procedure and finished operating in the emergency department of the adjacent tower.¹⁴

After the 1994 Northridge (California) earthquake, six hospitals were evacuated immediately. Ambulatory patients were escorted from the building to a nearby open area. Hospital staff next moved patients in wheelchairs and, lastly, those in beds. At one of the hospitals, the strategy was to remove as many patients as possible, as quickly as possible, because it was not clear how long the building would remain standing.³

Key factors that affect evacuation time are listed below and in the accompanying Evacuation Time Self-Assessment Worksheet (Table 5). They include:

- Number of patients and mix of patient acuity
- Available staff
- Available exit routes within the hospital
- Patient transportation requirements
- Available transportation resources (vehicles, as well as the necessary staff, equipment, and supplies that must be in the vehicles)
- Entry and egress points at the hospital
- Road and traffic conditions
- Location of receiving care sites

Number of Patients and Patient Acuity Mix

The total number of patients in the hospital who need assistance to evacuate safely will typically be substantially fewer than the total patient census. Some patients will be medically stable and likely to self-evacuate or evacuate with family members.^{vii 31}

Other patients will be ambulatory and can walk out of the hospital with assistance, while still others will require wheelchairs. Some will require sophisticated equipment and handling if they are to survive the

evacuation, and a few very ill patients will be unlikely to survive if moved. The Evacuation Time Self-Assessment should record the typical number of patients in the hospital who will require assistance from hospital staff to evacuate, by patient type or acuity, because different levels of assistance and types of hospital staff are required by different types of patients.

Census Reduction

In the aftermath of the Three Mile Island (Pennsylvania) incident, area hospitals, anticipating possible evacuation orders, discharged many ambulatory and stable patients, reducing the area-wide patient census from 80 to 50 percent of capacity.²

Of 575 hospitalized patients in Memorial Hermann Hospital and Memorial Hermann Children's Hospital (Texas), 169 were discharged prior to when Tropical Storm Allison made landfall, leaving 406 who sheltered in place during the storm (and who were subsequently evacuated with the assistance of hospital staff).⁴

During the Red River (North Dakota) flooding in 2009, patient census at Innovis Health was reduced from approximately 85 to 60 percent, through a combination of early discharges and halting transfers of trauma patients from hospitals more than 50 miles away.¹⁶

^{vii} An expert panel convened under an AHRQ-funded project studying the risk tolerance of early discharge concluded that patients whose risk of a consequential medical event (“unexpected death, irreversible impairment, or reduction in function within 72 hours of hospital discharge for which an in-hospital critical intervention would be initiated to stabilize or ameliorate the medical disorder”) during the next 72 hours was 4 percent or less can be safely discharged.

At a minimum, patients in the following hospital units should be considered:

- Adult ICU
- Pediatric ICU
- Neonatal ICU
- Adult medical/surgical (“floor”) units
- Pediatric medical/surgical (“floor”) units
- Psychiatric unit
- Burn Unit or Burn ICU
- Other specialty care units

In addition, within these units special consideration should be given to bariatric patients, patients requiring dialysis, patients in negative pressure/isolation rooms, and patients from correctional (prison) facilities.

Available Staff

Staff are required to move patients out of the hospital and may be needed to accompany patients during transport to a receiving care site. Depending on the type of disaster, there will likely be staff shortages. It is helpful to try to pre-estimate the attrition rate of a hospital’s workforce during a disaster, as many employees may themselves become victims of the disaster, or may have family responsibilities that interfere with their ability to staff the hospital (e.g. evacuating dependent children). Decision teams at some hospitals that face annual hurricane threats require essential staff to remain in the hospital throughout a declared disaster so that they are available to assist in an evacuation—this is a condition of employment and staff must make alternative arrangements for their dependents.³² Hospitals that have no such personnel policies may find their staff substantially depleted during a community-wide evacuation. A pre-disaster self-assessment should therefore consider the personnel policies in place and the staff deficits that could occur in different types of disasters that may involve community-wide evacuation orders.

Staff Shortages During Disasters

Memorial Hermann Hospital (Texas), which was evacuated after Tropical Storm Allison made landfall, was isolated by impassible roads. As a result, staff were delayed in reaching the hospital to assist with the evacuation and could not arrive for work until 9:00 a.m. the day of the evacuation, leaving staff already present at the hospital unable to leave.³³

Following the Three Mile Island (Pennsylvania) incident, area hospitals experienced severe staffing shortages, as hospital staff—especially those with small children—self-evacuated the community to protect their own safety. By the fourth day of the incident at the Three Mile Island nuclear facility, some hospitals had to combine units due to staffing shortages, and one hospital had only 6 of 70 physicians available to work.²

Hospitals also typically have significantly fewer staff on hand during night and weekend shifts, which would greatly affect the ability to quickly move patients out of the hospital in an urgent evacuation. Some hospitals rely more heavily than others on staff from temporary agencies, or ‘traveling’ staff who contract for short assignments (especially nurses and technicians). Such staff may not be as readily available as full-time hospital employees during an emergency. Volunteers, visitors, and family members may be available to assist in evacuating some patients. Volunteers must be assigned appropriate tasks, as trained medical staff are required to move and transport most patients with intensive care needs.

Volunteers Assist with Hospital Evacuation

Hundreds of volunteers, including Boy Scouts, were used to help move patients out of Memorial Hermann Hospital (Texas) after flooding caused by Tropical Storm Allison.³⁴

Moving NICU and PICU Patients

Children's Hospital of New Orleans (CHNO) reached out to other children's hospitals across the country for evacuation assistance. These hospitals responded by sending planes for air evacuation and teams trained in emergency transfer of fragile children and infants. Other children's hospitals also coordinated the transfer of each NICU and PICU patient to appropriate receiving hospitals. Administrators from CHNO believe that the evacuation was successful because all ICU patients were transported by experienced teams, and were received by hospitals prepared to meet their needs.⁷

Available Egress Routes From Within the Hospital

While unlikely to be a problem during an "orderly and planned" evacuation, egress from a hospital may be severely constrained during a "drop everything and go" evacuation. Stairwells or exits may be obscured by smoke or unavailable because of fire. Stairwells may be dark if backup power has failed. Elevators can also be out of service, lengthening the time required to move all patients out of the hospital.

Patient Transportation Requirements

The Self-Assessment Worksheet should include an estimate of the number (or percentage) of patients who will require transportation resources to be safely transported to other facilities. Transportation resources include not only the vehicle, but also the required accompanying staff, equipment, and supplies. Vehicle types typically include buses (if patients are ambulatory or need limited assistance), wheelchair vans (if they are capable of sitting up), BLS ambulances, and ALS ambulances. Some patients who are dependent on powered life support equipment may only be safely evacuated in an ALS or critical care vehicle with appropriate staff on board. For example, extracorporeal membrane oxygenation (ECMO) units typically have little or no battery backup, and patients requiring this equipment must be transported immediately when power fails in a vehicle equipped to power the ECMO unit.³⁷ Pre-disaster planning and coordination with ambulance providers and local, county, and State EMS agencies is essential so that hospital staff know what types of patients can be transported safely in the ambulances used in their area.

Out of Service Elevators

Because elevators were not operating, patients at Memorial Hermann Hospital in Houston, Texas, were carried down 10 flights of stairs on backboards without overhead lighting or air-conditioning. Up to five infants were secured to one backboard. Several adults were needed to carry out each adult patient. Evacuation was temporarily halted when staff and volunteers were exhausted, so as to avoid injuries.⁴

Rapid evacuation of patients from hospitals following the Northridge (California) earthquake included carrying patients on backboards and on canvas slings, after elevators failed.³⁵

During post-hurricane flooding in New Orleans, water entered the elevator shaft "wells" at the VA Medical Center in New Orleans, making the elevators unusable even though power was not interrupted.³⁶

Typically, a detailed census review will be required for a precise count of the number of patients that could be transported via bus, wheelchair van, BLS ambulance, or ALS ambulance because there is no formula based on patient diagnosis for mapping patient types (adult ICU, NICU, PICU, adult floor, pediatric floor, psychiatric unit, other specialty units) to vehicle types. As reference points, patient vehicle requirements assumed in planning and tabletop hospital evacuation exercises in New York City and Los Angeles may be instructive.³⁸ Using patient data from six hospitals in New York City, a planning exercise estimated the following percentages: 14 percent of patients would require transport via ALS ambulance, 13 percent via BLS ambulance, 40 percent via wheelchair van, and 33 percent via bus. The corresponding figures for Los Angeles, based on patient characteristics at three hospitals, were: 40 percent of patients would require transport via ALS ambulance, 20 percent via BLS ambulance, 20 percent via wheelchair van, and 20 percent via bus.

Of course, many other types of vehicles can be used to evacuate patients, particularly when post-event conditions limit access to the hospital. Depending on the circumstances, patients may have to be transported in vehicles (or accompanied by hospital staff) that do not conform to ordinary standards of care.³⁹

Available Transportation Resources

Transportation resources include not only the vehicle, but also the staff, equipment, and supplies that must accompany the patient in the vehicle. The number of vehicles of each type that are available to transport evacuated patients (assuming they are properly staffed and equipped) is a critical determinant in how long it will take to move all patients to receiving care sites. For example, if 100 patients require an ALS ambulance, and only five such ambulances are available, then each ALS ambulance will need to make 20 round-trips during the evacuation. In the New York City hospital evacuation planning exercise cited above, it was assumed that a relatively high percentage of ambulances could be devoted to the evacuation (40 percent of the city’s fleet of private-sector ALS ambulances) because it was an Advance Warning Event. By contrast, because the Los Angeles planning exercise was a no-notice evacuation representing an earthquake scenario, a much smaller percentage of ALS ambulances were assumed to be available for the evacuation (only 5 percent of the city’s ALS ambulance fleet).³⁸

Even with pre-existing contracts with ambulance and other transportation providers, there is no guarantee that vehicles will actually be available, particularly if multiple hospitals are evacuating simultaneously, in which case the “competition” for ambulance and other transportation resources will likely be significant. Vendors who had contracted to transport patients from Charity Hospital did not deliver on their contractual obligations, stating that they lacked both vehicles and drivers. During widespread disasters affecting an entire metropolitan area, all the medical facilities rely on local ambulance companies—and many rely on *the same* ambulance companies. It is important to

Other Types of Vehicles Used to Evacuate Patients Following Hurricane Katrina

Many hospitals have no rooftop helipads, and those that do can typically accommodate only one helicopter at a time—able to carry, at most, two patients and associated staff and equipment.³⁷ ICU patients from Tulane University Hospital (Louisiana) were evacuated by helicopter.

Patients may be moved to an airfield for evacuation by rotor or fixed wing aircraft. Many patients from Children’s Hospital of New Orleans were moved first to a nearby airport, and then to other children’s hospitals around the country.⁷

Boats may be needed to evacuate patients during floods. Patients were moved by boat from Charity Hospital (Louisiana), which had no helipad, to Tulane University Hospital across the street, and were then moved up to the helipad on the roof of the parking garage.⁴⁰

Tall, 18-wheel trucks were able to roll through the floodwaters after Hurricane Katrina; many bedbound and ventilator-dependent patients from Charity Hospital, who had to be moved on stretchers, were evacuated by truck.⁹

understand whether a hospital has an exclusive contract with one or more transportation providers, or whether they will be dependent on ambulance companies that also serve many other facilities. Even if a hospital has an exclusive contract, a backup plan is required because these resources may not be available when an entire community is trying to evacuate simultaneously.

Actions by government officials may also affect the availability of contracted ambulance services. A hospital administrator called his ambulance contractor the day before Hurricane Katrina's landfall to move 12 ventilator-dependent patients to Lake Charles, but he was told that the mayor had taken control of all ambulances and the traffic was so bad that they would not likely get back and forth before the storm hit.⁴¹

FEMA has entered into a national contract for emergency ambulance services.⁴² The contract currently covers two regions (the Atlantic Coast and the Gulf Coast), providing up to 300 ambulances, 25 air ambulances, and paratransit vehicles to transport 3,500 persons per region. Requests for additional ambulances can also be made from other States through the Emergency Management Assistance Compact (EMAC).⁴³ These additional ambulances coming from outside a disaster area may be more helpful in some hospital evacuations (e.g., prior to hurricane landfall) than in others (e.g., an earthquake). Because the ambulances may not be able to reach the scene quickly enough to assist in an immediate no-notice evacuation, hospitals must plan to be able to support temporary patient care outside of their physical facility until appropriate transportation capability arrives. Decision teams should also consider whether these ambulances and accompanying personnel will be equipped to transport neonates, children, and other special needs populations. The national ambulance contract includes all patients, regardless of age, condition, or special needs. Medical special needs patients are not covered in the U.S. Department of Defense's (DoD's) Memorandum of Agreement for aero-evacuation of patients via the National Disaster Medical System (NDMS), although the DoD is committed to assisting with the evacuation of all patients.⁴⁴

Entry and Egress Points

A hospital evacuation requires road access to ramp-equipped hospital exits. Some hospitals are located in densely-built urban areas, or have only a few exits with ramps. With these types of capacity constraints, an orderly and safe evacuation could take days, especially if the rest of the city (and all of its hospitals) are also trying to evacuate or if there is poor coordination between the hospital and transportation providers. Poor coordination can lead to numerous vehicles waiting for patients to transport, or numerous patients waiting at the hospital exits for vehicles.

A pre-disaster self-assessment should estimate the number of vehicles that can be loaded at ramp-equipped hospital exits, whether there is a single loading area or if there are multiple loading areas accessible from different streets, and how long it might take to evacuate all wheelchair and bedbound patients through these exits. Some hospitals have an interim plan to bring patients to a location (perhaps outdoors) where they could then be loaded into vehicles more quickly—in effect a two-stage evacuation.⁴³ Again, a self-assessment could ascertain how long it would take to move patients to this alternative location, and then how long it would take to load them all into vehicles for the second stage of evacuation.

Location of Care Sites Receiving Evacuated Patients

A hospital evacuation will be planned differently depending on whether the entire area is being evacuated or just one hospital. If just one hospital is evacuating (e.g., due to a fire inside that building), patients can be more easily dispersed among nearby hospitals. In most metro areas, this transport would be for a distance of less than 10 miles, and ambulances could cycle back and forth moving patients. An evacuating suburban or rural hospital may have to send patients farther away to appropriate receiving care sites. A self-assessment should determine how close the nearest appropriate hospitals are and what numbers of various types of patients—especially ICU and other specialty-care patients—those nearby hospitals can absorb, on an average day. Local or regional bed availability systems, if available, can assist with this task.

In a disaster that causes a widespread evacuation of health care facilities, transport destinations may include other States. Traffic-choked highways and lack of refueling stations could also slow the evacuation and prevent ambulances from cycling back for repeated evacuation trips. Evacuation plans therefore should anticipate the possible necessity of including aeromedical services in their patient transport and distribution systems. Again, pre-disaster planning and coordination with State EMS and emergency management agencies is critical for understanding available resources and for facilitating coordination with Federal agencies, should Federal assets be needed for the evacuation.

Whenever possible, patients must be transported to another health care facility with available services and staff appropriate to their medical needs. For example, a New Orleans hospital triaged patients by type, destination, and mode of transportation. ICU patients were evacuated to the triage area at the airport; psychiatric patients were medicated and sent by bus to a psychiatric hospital in Alexandria, Louisiana.⁴¹ There was no other hospital in Louisiana that could care for all of Children’s Hospital of New Orleans’ PICU patients, so these patients were transported out of State. Similarly, following the Three Mile Island (Pennsylvania) incident, neonates on life support were flown to Children’s Hospital in Philadelphia, more than 100 miles away.

Approaches to Estimating Evacuation Time

Given variability in all the factors discussed above, there may be a wide variety of estimated hospital evacuation times with different sets of assumptions. At a practical level, decision teams should focus on perhaps two or three of the most likely scenarios for their setting (e.g., earthquakes in California, hurricanes in Louisiana) and attempt to estimate the most probable evacuation times. One such scenario is a planned and orderly evacuation of the typical mix of patients, with systems operating normally (e.g., all elevators are functional), and assuming that the hospital

Actual and Estimated Evacuation Times

When confronted by immediate, life-threatening circumstances (e.g., fire in the building), hospitals can be evacuated very quickly. Mt. Sinai Hospital in New York City evacuated hundreds of patients from one hospital tower to another in less than 1 hour.¹⁴ Pomerado Hospital in San Diego moved its 77 patients out of the building in 2 hours and 20 minutes.¹³ Following the Northridge (California) earthquake, six hospitals evacuated all their patients and transferred them to other facilities within 24 hours.³ Similarly, the evacuation of Children’s Hospital of New Orleans was completed less than 24 hours after the evacuation decision was made.⁷ In May 2009, all 152 inpatients at Children’s Hospital of Pittsburgh’s Oakland (Pennsylvania) facility, which was in the process of being closed, were transported in less than 7 hours to a new hospital 2.5 miles away.⁴⁵

Very large hospitals may take longer to evacuate. The evacuation of 406 patients from Memorial Hermann Hospital and Memorial Hermann Children’s Hospital (Texas) required 31 hours.⁴ In addition, planners who have not faced an urgent evacuation may be unprepared for the speed with which patients can (or must) be moved.

is the only one in the area that is evacuating. A variation of this scenario is to assume that other hospitals in the area are also evacuating.

Listed below are four possible approaches to estimating the time required to evacuate patients.

- Experiences of other hospitals. The easiest—but least rigorous—approach is to estimate evacuation time based on how long it took other hospitals to evacuate and how closely those circumstances resemble the assumptions in the relevant planning scenario. Given that a host of factors affect evacuation times, this approach is not recommended. Still, data from other hospitals may offer some guidance.
- Exercises. The results of evacuation tabletop exercises, adjusted and confirmed by data from drills, can inform evacuation time estimates.
- Computer models. Simulations and other types of computer models are available for hospital planners. The AHRQ Mass Evacuation Transportation Model,³⁸ for example, estimates the time required to transport patients from one or more evacuating hospitals to one or more receiving care sites. (It does not consider the internal characteristics of evacuating hospitals that would affect the time to move patients from their rooms to a staging area location.)
- “Back of the envelope” calculations. An alternative approach for estimating the transport time is to estimate the number of round-trips required for each vehicle participating in the evacuation and the average round trip cycle time from staging area to receiving care site.

Table 5.
Evacuation Time Self-Assessment Worksheet

Evacuation-Relevant Resources	Implication
People	
<ul style="list-style-type: none"> • If a mandatory city-wide evacuation order is issued, what percentage of your staff is likely to leave with their families (and not report for work)? • Have additional trained staff been identified/located to assist, if necessary, with the evacuation? 	<p>High % = more vulnerable</p> <p>N = more vulnerable</p>
Evacuation Resources and Patient Mix	
Patient Census and Mix	
<ul style="list-style-type: none"> a. How many patients are in the ICU (including adult, pediatric, and neonatal intensive care units) and other units (e.g., burn units) with special evacuation needs (e.g., patient must be accompanied by two health care professionals)? b. Typical census of adult and pediatric patients? c. Typical census of patients with special evacuation needs (e.g., psychiatric patients, bariatric patients, patients from correctional facilities)? 	<p>The more ICU and specialty care patients, the more limited the options for where they can be transported.</p>
Patient Transportation Needs	
<ul style="list-style-type: none"> a. What percentage of patients could self-evacuate (e.g., be taken home or evacuated by family/friends)? b. What percentage of patients are ambulatory (e.g., could be evacuated in a bus)? c. What percentage can sit up but not walk (e.g., could be evacuated in wheelchair vans)? d. What percentage require medical attention at the BLS level during transport? e. What percentage require life support equipment (e.g., could only be evacuated in an ALS ambulance or medevac helicopter)? 	<p>Percentages in items a-e should sum to 100%.</p> <p>The higher the percentage, the more vulnerable if ALS ambulances are scarce.</p>

**Table 5.
Evacuation Time Self-Assessment Worksheet**

Evacuation-Relevant Resources	Implication
Evacuation Transportation	
<ul style="list-style-type: none"> • Does the hospital have an <i>exclusive</i> contract with transportation providers to supply vehicles, or is it dependent on public/private vehicles that must also provide services to other hospitals? 	No exclusive contract = more vulnerable
<ul style="list-style-type: none"> • Has the hospital established relationships with State and regional emergency management agencies and developed coordinated plans for sharing transportation resources? 	N = more vulnerable
<ul style="list-style-type: none"> • How many different access roads reach the hospital, where there are ramp-equipped exits for moving patients? 	1-2 = more vulnerable
<ul style="list-style-type: none"> • How long would it take to get all of the patients out of the hospital and on the road to another location (assuming the hospital is full, roads are not damaged/blocked, and appropriate vehicles and staff are available)? 	Hours = time until evacuation
<ul style="list-style-type: none"> • Does the hospital plan specify an off-site “assembly point” where patients could be moved without vehicles, and from which transportation/loading into vehicles would be faster? 	No off-site “assembly point” specified = more vulnerable
<ul style="list-style-type: none"> • How long would this two-stage evacuation take? 	Hours = time until evacuation
<ul style="list-style-type: none"> • How quickly could all the patients be moved out of the building (e.g. in case of a fire)? 	Minutes = time until evacuation
Closest Appropriate Care Site	
<ul style="list-style-type: none"> • How close is the nearest care site that could provide appropriate care for: <ul style="list-style-type: none"> - NICU patients - PICU patients - CICU patients - Other adult ICU patients - Psych patients - Other ventilator-dependent patients - Other patients with special/advanced medical needs 	<ul style="list-style-type: none"> < 1 mile 1-5 miles 6-10 miles 11-20 miles 21-50 miles 51-100 miles 100+ miles

Table 5.
Evacuation Time Self-Assessment Worksheet

Evacuation-Relevant Resources	Implication
<ul style="list-style-type: none"> • Are there nearby “sister” facilities under the same corporate or organization umbrella? 	N = more vulnerable
<ul style="list-style-type: none"> • What percentage of patients could that nearest care site or sister facility safely accept in an emergency (how many would they have room for)? 	The lower the %, the more vulnerable
<ul style="list-style-type: none"> • If capacity at the nearest care site is insufficient, how close is the next-nearest care site? 	<ul style="list-style-type: none"> < 1 mile 1-5 miles 6-20 miles 21-50 miles 51-100 miles 100+ miles

Chapter 3. Pre-Event Evacuation Decision Guide

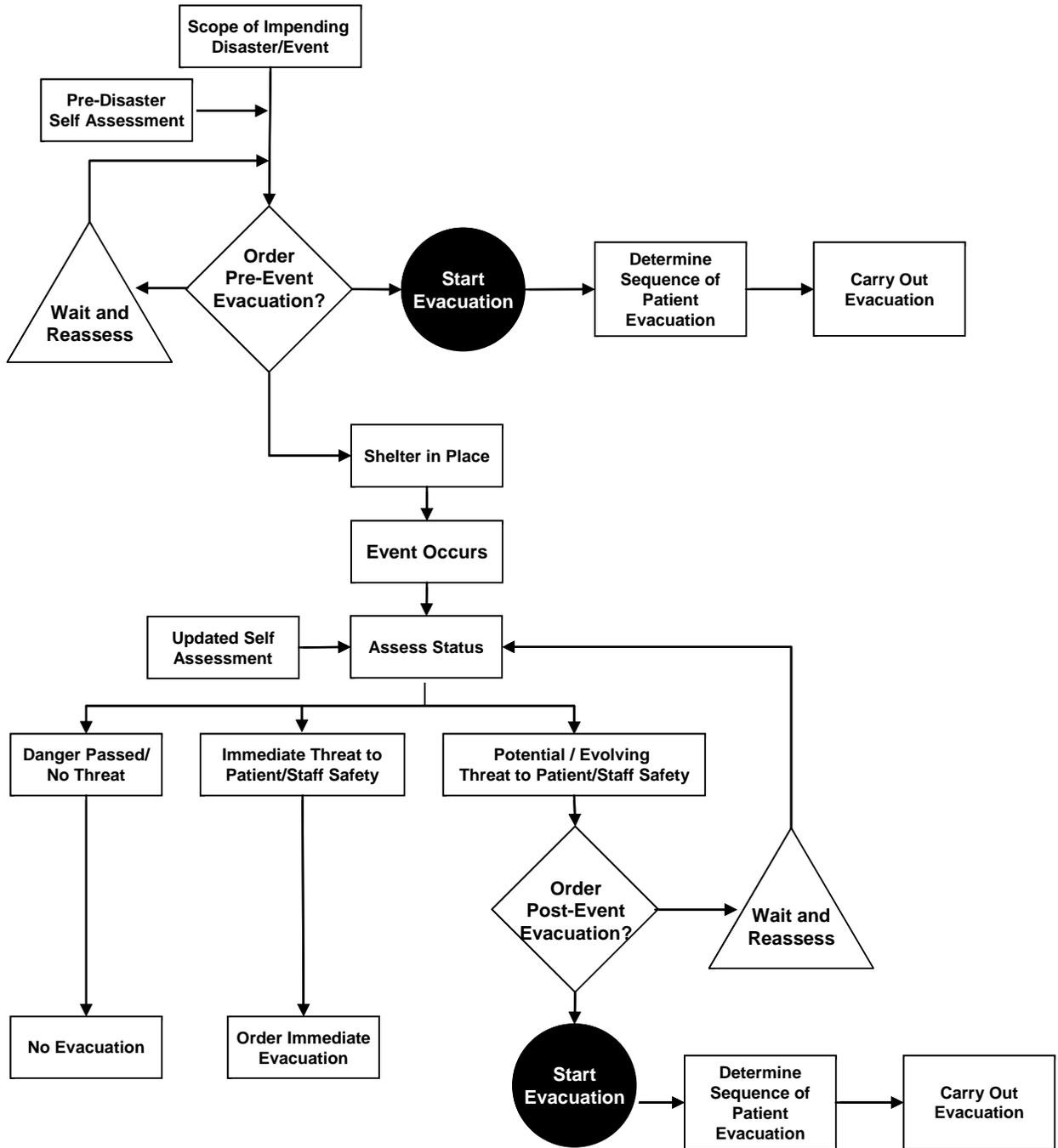
A pre-event evacuation may be carried out in anticipation of an impending event, when the hospital structure and surrounding environment have not yet been compromised. A pre-event evacuation is appropriate when decision teams believe the effects of the impending disaster may either place patients and staff at unacceptable risk, or when an evacuation after the event is likely to be extremely dangerous or impossible.

Pre-event evacuations are an option in Advanced Warning Events—disasters that decision teams and emergency officials can anticipate and track, as they assess the possible consequences of the disaster on their hospital and the surrounding community. Hurricanes are the most common example of Advanced Warning Events, and decision teams may decide to evacuate prior to hurricane landfall. Wildfires, rising rivers, and bomb or other terrorist threats can also force decision teams to decide to preemptively evacuate their hospital. If decision teams elect not to preemptively evacuate—deciding instead to shelter-in-place—a post-event evacuation may become necessary, depending on the impact of the event on the hospital and surrounding area. (Post-event evacuations are discussed in Chapter 4.) Thus, an Advanced Warning Event frequently requires two evacuation decisions: one pre-event and another post-event. By contrast, an event with no advanced warning involves only the post-event decision.

Figure 1 shows a flowchart that illustrates both the pre-event and post-event evacuation decisions that an Advanced Warning Event may require. There are several possible “paths” through the Figure 1 flowchart, including ordering a pre-event evacuation following a wait and reassess period; deciding to shelter-in-place, with no subsequent evacuation required; and deciding to shelter-in-place following a wait and reassess period, and then subsequently ordering a post-event evacuation.

The flowchart begins with an initial consideration of the decision to order a pre-event evacuation. Typically, this would occur as soon as a disaster is identified that could potentially threaten a hospital. This is often days before the disaster “hits,” such as when a hospital is inside a 3-day projected hurricane path. The flowchart highlights the three possible outcomes of this decision: wait and reassess, start an evacuation, or make an explicit decision to shelter-in-place during the event.

Figure 1.
Advanced Warning Event Evacuation Decisions



Wait and Reassess

The wait-and-reassess option defers the decision of whether to start a pre-event evacuation and is typically the preferred option early in the tracking period, when the disaster is not yet an immediate threat. The wait-and-reassess option is predicated on decision teams' belief that after reassessment, there will still be ample time remaining for an evacuation, if it is needed. In this option, disaster tracking meetings are held regularly, and decision teams cycle through the flowchart loop of "Order Pre-Event Evacuation?" and "Wait and Reassess," possibly several times (see Figure 1).

Decision teams rely on emergency management officials for accurate information about both the expected time and magnitude of the event, as well as explicit quantification of the uncertainty of estimates. Of course in some situations, such as a verified bomb threat, there may be no time to "wait and reassess."

In the wait-and-reassess option, the expected time until the event occurs should be compared to the time required to evacuate patients from the building and safely transport them to other facilities to determine if the decision to evacuate can be deferred. The evacuation time assumptions generated as part of the Pre-Disaster Self-Assessment (see Chapter 2) provide estimates for the time required to safely evacuate. These assumptions should be revisited based on current conditions in the hospital and the expected impact of the event.

Specific items to consider in the reassessment of the time required to evacuate patients include the following:

- **Current patient census and mix.**
How does the current patient census differ from the assumptions used to estimate evacuation time and resource needs in the self-assessment?

Hospitals Closely Monitor Track of Hurricane Rita

The University of Texas Medical Branch (UTMB) initiated its hurricane preparedness procedures on Sunday, September 18, 2005, 5 days prior to landfall of what was then Tropical Storm Rita. When Rita was officially classified as a hurricane on Monday and was headed towards UTMB's location on the upper Texas coast, the medical center initiated census reduction efforts to discharge as many ambulatory patients as possible. On Tuesday, 3 days prior to landfall, the incident command center opened in accordance with UTMB's emergency operations plan. All unit-level emergency plans were also activated, biosafety level three and four labs were closed and decontaminated, and medical students and nonessential personnel were dismissed. Late Tuesday evening, a teleconference was held between UTMB and the Texas Department of Public Safety's Division of Emergency Management, during which the Department guaranteed UTMB adequate ground and air transportation for a full evacuation, if the evacuation decision was made by 7:00 the following morning. From Tuesday evening until the time of the final decision Wednesday, UTMB assessed and triaged patients, copied medical records, assembled patient medication lists, and contacted a large hospital network to determine the number of transfers they could accept. At 7:00 a.m. Wednesday, 2 days prior to landfall of Hurricane Rita, a hospital-wide evacuation was ordered.¹¹

Bomb Threat at Galion Community Hospital

Galion Community Hospital (Ohio) received a bomb threat at 9:30 a.m. one Wednesday morning in 1999. After the threat was announced over the hospital's intercom system, members of the Incident Command System team met to discuss a possible evacuation while the local police and fire department worked with the facilities engineers to search the building for a bomb, which they did not find. An hour and 10 minutes after the initial threat, the hospital received a second warning. Within the next 5 minutes, the evacuation decision was made based on recommendations from consultants, police, and fire department officials.⁵

- **Availability of ambulances, wheelchair vans, and buses.** Are previous assumptions about the availability of transportation resources still valid? Are alternative sources of transportation resources available? Are other hospitals currently evacuating or planning to evacuate patients?
- **Location of facilities able to receive your hospital's patients.** Are the intended receiving care sites still able to accept patients? What alternative receiving care sites are available to accept patients?

When there is time—particularly in the days prior to a hurricane—decision teams usually discharge any patients who can safely be released to their families and stop admitting new patients. This is called census reduction, and it reduces the demands on the hospital as the focus turns to evacuating patients who require ongoing care.² Census reduction may take place before an official pre-event evacuation order is given, as in advance of hurricane; early discharges may also occur after a No Advanced Warning Event, such as an earthquake.^{3 5 46} Census reduction is a deliberate strategy to reduce the number of patients a hospital is responsible for transferring to other facilities.

Pre-Event Evacuation or Shelter-in-Place?

The wait-and-reassess option is viable for only a limited period of time; as the event progresses and conditions deteriorate, patients will not be able to be evacuated safely due to, for example, hurricane force winds or impassable roads. At some point, decision teams must decide whether to evacuate the hospital or shelter-in-place during the event. In our review of the literature and expert interviews, by far the most common decision during the approach of an Advanced Warning Event is to shelter-in-place. We note, however, that in the years since Hurricane Katrina, decision teams may be more inclined to evacuate in advance of a major storm.

Pre-Event Evacuation Decisions

During a flood of the Red River in March 2009, administrators at Merit Care Hospital in Fargo, North Dakota, first reduced the patient census to 180 high-risk patients who would have the most difficulty evacuating. When the predicted height of the river's crest rose dramatically, and a nearby dyke was jeopardized, Merit Care administrators decided to fully evacuate. A key factor in this decision was the concern that a later evacuation would force the hospital to compete for available ambulances and buses with other evacuating groups.⁴⁷

Rising water from the Cedar River, and uncertainty associated with the eventual crest, led to the evacuation of Mercy Medical Center in Cedar Rapids, Iowa, in June 2008.⁴⁸ Administrators initiated an evacuation of all 176 patients upon determining that the facility was likely to lose power.⁴⁹

In October 2007, the rapid spread of wildfires in San Diego County caused the evacuation of 77 patients from Pomerado Hospital, as administrators closely monitored the conditions of the fire throughout the afternoon and evening.¹³ The decision to evacuate was made because the fire was visible from the hospital's grounds,⁵⁰ and the fire department might not be able to protect the building due to the community-wide disaster.¹³

Deciding to Shelter-in-Place

Despite rising flood waters and disrupted roadway systems, Innovis Health administrators decided to shelter-in-place during the March 2009 flood in Fargo, North Dakota, and continue providing care, even though the hospital was in an area where officials had requested a complete evacuation. A key factor in this decision was the hospital's ability to remain operational for up to 10 days without city water, power, sewer, or other services—capabilities that had been intentionally designed when the hospital was constructed in 2000. In the end, the hospital was able to stay open throughout the incident.¹⁶

Sheltering-in-place was standard operating procedure at many of New Orleans' hospitals, and most did not consider preemptively evacuating prior to landfall of Hurricane Katrina.^{7 9 46} Administrators at Children's Hospital of New Orleans regularly updated the facility's adverse weather plan, "Code Gray," and coordinated with the State of Louisiana Emergency Operations Plan and the City of New Orleans Office of Emergency Preparations whenever there was advance warning of a category 3 or higher hurricane.⁴⁶ CHNO had sufficient generators and fuel on site to maintain HVAC, and staff moved necessary equipment to the second floor in case of flooding.⁴⁶ As Hurricane Katrina approached and strengthened, staff moved all patients to higher floors.⁴⁶ CHNO evacuated following the subsequent flood, at great risk to its tiny and fragile patients. In the years since this event, CHNO administrators have taken steps to "harden" the hospital so that evacuation will never again be necessary. Investments in security, backup water sources, and other infrastructure should make sheltering-in-place a safe option during future hurricanes and floods.⁷

Deciding whether to preemptively evacuate or shelter-in-place requires consideration of two factors:

- the nature of the event, including its expected arrival time, magnitude, area of impact, and duration; and
- the anticipated effects on both the hospital and the community, given the nature of the event and the results of the Pre-Disaster Self-Assessment (see Chapter 2).

Table 6 below is intended to help decision teams facing this complex set of considerations. The first section of the table focuses on issues to consider and implications of different characteristics of the event. Decision teams will, of course, closely monitor impending disasters in order to gauge anticipated effects on the hospital and the surrounding area. Four generic disaster characteristics to be monitored include: arrival time, magnitude, geographic area affected, and duration. Perhaps more important than the estimate of these characteristics is the variability around that estimate and how likely the variability could potentially change. The most common example of variability is the width of the hurricane “cone” showing the projected path of the hurricane.

Local emergency management and other experts are the best source of information on event characteristics. At a minimum, hospital decision teams should educate themselves on disaster-specific characteristics, their variability, and what factors affect variability. For example, movement of wildfires is affected by three main factors: weather, fuel (e.g., ground material), and topography. In the case of river flooding, the areas that will be flooded at varying flood stages—in particular, the key roads to a hospital—should be documented and included in hospital evacuation plans.

The second part of Table 6 provides a framework for assessing the anticipated effects of the event on key resources needed to care for patients (water, heat, and electricity), the overall structural integrity of the building, and the surrounding community. The latter may include road conditions, community security, evacuation status of nearby health care facilities, the official evacuation orders, and the availability of local emergency response agencies. Specific questions are listed for each of these factors, the answers to which will highlight the risk of ordering a pre-event evacuation relative to the risk of sheltering-in-place.

Table 6.
Factors to Consider in Deciding Whether to Begin a Pre-Event Evacuation

Factor	Issues to Consider	Implications
Event Characteristics		
<ul style="list-style-type: none"> • Arrival 	<ul style="list-style-type: none"> • When is the event expected to “hit” the hospital? The metropolitan area? • How variable is the time the event is expected to “hit”? 	<ul style="list-style-type: none"> • The amount of time until the event “hits,” combined with the anticipated time to evacuate patients, determines how long an evacuation decision can be deferred.
<ul style="list-style-type: none"> • Magnitude 	<ul style="list-style-type: none"> • What is the expected strength of the event? • How likely is the event to gain or lose strength before it reaches the hospital? The metropolitan area? 	<ul style="list-style-type: none"> • The magnitude of the event forewarns the potential damage to a facility and utilities, which could cut off the supply of key resources, or otherwise limit the ability to shelter-in-place and care for patients.
<ul style="list-style-type: none"> • Area impacted 	<ul style="list-style-type: none"> • How large is the geographic area to be affected by the event? • How many vulnerable health care facilities are in this geographic area? 	<ul style="list-style-type: none"> • Competition for resources needed to evacuate patients (especially vehicles) increases when more facilities evacuate simultaneously.
<ul style="list-style-type: none"> • Duration 	<ul style="list-style-type: none"> • How long is the event expected to last? • How variable is the expected duration of the event? 	<ul style="list-style-type: none"> • The duration of the event will affect how long hospitals have to shelter-in-place or operate on backup, alternative, or less predictable sources of key resources.
Anticipated Effect of the Event on Key Resources Needed to Care for Patients		
<ul style="list-style-type: none"> • Water source 	<ul style="list-style-type: none"> • Is the main city water supply in jeopardy? Already non-functional? • Is there a backup water supply (well, nearby building with intact water mains)? • If not, how soon will city water return? 	<ul style="list-style-type: none"> • Water loss of unknown duration (more than 1-2 days) is almost always cause for evacuation.
<ul style="list-style-type: none"> • Heat source 	<ul style="list-style-type: none"> • Is the heat source in jeopardy (steam, water for boilers, etc.)? Already non-functional? • Is there a backup (intact nearby building that still has power/heat)? • If not, will the building be too cold for patient safety before adequate heat returns? 	<ul style="list-style-type: none"> • Loss of heat, especially during a northern winter, is almost always a cause for evacuation—often within 12 hours.

Table 6.
Factors to Consider in Deciding Whether to Begin a Pre-Event Evacuation

Factor	Issues to Consider	Implications
<ul style="list-style-type: none"> Electricity 	<ul style="list-style-type: none"> Is power in jeopardy? Just for the hospital or a wider area? Are backup generators functional? How long can they run without refueling? Is refueling possible (e.g., intake not under water)? Can some sections/wings be shut down to reduce fuel consumption and stretch fuel supplies? 	<ul style="list-style-type: none"> Loss of electricity endangers ventilated patients, among others, and may affect the sequence in which patients are evacuated.
<ul style="list-style-type: none"> Building structural integrity 	<ul style="list-style-type: none"> Is the building obviously/visibly unsafe? All of it or only portions (e.g., can people be consolidated in safer sections)? Was there a water tower on the roof, and is it intact? Is a building engineer needed to determine structural integrity/safety? 	<ul style="list-style-type: none"> Earthquakes or explosions may cause rooftop water towers to fail, flooding the building. Safety/integrity may not be obvious to untrained occupants.
<p>Anticipated Effect of the Event on the Surrounding Environment and Community That Could Affect an Evacuation Decision</p>		
<ul style="list-style-type: none"> Road conditions 	<ul style="list-style-type: none"> Are any major routes from the hospital to potential receiving care sites closed? Is traffic at gridlock on major routes from the hospital to potential receiving care sites? Are access routes to the hospital cut off? 	<ul style="list-style-type: none"> There may be a limited window of opportunity to carry out a ground-based evacuation. Increased use of helicopters to evacuate patients may be required. Staff may not be able to get to the hospital to relieve existing staff or assist in the evacuation.
<ul style="list-style-type: none"> Community/building security 	<ul style="list-style-type: none"> Have any nearby areas experienced increases in disorder or looting? Are local law enforcement agencies understaffed due to self-evacuations or significant additional responsibilities? Are additional private security officers available to secure the hospital? 	<ul style="list-style-type: none"> If patient and staff safety cannot be assured, evacuation will be necessary.

Table 6.
Factors to Consider in Deciding Whether to Begin a Pre-Event Evacuation

Factor	Issues to Consider	Implications
<ul style="list-style-type: none"> Evacuation status of other nearby health care facilities 	<ul style="list-style-type: none"> Are other hospitals or other health care facilities already evacuating or planning to evacuate, or have they decided to shelter-in-place? 	<ul style="list-style-type: none"> If other hospitals or health care facilities are evacuating: <ul style="list-style-type: none"> the competition for ambulances, wheelchair vans, and buses may be substantially increased. the hospital may be asked to accept additional patients. patients may have to be relocated to facilities further away than anticipated.
<ul style="list-style-type: none"> State/county/local evacuation order 	<ul style="list-style-type: none"> Have evacuation orders been issued in areas that are closer to the event? Have any public or private statements been issued regarding the possibility of an evacuation order? Have any other incidents occurred that increase the likelihood that an evacuation order will be issued? 	<ul style="list-style-type: none"> You may have no choice but to evacuate.
<ul style="list-style-type: none"> Availability of local emergency response agencies 	<ul style="list-style-type: none"> Are local emergency response agencies understaffed (or otherwise unavailable) due to self-evacuations or additional responsibilities? 	<ul style="list-style-type: none"> Unavailability of local fire agencies increases the risk of sheltering-in-place.

Evacuation Sequence in a Pre-Event Evacuation

If the decision is made to begin a pre-event evacuation, decision teams must also decide in what sequence to evacuate patients. While this is an operational issue, it is included in this *Guide* because decision teams that have considered this issue a part of evacuation planning and have trained staff according to the plan may be better prepared to carry out an evacuation.

Many hospital evacuation plans focus on keeping patients together with the staff who know them best, and evacuating entire floors or units together.¹⁸ This is more difficult if many hospital personnel are absent, as may happen when staff evacuate a city with their families in advance of a hurricane, flood, or fire.^{2 12 33} Safe transportation must be arranged for non-ambulatory patients, and it may not be possible to evacuate all ICU patients together with their staff when there are insufficient ambulances available, or when air evacuation is necessary.^{7 35} ICU and NICU patients will likely require more staff assistance and equipment during evacuation, and decision teams must decide whether to send out these precious resources with the first wave of evacuees (leaving fewer behind for the remaining patients) or wait to move the most resource-intensive patients last.⁹ Finally, in the hours before a hurricane, flood, or wildfire, decision teams must decide whether the most fragile patients are at more risk from an evacuation than from sheltering-in-place.

Every hospital has an evacuation plan, and although most acknowledge that specific circumstances may alter evacuation decisions, some plans/protocols do not acknowledge this need for flexibility.⁵¹ A one-size-fits-all evacuation plan may become obsolete in the midst of a disaster, especially in responding to a No Advanced Warning Event, such as an earthquake. Lessons learned from the experience of others in many different and challenging disaster scenarios will help decision teams adjust their plans to suit specific disaster circumstances.

After census reduction has occurred and a pre-event evacuation has been ordered prior to an Advanced Warning Event, decision teams must decide whether to evacuate their most medically unstable patients (e.g., those requiring powered life-support equipment) or keep these patients in the threatened hospital and hope that essential services will not be disrupted.⁷ The risks of moving medically unstable patients are high, and physicians and decision teams must weigh the risks of moving these patients against the risks of sheltering-in-place.⁷

The deliberate strategy of evacuating the most resource-intensive patients first in a pre-event evacuation emerged following Hurricane Katrina.⁹ The experience of waiting too long, and then being stranded in hospitals without water or power, was a powerful lesson for decision teams and staff. Those who went through this ordeal advise that it is preferable to preemptively evacuate resource-intensive patients, so as to avoid having to evacuate them in even more treacherous conditions after the storm hits.^{viii}

^{viii} Advice from the technical expert panel on hospital evacuations convened by Abt Associates on January 14, 2009 (see Appendix A).

This advice was followed by several decision teams a few weeks after Hurricane Katrina, as Hurricane Rita approached the Gulf Coast. At eight hospitals that were evacuated (partially or fully) prior to landfall of Hurricane Rita, decision teams chose to evacuate their most medically unstable patients first, as soon as appropriate transportation teams and equipment were available. For example, the University of Texas Medical Branch (UTMB) evacuated critically-ill patients first because this was deemed safer than having them shelter-in-place.¹¹ Seven other hospitals within one medical system first evacuated the NICU and then ICU patients, as appropriate transportation became available.¹²

Staff and transportation shortages, or fear of them, may also prompt pre-event evacuations and affect the sequence of patient transfers.¹² In the case of a community-wide evacuation order, hospital workers may be dispersed, leaving hospitals with insufficient staff to shelter-in-place or without enough able bodied people to assist during an evacuation.² The evacuation process drastically reduces the number of staff available to stay in the hospital and care for patients, as some staff must join transport teams. Medically unstable patients are particularly resource-intensive and may need to be transferred with several care givers (to provide manual ventilation, monitor cardiac status, and provide other services in the absence of electricity) on specialized vehicles. Evacuating resource-intensive patients well before disaster strikes allows at least some opportunity for transport staff to return to the hospital to care for those sheltering-in-place or to evacuate additional patients. In addition, an early pre-emptive evacuation may allow time for more staff to arrive as replacements for the departing transport teams.⁹ This strategy also prevents patients from potentially being transferred in post-event conditions, such as a flood, which may preclude the use of ambulances and other specialized transport equipment.

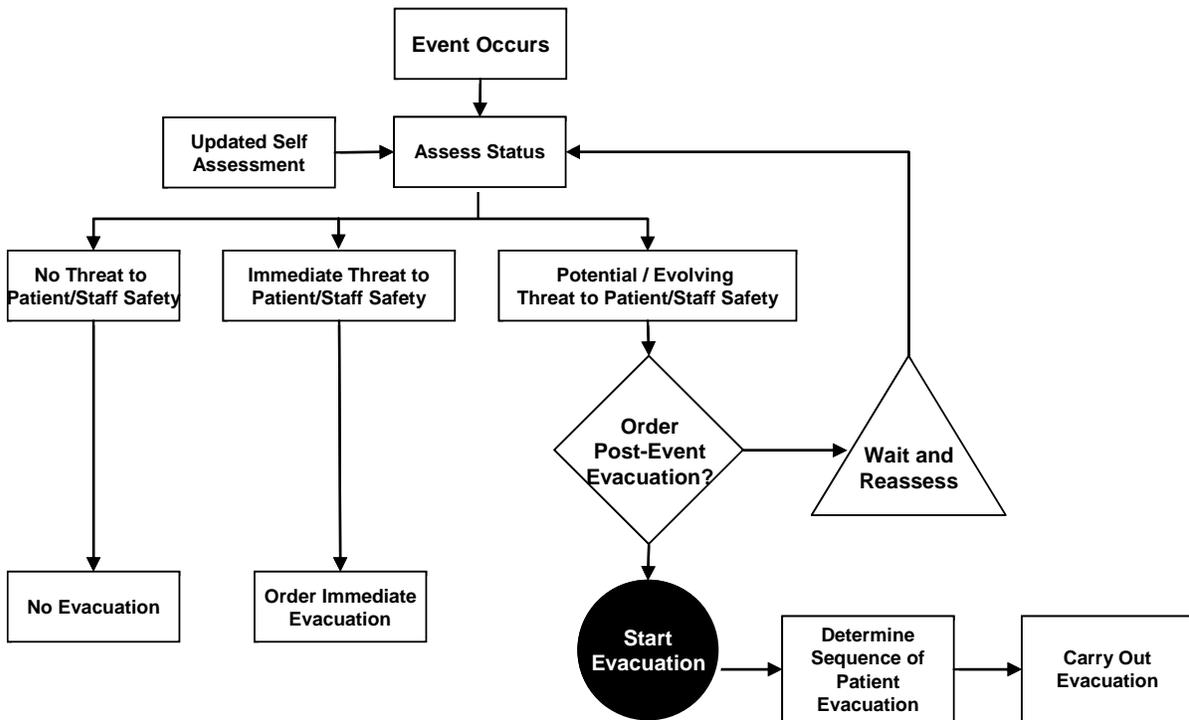
Unlike other hospitals that triaged patients by transportation needs and acuity, Pomerado Hospital (California) evacuated all patients simultaneously in response to San Diego wildfires in 2007.¹³ In this case, appropriate transportation, including buses and ambulances, had been pre-staged near the facility. There was no shortage of evacuation teams or equipment, and therefore it was not necessary to triage patients as is often the case prior to hurricanes.⁵⁰

Chapter 4. Post-Event Evacuation Decision Guide

Chapter 3 focused on pre-event evacuations, which are possible with Advanced Warning Events. Post-event evacuations—the focus in Chapter 4—have occurred either following Advanced Warning Events (i.e., if the decision was made to shelter-in-place during the event, but subsequent damage was sufficient to necessitate evacuation) or during No Advanced Warning Events. No Advanced Warning Events include, most notably, earthquakes, building fires, tornadoes, and explosions (both accidental and terrorist acts).

Figure 2 shows a flowchart that illustrates the post-event evacuation decision process. The steps in the flowchart are identical to the bottom half of Figure 1, the decision process for an Advanced Warning Event in which the decision team decides to shelter-in-place. There are several possible paths through the Figure 2 flowchart, as illustrated in the examples of pre-event evacuation decisions listed in Table 6. Some of the possible paths are determining there is an immediate threat to patients and ordering an immediate post-event evacuation; monitoring a potential/evolving threat to patient safety during a wait-and-reassess period, and then ultimately not evacuating the hospital; and monitoring a potential/evolving threat to patient safety during a wait-and-reassess period, and then deciding to evacuate the hospital.

Figure 2.
No Advanced Warning Event Evacuation Decisions



As soon as possible after the event occurs, building integrity, critical infrastructure, and other environmental factors must be assessed to determine whether the hospital can continue to provide appropriate medical care to patients or should instead be evacuated. As shown in Figure 2, the flowchart assumes that hospitals will be in one of three conditions following the event:

- **No threat to patient/staff safety.** In this situation, it is immediately clear that the hospital did not suffer any significant damage that would cause decision teams to order an evacuation. This is the usual outcome for hospitals that experience minor earthquakes or that shelter-in-place throughout a hurricane and suffer little or no significant damage.
- **Immediate threat to patient/staff safety.** At the other extreme are situations in which the event clearly causes an immediate life-threatening risk to patients and staff, and the hospital must be rapidly evacuated. The evacuation of major portions of Mt. Sinai (New York) hospital during a building fire in 2009 illustrates this situation. Similarly, six of eight hospitals damaged in the Northridge, California, earthquake evacuated within hours of the earthquake.³
- **Potential/evolving threat to patient/staff safety.** Between these two extremes are situations when it is not immediately obvious whether or not the hospital should be evacuated. Hurricane Katrina illustrates this situation; many decision teams chose to shelter-in-place, only to find that catastrophic damage from the subsequent flood necessitated evacuation. A careful assessment of the factors listed in Table 4—in particular the risks posed to the hospital’s water, sewer, electricity, and heat supply, as well as the overall building integrity—is required in order to decide whether an evacuation should be ordered, or if the decision should be deferred and the situation reassessed.

Wait and Reassess, or Evacuate?

Faced with a potential/evolving threat to patient and staff safety, decision teams must consider whether to evacuate. As shown in Figure 2, this decision has two possible outcomes:

- **Wait and reassess.** Absent a compelling reason to evacuate, the decision should be deferred and reconsidered at a later point, at which time the situation could significantly improve (i.e., no threat to patient/staff safety), significantly worsen (i.e., immediate threat to patient/staff safety), or not change significantly and require further careful assessment. For example, several decision teams deferred the evacuation decision for a lengthy period of time in the aftermath of the Three Mile Island (Pennsylvania) incident, the Northridge (California) earthquake, and Hurricane Katrina (Louisiana).
- **Start evacuation.** The factors that should be considered in the pre-event evacuation decision (see Table 6) are the same for post-event evacuations. Actual post-event evacuations are often delayed as long as possible and are sometimes unavoidable due to loss of critical resources.

Three Mile Island and Hospital Evacuations

Lacking information from local emergency management agencies for the first 3 days after the Three Mile Island (Pennsylvania) incident, hospital staff in the affected area triaged patients, reduced their censuses, and initiated contacts with other facilities outside the risk zone to coordinate patient transfers if needed. Some facilities also condensed patient units due to staffing shortages. The wait-and-reassess period continued for 5 days.²

Hospitals Evacuate Following Hurricane Katrina

In the aftermath of Hurricane Katrina, hospitals in New Orleans ultimately evacuated due to loss of power, city water, civil unrest, and flooding.^{6,7,8,9} Although emergency power was maintained at the VA Medical Center of New Orleans, loss of city water caused administrators to order a full evacuation.⁸ Charity Hospital evacuated for reasons related to loss of power and water loss—they had insufficient generator capacity to maintain their ventilator-dependent patients, and lost air conditioning.⁹ When the city's water supply failed, impairing the air conditioning systems at Children's Hospital New Orleans⁷ and ice machines at Kindred Healthcare,⁶ both facilities evacuated.

Evacuation Sequence in a Post-Event Evacuation

If the decision is made to begin an evacuation after the event has occurred, a subsequent judgment must be made regarding the sequence in which to evacuate patients. As was the case with the sequence in pre-event evacuations (see Chapter 3), with many post-event evacuations the most resource-intensive patients were evacuated first.^{3,4,8,9,11,33,35} For example, physicians at the VA Medical Center in New Orleans decided to evacuate ventilator-dependent patients after Hurricane Katrina, and eventually all other patients as well, when the hospital was forced to operate on generator power and its fuel line was submerged under several feet of water, threatening the ability to refuel the generators.⁸

Columbus Regional Hospital Evacuates

An unexpected and abnormally high rainfall during summer 2008 led to a levee break in southern Indiana, causing water to surge and breach riverbanks and dams.⁵³ Columbus Regional Hospital in Indiana was forced to immediately evacuate as the basement of the hospital quickly filled with water from the nearby Haw Creek and power was lost.⁵³ The full evacuation of 157 patients occurred within 3 hours. The main floor of the hospital was submerged under eight inches of water by the time the evacuation was complete.⁵⁴

Decision teams at Memorial Hermann Hospital and Memorial Hermann Children's Hospital in Houston, Texas, decided to evacuate critically-ill patients after power, water, and telephone service were lost following landfall of Tropical Storm Allison in 2001.³³ In the neuroscience/trauma ICU (NTICU), "those who required essential services were evacuated to other hospitals" first and, when the situation was reassessed, all other inpatients were also transferred.⁵⁵

Following Hurricane Katrina, there were limitations on medical transportation teams and equipment (e.g., ALS ambulances, medevac helicopters). At some hospitals, the decision was made to triage patients according to acuity and available transportation resources. For example, Charity Hospital's evacuation plan was to move ICU patients first, but because streets were flooded and these patients could not be moved in boats, they stayed in the hospital until 18-wheelers arrived, rolling through the floodwaters.⁹ Children's Hospital New Orleans (CHNO) also prioritized patients by transportation requirements during their post-Katrina evacuation. With assistance from other children's hospitals

that supplied equipment, teams, and coordination,⁵⁶ CHNO was able to evacuate each critical patient accompanied by “care teams that had clinical competencies in transporting critical kids.”⁷ Matching patients with properly trained staff and appropriate transport technology was considered more important than getting the sickest patients out first, due to the hazards inherent in moving these exceptionally fragile patients.

Following the Northridge earthquake in California, staff at six hospitals immediately evacuated due to fears about structural damage. At five of these six, unit staff evacuated their sickest patients first, followed by those who were less fragile.³ At the sixth hospital, staff feared an immediate building collapse and evacuated the most mobile patients first. Beginning on the ground floor and working upwards, ambulatory patients were escorted from the building first, followed by people who could not walk but were otherwise self-sufficient. The ICU patients were evacuated next, and when all other patients were in a safe area outside, trapped patients were rescued. This strategy was selected as the best approach to maximize the number of lives saved.³

As this latter example illustrates, there are some circumstances when decision teams must focus on saving the greatest number of patients. As in Northridge, they may decide to move the most mobile patients (the majority in most hospitals) first, returning later for the less numerous ICU and ventilator-dependent patients, who are more difficult to move. This approach would be less useful for facilities like Kindred Hospital of New Orleans, where half of all patients are ventilator-dependent.

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