



HEALTH CARE and DISASTER PLANNING

Understanding the Impact of Disasters on the Medical Community

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PURPOSE OF THE PROJECT

This project was undertaken to share the experiences of the Louisiana medical community during and after Hurricanes Katrina and Rita in hopes that other regions can be better prepared to deal with the short term and long range impact of a major disaster. Three and one half years post disaster, south Louisiana and the other impacted Gulf Coast states continue their struggle to recover from the storms and restore the health care infrastructure that was literally washed away. Perhaps no professional community suffered greater impact from the storms than the medical community. Hospitals, medical facilities, and many medical practices were changed forever or completely lost. This report attempts to provide insight to what can happen to a medical community when a catastrophic event takes place. The information is presented through empirical literature and, most importantly, through the experiences of medical professionals who worked on the front lines during Katrina and Rita and who have continued to deal with the impact of post-disaster recovery efforts.

This is an important story, not because of what happened in Louisiana, but because of the real probability that other communities face similar catastrophic events as well. Whether it is a hurricane, a pandemic flu, a terrorist attack, or an earthquake, all disaster preparedness and recovery planning involve

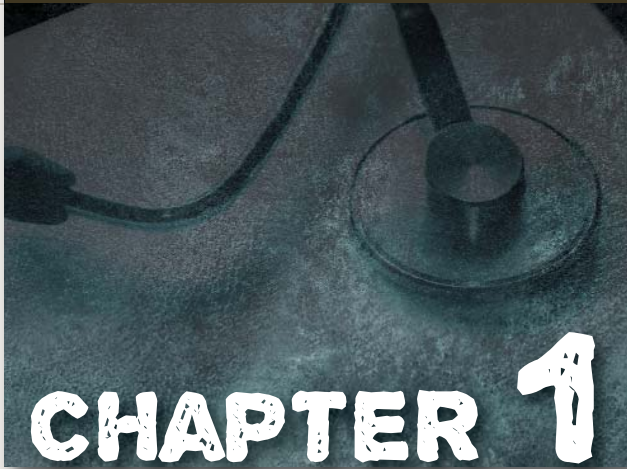
many of the same principles and practices in order to avoid the worst case scenarios. This report communicates to other medical communities through the words of physicians, health care providers and administrators who have shared their “lessons learned” in detailed and informative accounts. This work has been expanded by the research of the LSU Hurricane Center, through collection of information showing the real threat of additional disasters across the nation – disasters for which many communities are unprepared.

Prior to Hurricanes Katrina and Rita, the Louisiana health care community was unaware of the myriad of problems that could be encountered in meeting patient health care needs during and after a large-scale disaster. The ability of a physician to render, or the ability of a patient to receive, appropriate healthcare was fragmented or destroyed by the disaster. This fragmentation greatly impeded the delivery of emergency medical care and disrupted the continuity of care in the post-disaster period. Immediately after the hurricanes, many Louisiana physicians were unable to access vital patient information, locate patients, prescribe medications or communicate with their patients, staff, hospitals, and colleagues. Without proper planning, a disaster will seriously compromise the ability of physicians to render even basic medical care. The unthinkable hap-

pened in Louisiana and it can happen anywhere. To protect their patients and their practices, all physicians should take note of the mistakes made and lessons learned in Louisiana.

The Louisiana State Medical Society Educational and Research Foundation (LSMS ERF) has undertaken this project to document lessons learned in the aftermath of major hurricanes in 2005 and 2008. The project documents the major breakdowns and failures of emergency preparedness plans and emergency responses related to health care in an effort to persuade physicians and the health care community to reassess their emergency preparedness plans. The Physicians Foundation for Health Systems Excellence (PFHSE) funded this project because of its belief that Louisiana is in an unfortunate but unique position to share lessons learned from a major disaster with other states. The primary goal is to share with physicians, patients, state medical societies, and others vested in the delivery of health care the first-hand perspectives on how and why the health care delivery system collapsed during these disasters. The project also has a secondary goal of inspiring meaningful dialogue between physicians, state medical societies, and local, state, and federal agencies as they evaluate various long term solutions to the problems that were revealed during the Katrina and Rita disasters.





Overview of Disasters and Effects on the Medical Community

It is around midnight, and the water is rising in the hospital basement. The region's flood control system has been overwhelmed and everyone expects the flood conditions to worsen during the night. Both primary and backup power have been lost to the hospital and its Level 1 trauma center. Over 1,000 patients need evacuation immediately. The flooded streets have blocked vehicular access to the hospital and tomorrow morning's evacuation will be difficult. Such a scene could only describe a New Orleans area hospital, probably the infamous Charity Hospital, after Hurricane Katrina, right?

Opposite left:

Survivors of Hurricane Katrina arrive at New Orleans Airport where FEMA's D-MAT teams have set up a medical hospital and where people will be flown to shelters in other states.

Photo Credit: FEMA / Michael Rieger

Wrong. It is June 2001, and this scene is taking place just south of downtown Houston. The Memorial Hermann Hospital, part of the Texas Medical Center (TMC), is the medical facility in peril this time. Over the last 10 hours Tropical Storm Allison, with winds that never topped 60 mph, has dropped over 10 inches of rain on the Houston area. Located on the banks of Brays Bayou, the TMC has been described as a huge medical “city within a city” and as “one of the most sophisticated medical centers in the world.” It spreads over 695 acres and contains two medical schools, four nursing schools, and 13 hospitals. Of the 13 hospitals on the TMC, nine closed due to flooding, including the Memorial Hermann Hospital, a Level 1 trauma center with over 1,000 patients.

Hurricane Katrina brought an unprecedented level of attention to the impact that disasters can have on health care and the medical community; however, many of the themes that are so deeply associated with the disaster in New Orleans are not without precedent. Unfortunately, too much of the post-Katrina dialogue has instilled an “only in New Orleans” mentality towards the dismal conditions that occurred after Hurricane Katrina, particularly the conditions seen in hospitals, nursing homes, and other health care related facilities. As such, an extra effort is needed to remind all members of the medical profession that much of what happened in New Orleans has happened before and can happen in any community or facility across the nation.



Many roads, including bridges and elevated highways were damaged by the 6.7 magnitude Northridge earthquake. Approximately 114,000 residential and commercial structures were damaged and 72 deaths were attributed to the earthquake. Damage costs were estimated at \$25 billion.

Photo Credit: FEMA News Photo

It is mid-July 1995 and a heat wave has gripped Chicago. The city's Emergency Medical Services (EMS) are overwhelmed by the thousands of calls they have received. For nearly 4,000 imperiled callers, no ambulances are available, and the city sends fire trucks. Some callers succumb to the heat before help arrives. Many hospitals go into “Bypass Status” and start to turn away new patients. The morgue at the Cook County Medical Examiner's Office has filled up and a line has formed outside. The medical examiner has had to order refrigerated trucks to store the hundreds of deceased victims. The strain of so

many air conditioners running simultaneously has overwhelmed the electric grid and blackouts are occurring. During this period daytime high temperatures reached well over 100° F and nighttime temperatures rarely dropped below 80° F. Over 700 deaths were observed during the week of July 14th to 20th, the majority of them elderly residents of the city's poorer neighborhoods. Just as the hot and dry weather conditions overwhelmed Chicago's health care system, Katrina's wind and water would similarly overwhelm the medical response capabilities of southeast Louisiana.

It is early on the morning of January 17, 1994, and a massive 6.7 magnitude earthquake has struck the Los Angeles area. Nearly 9,000 people have been injured and 1,600 require hospitalization. However, the earthquake has damaged many of the area hospitals and 11 had to close. The surge of injured people along with a flood of patients evacuated from other hospitals strain the hospitals that remain open. In the days and weeks that follow, the emergency response phase, gives way to the disaster recovery phase and new health threats emerge. The dust and mold from numerous landslides caused by the earthquake has resulted in 200 cases of Valley Fever, an additional strain on the recovering health care system.

It is the peak of the 2004 hurricane season, and Hurricane Frances is bearing down on Ormond Beach, Florida. The nursing shift manager is huddled with other administrators and managers at the Florida Hospital-Ormond Memorial Hospital reviewing the hospital's preparations and current status. Everyone in the room is concerned about their home and family. But currently, the biggest concern is fulfilling professional obligations, including 25 nurses who are no shows. It is difficult to blame them, as most of the nurses are dedicated employees with legitimate reasons for not arriving for work. Conditions outside are horrible, making commuting to work difficult, and (like everyone else) nurses have families, homes, and pets to worry about during disasters. Still, the winds are about

to die down and the hospital is about to receive a surge of patients. There is a severe shortage of personnel to handle this crisis.

These are just a few examples of the challenges that confront the medical community during disasters. These examples illustrate that some of the problems that were seen in New Orleans after Hurricane Katrina have been seen in previous disasters and will be seen again in future disasters. Instead of dismissing these horrible circumstances as something that can only happen in New Orleans, those involved in the medical community need to acknowledge that, without adequate preparation, disasters can cripple an entire medical community.

Natural Disasters and the Vulnerability of the Health Care Sector

Natural disasters are becoming more frequent and more severe, and the capabilities of the medical community are increasingly being pushed to the limit. Every disaster brings new challenges; a few disasters create what seem to be intractable challenges. The disasters described in this section provide just a small sample of events that resemble aspects of the 2005 Gulf Coast hurricanes. There are many more cases of floods, winds, seismic movements, landslides, heat waves, and other physical hazards creating both an increased need for health care services and a significant loss of capability to provide such services. On numerous occasions, hospitals, clinics,

and EMS fall victim to these hazards at a time when they are expected to show leadership and provide help to the impacted population.

Physical hazards alone are not enough to cause a disaster. Disasters result when vulnerable populations and infrastructure are exposed to these physical hazards. It is this exposure that results in injuries, deaths, and destruction. In turn, these outcomes reflect both the magnitude of the hazards and the level of vulnerability of the population and infrastructure. Although vulnerability is a difficult concept to measure directly, it is generally accepted that more vulnerable populations experience the worst impact from hazardous events. There are a number of social, economic, and demographic variables that are linked to a population's vulnerability to disasters, including characteristics such as income level and age.

The vulnerability of the medical community to disasters must be an important consideration for all involved in health care. First, the medical community centers around one of the most vulnerable segments of the population: the patients. People seek treatment for different reasons, including injuries, chronic conditions, and diseases – nearly all of which potentially hinder the patient's physical ability to confront the hazards present during a disaster. Paradoxically, while the medical facility often provides safe refuge to shield patients' exposure to physical hazards, the unique vulnerability of these same facilities also

It is not unusual for nurses, doctors, administrators, and others to face a **basic conflict** between their professional and their personal obligations **during a disaster**.

threatens patients, health care providers, and their respective families in the days following a disaster.

The second source of vulnerability for the health care community reflects the dependence of the medical system on outside resources. A fully functioning hospital consumes large amounts of energy; requires daily deliveries of food, medicine, and other supplies; and depends on a highly skilled and specialized workforce. In the modern world, most hospitals also depend on high bandwidth telecommunications systems for a variety of functions. During disasters some or all of these outside lifelines are disrupted, limiting the ability of the facility to function.

Finally, when discussing the vulnerability of the medical community, it is essential to consider the effects of a disaster on the people who work in hospitals and other facilities. Often, when medical personnel must work through a disaster, they are very preoccupied with the safety of their homes, possessions, and loved ones. It is not unusual for nurses, doctors, administrators, and others to face a basic conflict between their

professional and their personal obligations during a disaster. Clearly, the personal stresses experienced by nurses, doctors, and other personnel during times of crisis create an additional vulnerability for the medical community.

Disasters are complex processes with complex consequences. Because of this inherent complexity, analyzing disasters is a difficult task. Effective disaster planning, which requires a thorough analysis of hazards and vulnerability, is even more difficult. Thorough disaster planning requires the consideration of numerous hazards and the potential impact that they have on different populations and various types of infrastructure. Additional complications result from the high degree of uncertainty, both in predicting the occurrence of an event and in estimating the consequences of that event. Fortunately, the science of risk analysis provides a simple but powerful tool for disaster analysis and planning.

In the science of risk analysis, risk is typically defined as the probability of an adverse event times the consequences of that event. Using this basic

framework, health care practitioners can conduct quantitative risk assessments of their facilities, human resources, and services. Once information is gathered, it can be used to guide priority setting, policy making, and action planning aimed at reducing risk. In practice, quantitative risk assessment requires thorough assessments of potential hazards and vulnerabilities along with quantitative estimates of the probability and consequences of the different possible disasters. Implementing the results of the quantitative risk assessment can be even more difficult, as numerous resources, managerial, and institutional constraints will be encountered. In spite of these complications, risk analysis is an important tool in preparing the health care system for disasters.

Hazard Types and the Associated Impacts

Disasters occur when vulnerable people and infrastructure are exposed to some type of physical hazard. Many types of physical hazards exist on earth and each hazard type has certain associated impacts on the general population and on the health care system. These hazards include floods, earthquakes, heat waves, windstorms, and mass displacement of earth materials. In general terms, floods are the most frequent hazards and are responsible for the greatest accumulated damage. Earthquakes tend to produce the most destructive and deadly events. This section briefly describes these different hazard types and their associated impacts.

Floods are generally described as the presence and accumulation of water in an otherwise dry location. They are the most common type of natural disaster. During 2008, the Federal Emergency Management Agency (FEMA) responded to 52 flood related federal disaster declarations, approximately one every week (FEMA, 2009). Because floods are so common, they are also responsible for the greatest total loss of the different disaster types. A variety of processes cause the accumulation of water in an otherwise dry location, leading to different types of flood events. Four main flood types are 1) riverine flooding, 2) coastal flooding, 3) dam break floods, and 4) floods that result from poor drainage in urban areas. Additionally, flood conditions can vary along a wide variety of physical characteristics. Naturally, water depth is an important physical characteristic of the flood, but the rate-of-rise, the flow velocity, the height of waves, the water temperature, and the duration of inundation all influence the severity of the flood disaster.

The most obvious and direct impact of floods is the inundation of communities and structures. Such inundation causes damage to structures and creates a drowning risk for those exposed to flood waters. Persons exposed to cold temperature flood waters also face a hypothermia risk. In addition to inundation, floods cause structural damage when the waters are either fast moving or have significant wave action. Damaged structures then become water borne debris,

which can cause injuries and deaths. Also of concern, floods disrupt public services, cut off access to health care facilities, and block the delivery of important supplies. Once the waters recede, mold remains as an important environmental health concern.

Although, not as common as floods, many of the most severe disasters result from earthquakes. This fact reflects the extensive structural damage that earthquakes can cause. Within a matter of a few seconds, an earthquake can level thousands of buildings, including hospitals. Two nurses, describing the 1971 San Fernando Valley Earthquake, observed that “the earth shrugged, and 1,700 hospital beds were lost in 52 seconds” (Braverman and Jenks, 1971). Earthquakes occur when tectonic energy is suddenly released, resulting in seismic waves that cause shaking and displacement on the surface.

The widespread damage that earthquakes cause reflects the response of the built environment to the ground shaking and displacement. Injuries and deaths result from the collapse of structures during earthquakes. This fact distinguishes earthquakes from floods, heat waves, and wind storms, where the physical forces are directly responsible for many of the injuries and deaths. Although considerable progress has been achieved in earthquake resistant designs for homes and other structures, earthquakes still pose a significant threat to people and infrastructure.



The remnants of Hurricane Ike cause extensive flooding in Munster, Indiana. Residents shown boating down the street.

Photo Credit: FEMA / Leo Skinner

Heat waves do not produce the images of loss and destruction associated with floods, earthquakes, and landslides; however, it is likely that they result in more deaths than all other natural hazards combined. It is estimated that heat waves result in nearly 400 deaths in the United States (US) every year. In 2003, a heat wave in Europe was responsible for nearly 35,000 deaths. High temperature, as a physical hazard, is most threatening to frail, elderly persons. Although not as destructive as other types of physical hazards, heat waves can still cause damage to infrastructure. Roads and bridges can buckle and bend in the heat, sometimes becoming inoperable. Additionally, electrical transformers and other parts of the electric grid can also suffer damage during high temperature periods. Damage to the electric grid is especially problematic during heat waves because of the extra strain put on the grid by increased use of air conditioners. The human body also responds adversely to high temperatures. After about 48 hours of uninterrupted exposure to excess heat, the body's natural heat regulation mechanism begins to become overwhelmed. As the body's temperature rises to 104°F and above, damage to the central nervous system starts to occur. The heat conditions are more likely to occur in urban areas, where the "heat island" effect causes extreme daytime high temperatures, along with little cooling during nighttime. When coupled with the population densities of urban areas, heat wave disasters occur when hot, dry air masses envelop these areas.



Tornado outbreak on March 8, 2007, causes damage in many areas of Georgia. Sumter Regional Hospital shown here was damaged extensively.

Photo Credit: FEMA / Wolfe

Windstorms constitute a broad class of weather related hazards, characterized by extreme winds along with lightening and precipitation. Windstorms include hurricanes, tornadoes, and severe storms. The wind alone is capable of widespread physical destruction and injuries. Additional losses can result from the lightening and precipitation. When extreme winds occur over water, they can push the water onshore resulting in storm surge flooding.

Effects of Disasters on Health Care

Regardless of the type of disaster, the impact felt by the medical community can be summarized in five basic areas: 1) physical destruction of facilities, 2) loss of crucial lifelines, 3) surge of persons needing medical care, 4) loss of personnel, and 5) emerging long-term threats.

Earthquakes, floods, and windstorms are all capable of causing considerable physical damage

to the facilities that house the medical community. Floods can inundate lower levels, destroying any equipment, including generators and data servers that may be located on flooded lower-level floors. Windstorms can cause windows to blow out, and then toss about any equipment that may be located in rooms that have lost windows. Earthquakes can cause sections of buildings or even entire buildings to collapse. Although not as common a threat, heat waves can also damage any equipment, such as air conditioners and backup generators that are located in areas without cooling.

When equipment and facilities suffer damage, the capabilities of the medical system become compromised. Certain procedures that require specialized equipment are not possible if that equipment has been rendered inoperable. Damaged facilities sometimes must be evacuated. Other times, they simply go into lockdown mode. In rare occasions, the destruction of a facility has meant that medical care must be delivered in temporary clinics setup in parking lots and greenspace.

In addition to the physical destruction of facilities and equipment, the capabilities of the medical community are further reduced when crucial lifelines, such as power, water and sewerage, supply deliveries, and telecommunications, are lost during disasters. One common characteristic of almost all disasters is the loss of electric power. Most hospitals have backup generators for such



A FEMA National Disaster Medical Team (DMAT) truck drives through floodwaters at the New Orleans Superdome to assist victims of Hurricane Katrina.

Photo Credit: FEMA / Marty Bahamonde

occasions; however, backup generators only work if they survived the event without major damage and if they have fuel. Once the fuel stored at the facility has been used, it must be delivered from outside, a complicated task when roads are blocked by floodwaters, wind debris, or collapsed buildings. Delivery of other supplies, both basic and crucial lifesaving medicines, can also be difficult or impossible when a disaster has rendered the roads impassable. Finally, no modern hospital operates without high bandwidth data connections for communication and data transfer. Losing this asset during disasters complicates facility management, cuts off access

to electronic medical records and diagnostics, hinders communication among staff, and, ultimately, leads to reduced patient care.

At the same time that disasters reduce the capabilities of the medical system, they also create substantial additional demand for medical services. Nearly every disaster is accompanied by a surge of patients with a variety of ailments. Many patients require treatment for injuries that resulted directly from the disaster. Other patients seek medical attention for chronic conditions that can be exacerbated during stressful times. When a disaster forces a hospital to close and evacuate its patients, those patients inevitably arrive at nearby facilities. Even though the nearby facilities may have escaped the worst of the disaster and may even have experienced no physical damage, they usually suffer from reduced capabilities alongside a surge in admissions. This surge (both in regular and emergency admissions) regularly results in serious shortages in personnel and supplies.

Shortage of personnel is another important impact that the medical community will experience during disasters. For many in the profession, these times of crisis create conflicting obligations. The need to take care of personal responsibilities often outweighs the obligation to perform professional duties during a community crisis. Even when personnel are willing to work, they are sometimes unable to work. Personal vehicles may have been destroyed and roads may



Damaged photograph on a wall of a home in the Lower 9th Ward. Flood waters from Hurricane Katrina destroyed everything in the house and turned the walls green from mold.

Photo Credit: FEMA / Andrea Booher

have been blocked. Other times, medical professionals might find themselves in a situation where they must deliver medical care to disaster victims on the spot. Although the community certainly benefits when a nurse or doctor is able to treat injured people in the disaster zone – often without communication with the medical facility – this still leaves the hospital short of personnel.

Disasters also impact the medical community by facilitating the emergence of new health threats. Such threats can result from a variety of circumstances. Mold and similar air borne particulate hazards are common problems following disasters. Damage to water supplies and treatment facilities also poses a health threat. In some cases, harmful substances get released into the community because of a disaster. Even the mass trauma experienced by the survivors can lead to widespread mental and physical health challenges.

In addition to the immediate challenges during the emergency phase, a disaster also produces a variety of long-term challenges. Once a hospital has been evacuated and forced to close, the process of reopening it can be complex, time consuming, and resource extensive. This complexity extends to many of the external lifelines, such as water and sewerage that have been severed because of a disaster. When evacuation facilities are closed, other medical facilities in the area that remain open will be forced to accept

the additional load. Even if the facility has been repaired and external services are available, personnel shortages can continue, especially if the disaster has destroyed a significant portion of the housing stock. Finally, emerging health threats can last for years and decades – a problem that emerges especially when the disaster has resulted in large numbers of people being exposed to some sort of environmental toxin because of the disaster. For example, the Katrina evacuees have been exposed to formaldehyde, which was found extensively throughout the FEMA trailers.

Disaster Frequencies and Impacts

Planning for disasters begins with an assessment of the hazards that may be confronted. This assessment should look at both the frequency and consequences of different hazard events. This assessment can be conducted on a variety of spatial scales, from the exact city block where a medical facility is located to a global scale that covers the entire population of earth. This section covers a preliminary county-level hazard assessment for the US. Hazard assessment knowledge is critically important for administrators of all medical facilities, because the US is prone to a variety of disasters and every element of the health care system needs to be prepared. In Table 1, an assessment of the frequency and level with which different hazard types impact the US is shown. This assessment utilizes data from the SHELDUS (Spatial Hazard Events and Losses Database for the United States) Database,

which is maintained and provided by the University of South Carolina's Hazard Research Laboratory. The SHELDUS Database provides one of the most comprehensive listings of disasters for the US. It spans from 1960 until 2005 and lists important information on each disaster, such as the hazard type and subtypes, the state and county affected, the number injured and killed, the total property damage, and the total crop damage. The database is compiled from publications of various government agencies, including the National Oceanic and Atmospheric Administration (NOAA) and the United States Geological Survey (USGS). This particular table

is based on all disasters listed in the database between 1990 and 2005.

The SHELDUS Database records disaster events based on the counties (or equivalent unit of jurisdiction) that have been impacted by natural hazard events. Each entry in the database reflects a county that has been impacted by single events and any events that impact multiple counties. This method of organizing the database makes it useful for county-level hazard assessments. Each hazard event is classified according to one primary hazard type, with additional hazard sub-types listed when necessary.

This dataset makes it clear that local jurisdictions are regularly impacted by hazard events. During the period 1990-2005, a total 170,467 hazard events are recorded in the database, as seen in Table 1. This corresponds to approximately 30 county-level natural hazard events each day. During this period, nearly 55,000 people have been injured and over 7,000 fatalities have occurred. According to the database, severe storms are the most common event, with almost nine occurring per day. Tornadoes produce the most injuries, with over 15,000 tornadoes reported. Heat waves cause the most fatalities, with over 2,300 listed. Hurricanes are responsible for the most property damage and droughts have caused the most crop damage.

Table 1 (<http://www.cas.sc.edu/geog/hrl/SHELDUS.html>) *In dollars.

Type	Number of County Events	Injuries	Fatalities	Property Damage*	Crop Damage*
Avalanche	298	79	119	1,610,001	0
Coastal	1,063	638	369	992,897,015	655,000
Drought	3,114	15	111	1,396,027,167	11,519,937,119
Earthquakes	21	70	70	22,622,200,000	0
Floods	27,500	8,807	1,051	25,691,824,788	7,537,414,281
Fog	344	1,174	100	18,635,500	0
Hail	13,209	2,028	14	7,636,473,695	1,798,531,171
Heat	3,256	5,912	2,370	22,677,526	464,797,000
Hurricane	1,749	1,142	159	39,359,786,599	4,358,195,821
Landslide	100	24	26	919,016,100	0
Lightning	7,216	3,115	484	406,092,080	7,100,146
Severe Storm	51,633	4,734	334	9,441,631,955	2,888,170,921
Tornado	8,520	15,145	782	9,597,711,402	142,074,310
Tsunami	5	0	0	20,855,000	0
Wild Fire	867	1,423	67	9,023,645,600	187,522,000
Wind	21,993	2,456	357	4,790,780,832	672,469,060
Winter Weather	29,579	7,446	943	5,975,459,038	4,104,101,128
Total	170,467	54,207	7,355	137,917,324,298	33,680,967,956





CHAPTER 2

Anticipating Potential Disasters Across the United States

Emergencies, such as severe storms or industrial accidents, are an everyday occurrence within the US. Similarly, on a daily basis, a community somewhere in the US will see a small number of homes damaged or businesses disrupted due to floods or high winds. Few communities have escaped the impact of such regularly occurring, low-level natural weather events. Residents of communities are likely to experience significant destruction from floods, high winds, earthquakes, heat waves, or other possible natural disasters at some point in their lives. Major catastrophes, on the other hand, are infrequent and relatively rare throughout history. It is unusual for a community to lose a large portion of its housing stock, see most of its businesses disrupted, and have so many of its citizens in a state of disarray. Although infrequent, America has experienced a number of catastrophes since the beginning of the 20th Century. This chapter describes some of these major events, from the perspective of the number of fatalities and the degree of economic loss. In the latter part of the chapter, there is an examination of the research related to potential disasters that will likely affect the US sometime in the future.

Opposite left:
**People standing on the overpasses and bridges to
keep out of the New Orleans flood waters.**

Photo Credit: FEMA / Marty Bahamonde

High Fatality Events

1) 1900 Galveston Hurricane

In 1900, a Category 4 hurricane made landfall near Galveston, Texas, with 135 mph winds and a 15 foot storm surge. With a population of 42,000 and located where the Houston Bay meets the Gulf of Mexico, Galveston was the largest city in Texas and a prominent port of entry. The town sits on a low lying barrier island. The highest point was just below 9 feet elevation. The storm caught the town largely by surprise and few preparations had been undertaken. As the storm passed overhead, the storm surge completely washed over the island. Over 3,600 homes were destroyed and it is estimated that between 6,000 and 12,000 people lost their lives.

2) 1906 San Francisco Earthquake

In 1906, a major earthquake struck San Francisco, California, which had a population of about 400,000 at the time. Many structures were destroyed in the initial earthquake and numerous fires burned throughout the city, contributing significantly to the extent of the disaster. Nearly 225,000 people were left homeless. In the days that followed, the impacted residents faced dire circumstances. An evacuation of the city was soon ordered. Early estimates placed the number of fatalities in the hundreds; however, it is now widely believed that as many as 3,000 people perished due to the earthquake, the fire, and the lawlessness.

3) 1928 Lake Okeechobee Hurricane

In mid-September 1928, a major hurricane made landfall on the Florida coast near Palm Beach and then followed a track that took the storm up the Florida peninsula. Although there were no reliable wind measurements available in Florida, 144 mph winds (Category 4) were measured in Puerto Rico from this storm. Before turning northeast, the eye of the storm skirted Lake Okeechobee in south central Florida, causing a lake surge of 6 – 9 feet. Overall 1,836 people (some experts estimate up to 3,000) died in Florida because of this hurricane, most of them from the Lake Okeechobee surge.

4) Heat Wave June-September 1980

During the summer of 1980, a high-pressure ridge over the south and central US caused extreme heat throughout these regions of the country. From June to September, temperatures well over 90° F occurred daily in numerous cities across these regions. The Heat Wave of 1980 resulted in 1,700 deaths and nearly \$20 billion in damage to crops. A concurrent drought contributed to crop damage.

5) Drought/Heat Wave Summer 1988

Eight years later, the central and eastern regions of the US experienced more losses to drought and extreme heat. Agricultural damages were estimated at \$40 billion and the deaths attributed to this disaster are estimated to be between 5,000 and 10,000.

6) September 11, 2001

By means of comparison, the coordinated terrorist attacks on September 11, 2001, resulted in 2,974 known deaths, with 24 people still missing and presumed dead. Thorough investigations have provided significant insight into how these victims died. Of the known deaths, 2,603 occurred in or around the World Trade Center, 125 at the Pentagon, and 246 on the plane that crashed in Pennsylvania. In the final report on the World Trade Center disaster, the National Institutes of Standards and Technology (NIST) provide a thorough analysis of the fatalities and the population at risk.

Deadly Hurricanes Since 1950

During the first 30 years of the 20th century, two hurricanes caused fatality counts over 1,000. No tropical system, prior to Hurricane Katrina, resulted in the comparable loss of life since that time. Still, hurricanes have been a deadly part of US disaster experiences since the middle of the century. Between 1950 and 1975, four hurricanes resulted in over 100 deaths. These include: (1) Diane (1950) – 180 deaths; (2) Audrey (1957) – 390 deaths; (3) Camille (1969) – 256 deaths; and (4) Agnes (1972) – 172 deaths. Following Hurricane Agnes in 1972, no hurricanes or tropical systems had caused over 100 deaths in the US until Hurricane Katrina in 2005. This trend is often attributed to improvements in hurricane forecasting and evacuation procedures. However, it is also possible

that this trend simply coincides with the phase of the North Atlantic Oscillation characterized by less frequent and intense Atlantic basin hurricanes.

The 1993 Blizzard and the 1995 Chicago Heat Wave

Prior to Hurricane Katrina, only two natural disasters in the US since 1990 had resulted in over 100 deaths. In March 1993, a large blizzard delivered freezing temperatures and significant snowfall to much of the southeast region of the country. In parts of Tennessee, over 60 inches of snow fell and the Florida panhandle experienced 2 inches of snow along with hurricane force winds (>74 mph). The 1993 blizzard resulted in 300 deaths throughout the US.

In July 1995, an extreme heat wave gripped the Midwestern cities of Chicago and Milwaukee. Over 600 heat-related deaths occurred in Chicago and nearly 200 people succumbed to the heat in Milwaukee.

Multi-Billion Dollar Events

In 2005, the National Climatic Data Center (NCDC) added five events to its ongoing list of billion dollar weather related disasters. In addition to Hurricane Katrina, three other Atlantic basin hurricanes and a Midwest drought caused over \$1 billion in damage. In 2007, scientists added five more disasters to the list: a drought,

a wildfire, two freezes, and a severe weather event. It seems that billion dollar disasters are a relatively common occurrence in the US. The NCDC scientists count 78 events with costs over one billion dollars that have occurred between 1980 and 2007, an average of nearly three per year.

Similarly, a list of billion dollar disasters compiled by Dr. Wayne Blanchard for FEMA lists 118 events. The top five natural disasters on this list, excluding Hurricane Katrina, are described below. As would be expected, some, but not all, of the disasters on this list appear on the list of the most lethal disasters also. From an examination of the list, it is apparent that all five of the billion dollar events were Atlantic basin hurricanes, with four of the five impacting the Gulf Coast. These include:

1) Great Miami Hurricane 1926

Although not on the list of deadliest disasters, this unnamed hurricane that struck Miami in September 1926 tops the list of the most expensive disasters. When normalized to 2005 dollars, estimates of damage are in the \$100 - \$160 billion range. Interestingly, this estimate may make the Great Miami Hurricane more expensive than Hurricane Katrina.

2) Galveston Hurricane 1900

In addition to causing the greatest loss of life from a natural disaster in the US since the beginning of the 20th century, the Galveston Hur-

ricane of 1900 ranks second in the list of most expensive natural disasters. Estimates of the damage, normalized to 2005 dollars, range from \$38 to \$78 billion.

3) Galveston Hurricane 1915

Fifteen years after the 1900 hurricane, Galveston was again struck by a hurricane in 1915. Following a very similar path to the previous hurricane, this storm still resulted in considerable loss of life (over 400 fatalities) and an estimated \$32 - \$62 billion (normalized to 2005) in damages.

4) Hurricane Andrew 1992

In August 1992, Hurricane Andrew became the first named hurricane (the National Hurricane Center started naming storms in 1953) to be placed on the list of most expensive natural disasters. First crossing Florida and then making a second landfall in Louisiana, Andrew resulted in 61 deaths and between \$54 and \$84 billion (normalized to 2005) in damages.

5) New England Hurricane 1938

In September 1938, the New England region experienced its first major hurricane in nearly 70 years. This storm, which made landfall on Long Island, New York, as a Category 3 storm, resulted in 682 deaths and between \$37 and \$70 billion in damage (normalized to 2005). For means of comparison, the September 11, 2001, terrorist attacks are listed by Dr. Blanchard with damage estimates to be \$27 to \$80 billion.

Table 2 Comparison Katrina and Rita to Other Disasters

Disaster	Description	Damage (Year of Currency)	Homes Damaged	Deaths
Hurricane Katrina	110 mph winds and 20 ft storm surge in SE La.	\$100 - \$150 billion (2005)	140,000	~1,500
Hurricane Rita	115 mph winds and 15 ft storm surge in SW La	\$27 to \$80 billion		
September 11, 2001	Terrorist hijack four airplanes, crash two in WTC and one into pentagon			2,998
1900 Galveston Hurricane	135 mph winds and a 15 ft storm surge		Over 3,600	6,000 to 12,000
1906 San Francisco Earthquake			225,000 people left homeless	~3,000
1928 Lake Okeechobee Hurricane	Category 4, a lake surge of 6 – 9 ft high temperatures over 90° F			1,836
Heat Wave June-September 1980		\$20 billion in damage crops		1,700
Drought/Heat Wave Summer 1988		\$40 billion in crop damage		5,000 - 10,000
Hurricane Diane (1950)				180
Hurricane Audrey (1957)				390
Hurricane Camille (1969)				256
Hurricane Agnes (1972)				172
1993 Blizzard	Tennessee, over 60" inches of snow fell			300 throughout the United States
1995 Midwest Heat Wave				800
Great Miami Hurricane 1926		\$100 - \$160 billion (2005)		
Galveston Hurricane 1900		\$38 to \$78 billion (2005)		
Galveston Hurricane 1915		\$32 - \$62 billion (2005)		>400
Hurricane Andrew 1992		\$54 - \$84 billion (2005)		61
New England Hurricane 1938		\$37 - \$70 billion (2005)		682

Potential Disasters

Since disasters of all sizes and types occur throughout the US on a regular basis, every health care community needs to be prepared. The impact of these disasters varies greatly as both a reflection of the physical hazards and the vulnerabilities of the population being affected. In a few rare cases, major catastrophes occur when extreme hazards affect extremely vulnerable people and infrastructure. During these events, widespread destruction and injury are compounded by significant disruption to the basic public safety infrastructure. During these times of crises, hospitals and medical professionals must be prepared for a leadership role in preparedness and recovery efforts. Preparedness begins with the recognition of what could happen in a major disaster. This section describes some of the major catastrophes that empirical evidence suggests will eventually happen in the US. Such a list could never include all possibilities; rather, these scenarios are meant to illustrate the possibilities that are known and whose effects can be mitigated.

1) New Madrid Fault Earthquake

The New Madrid Fault runs through southeast Missouri, northeast Arkansas, and parts of western Tennessee. One of the largest earthquakes ever recorded on the continental US occurred along this fault in 1812. Almost half of the town of Madrid, population 400, was destroyed. With an estimated magnitude of 8.0, ground shaking

was felt over an area estimated to be greater than 50,000 square miles. Given the low population density of that region at the time, the damage and death estimates were small.

Two major cities, St. Louis and Memphis, are now located near this fault line, creating the potential that a similar seismic event today would have major consequences. Recognizing this potential for catastrophe, FEMA has initiated the New Madrid Seismic Zone Catastrophic Planning project. According to modeling for the project, such an event would cause an estimated \$70 billion in damages to buildings. Damage would cover eight states and four different FEMA regions. Over 1 million people would lose access to water and an estimated 250,000 households would be displaced long term. Depending on the time of such an event – for example, in relation to commuter trends – the number of casualties could be as high as 17,000.

2) Hurricane Hits Miami / Herbert Hoover Dam Breaks

A second catastrophic planning initiative looks at two possible disaster scenarios in southern Florida. One scenario, a break in the Herbert Hoover Dike around Lake Okeechobee, would flood approximately 45,000 people. As many as 7 million people would be impacted in the second scenario, which depicts a major hurricane striking Miami. Hurricane Ono, the fictitious storm developed for this catastrophic planning initiative, would do both.

3) California Earthquake

Third on the list of potential catastrophes is a major earthquake striking California. According to a recent report by the United States Geological Survey (USGS), within the next 30 years, there is a 99% chance that shifting in the San Andreas Fault will cause a magnitude 6.7 or larger earthquake and a 46% chance of a magnitude 7.5 or greater. Recently, residents from Los Angeles to San Diego felt shaking from a 5.4 magnitude earthquake. This caused minimal damage and rattled nerves; however, most residents and officials felt relief when they found out this event was not “the Big One.”



Older masonry buildings are particularly vulnerable to damage from earthquakes, as shown in this photo from the Northridge Earthquake in 1994.

Photo Credit: FEMA News Photo

According to modeling from the USGS, “the Big One” could potentially result in damages to buildings totaling \$30 billion, and could cause significant damage to municipal water distribution systems and other crucial parts of the public safety infrastructure. Additionally, an estimated 1,600 building fires would take place. Approximately 1,800 fatalities will occur, with a projected surge of 50,000 patients to undamaged and open hospitals. The total damage is estimated to be over \$200 billion.

Much of the area depends on aged and deficient levees to prevent flooding. Historically, settled areas are protected by levees that were built long ago and not sufficiently maintained. Recent urban expansion has occurred on low lying farmlands protected by levees built to protect crops, not neighborhoods. Throughout the area, neighborhoods depend on levees that do not meet basic engineering standards. A recent survey by the Corps of Engineers found 36 sub-standard levees within the Sacramento district.

Sacramento region would suffer catastrophic consequences. Many areas in the region would experience water depths over 15 feet. The California capital building, located in historic Sacramento, could be surrounded by 5 feet of water. As many as eight hospitals could experience flooding.

5) Mississippi River Flood

The Mississippi River watershed constitutes the largest drainage basin in North America and

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4) Sacramento Flood

Located near the confluence of the Sacramento River and the American River, the Sacramento metropolitan area is home to over 2 million residents and sits on low lying, flood prone land. Originating as a pioneer town, Sacramento grew into a major distribution center during the gold rush years. The urban area has expanded considerably in recent years.

In January 2006, heavy rain caused flooding throughout the Sacramento Valley, though most of Sacramento was spared. Shortly afterward, the governor of California declared a state of emergency to prioritize levee repairs, upgrades, and maintenance.

Extreme rainfall in the Sacramento Valley would cause high water levels in the Sacramento River. If the worst case scenario of multiple levee breaches were to occur, most of the metropolitan

third largest in the world. The lower portion of this watershed, referred to as the Mississippi Alluvial Plain, consists of low lying land created over the eons through deposition from floods along the Mississippi River and its tributaries. This floodplain stretches from southern Illinois through parts of Kentucky, Tennessee, Arkansas, Mississippi, and Louisiana, and includes a handful of major cities along with numerous small communities and agricultural areas.

During the 20th century, numerous floods have occurred through the Mississippi Alluvial Plain, though two events are the most memorable. In 1927 and 1993, record snowmelt and precipitation in the Mississippi River watershed caused widespread flooding throughout the alluvial plain. In 1927, water overtopped levees and flowed through over 140 breaches, causing flooding that reached 30 feet in some places, over \$400 million in damage, and 246 deaths spread across seven states. This disaster event and the response to it also exerted an undeniable impact on American politics. In 1993, flooding impacted an area of comparable size in the alluvial plain, causing \$15 billion in damage and over 50 deaths.

A future, worst case flooding event in the Mississippi Alluvial Plain could impact millions of people. Memphis, St. Louis, Little Rock, Vicksburg, Baton Rouge, and New Orleans could all be impacted. Crop losses throughout the region could be devastating and commerce along the river system would be disrupted. In addition to thousands of displaced residents, these cities would have to deal with injured residents and widespread disruption of medical services.

6) Hurricane hits Houston / Galveston

In September 2008, residents of Houston and Galveston experienced what many perceived to be the “Big One” when Hurricane Ike traveled up Galveston Bay. East of the bay, Ike’s 20 foot storm surge completely inundated the Bolivar



Cadaver locating dog (upper left) works a pile of debris on Bolívar Peninsula after Hurricane Ike, while his trainer and flanker look on.

Photo Credit: FEMA / Mike Moore

Peninsula and destroyed most homes, including many built on stilts. In Galveston, the surge inundated most of the island while Houston experienced widespread wind damage and limited flooding. Over 30 persons died in the Houston-Galveston area from Ike and damages have surpassed \$10 billion. Over 6 million people were left without power, with millions in Houston in the dark for many weeks. Over 100,000 homes suffered flood damage. Four months later, 45 people remain missing.

Houston and Galveston certainly did not dodge the bullet during Ike; however, the region did escape a direct hit from “the Big One.” Perhaps a nearly lethal grazing hit is an accurate description. At the time of landfall, Hurricane Ike had wind speeds around 110 mph, making it a weak Category 3. Further, Ike’s trajectory brought the eye over Galveston Bay, about 10 miles east of downtown Houston. This placed Houston and Galveston on the “good side” of the storm, with Ike’s most severe winds and surge impacting



Hurricane Katrina heavily damaged or destroyed dozens of bridges in coastal Louisiana and Mississippi, severely disrupting response and recovery activities.

Photo Credit: LSU Hurricane Center/ Marc Levitan

areas east of Houston-Galveston. Bolivar Peninsula, where Ike's worst impact was felt, consisted of low density beach homes, many of which were vacation homes. As the surge still pushed inland, many residents escaped flooding because the peninsula diminished the height of the storm surge.

Having spared Galveston and Houston from the worst effects, Hurricane Ike still ranks as the third costliest Atlantic basin hurricane with a total estimated damage at just under \$30 billion. Given Ike's impact, one should expect a direct hit on Galveston and Houston to have cata-

strophic consequences. With a trajectory moved a few miles west, Galveston Bay would suffer complete inundation along with the ravaging effects of monster waves. If the eye passes over Galveston Island and moves inland toward Houston, the 20 foot surge would be pushed unimpeded into Galveston Bay, and then amplified as the Bay topography funnels the surge toward downtown Houston. Flooding in Houston would be widespread and catastrophic. Medical services in the US's sixth largest metropolitan area would be devastated and overwhelmed.

7) Hurricane Hits New York City

The last major hurricane strike near New York City occurred in 1938 and it has been nearly 18 years since the residents of New York City felt any hurricane winds. Considered sufficiently north of the southern East Coast's Hurricane Coast, hurricane strikes near New York City are rare and most of the residents of the area do not consider hurricanes to be a major source of risk. Still the risk of a major strike is considerable and the consequences could be catastrophic.

Following a path that brings the eye of the hurricane southwest of the city, a major hurricane could push a storm surge up New York Bay into the Hudson River and even into the Long Island Sound. All five of the boroughs that make up New York City could be impacted by flooding, with Brooklyn and Queens suffering the worst impact. Much of south Manhattan, including the World Trade Center site, would be inundated with water.

8) East Coast Tsunami

In December 2004, the world watched in shock as much of the coast of the Indian Ocean suffered a devastating tsunami producing waves as high as 30 feet that destroyed coastal cities and villages from Indonesia to India and resulted in hundreds of thousands of deaths. Even the parts of the east coast of Africa experienced tsunami damage. A large earthquake along the Sumatra fault line at the ocean bottom caused this tsunami. Many experts fear that a massive land-

slide on the Canary Islands could send a huge tsunami racing across the Atlantic Ocean, striking numerous US cities along the east coast. Cities from Boston to Miami would suffer deadly and destructive flooding.

9) National Heat Wave and Blackout

Though little noticed, heat waves are one of the most common and lethal types of natural disasters. During summer months, cities throughout America experience crippling heat resulting in many deaths. Air conditioning usage during even a normal summer places strain on the nation's energy infrastructure and often causes localized temporary blackouts. A widespread and sustained heat wave could cause considerable strains on vulnerable individuals and the nation's vulnerable grid. Numerous heat illness patients would seek medical care, but many hospitals that lack backup power would close and those that remain open would quickly fill to capacity.

10) Extreme Winter and Heating Fuel Shortage

Every winter, millions of Americans depend on a fragile network of natural gas fields, processing plants, pipelines, and liquid natural gas terminals to maintain warm, safe homes. Although natural gas fields exist throughout the US, maintaining adequate supply depends on significant production along the central Gulf Coast and five liquid natural gas terminals spread across the US. Any supply disruption could impact the entire system. A particularly deadly disaster could

result if a major supply disruption occurred during an extended period of widespread frigid weather.

Assessing Preparedness for Potential Disasters

Since disasters are inherently geographic processes, it makes sense that geospatial technologies are important tools in preparing for, responding to, and recovering from disasters. Geospatial technology is a general term used to

describe a broad set of software and instruments for gathering, compiling, storing, analyzing, modeling, and visualizing geographic data. A Geographic Information System (GIS) is one type of geospatial technology that is used extensively in hazard assessment handbooks. Simply put, GIS is software for making maps. More specifically, a GIS user has the ability to store, manipulate, and represent spatial data. Therefore, one can look at the spatial extent of possible hazards overlaid on data that shows vulnerable populations and infrastructure.



Plows work to keep street passable as a December 2006 blizzard hits Denver with up to 28 inches of snow.

Photo Credit: FEMA / Michael Rieger

Other geospatial technologies include Global Positions Systems (GPS) and Remote Sensing (RS). GPS provides high precision measurements of an individual position. It utilizes a handheld receiver and a system of satellites. RS refers to instrumentation and data analysis techniques that provide data on location without visiting that location. Using RS, hazard scientists can map flood and seismic hazards.

Hazard Assessment guidebooks provide lists of relevant datasets and analysis techniques for hazard and/or vulnerability assessments. A handful of hazard assessment guidebooks and references are listed below:

1. Social Vulnerability Index for the United States (SoVI)

“The SoVI measures the social vulnerability of US counties to environmental hazards. The index is a comparative metric that facilitates the examination of the differences in social vulnerability among counties. It graphically illustrates the geographic variation in social vulnerability. It shows where there is uneven capacity for preparedness and response and where resources might be used most effectively to reduce the pre-existing vulnerability. SoVI is also useful as an indicator in determining the differential recovery from disasters” (Hazards and Vulnerability, 2008).

2. Spatial Hazard Events and Losses Database for the United States 1960-2007 (SHELDUS)

“SHELDUS is a county-level hazard data set for the US for 18 different natural hazard events types such as thunderstorms, hurricanes, floods, wildfires, and tornados. For each event, the database includes the beginning date, location (county and state), property losses, crop losses, injuries, and fatalities that affected each county. The data set does not include Puerto Rico, Guam, or other US territories” (Hazards and Vulnerability, 2008).

3. Handbook for Conducting GIS-Based Hazards Assessment at the County Level

This guidebook provides the user with a county-level method for hazards analysis. It begins with a list of computer hardware, software, and basic requirements. It then provides a list of GIS data and techniques needed to identify and map hazard zones along with estimating vulnerable populations within the hazard zones. Additional steps include special-needs populations, key infrastructure and lifelines within the hazard zones. This guidebook is geared toward county-level emergency managers, but it also provides planning insight for medical professionals. The guidebook helps determine the hazards that an institution and its market community might face, helps identify the crucial infrastructure, and lifelines that could cease, and it helps estimate the population that may need medical assistance (Cutter, Mitchell & Scott, 1997).

4. UCLA Center for Public Health and Disaster (CPHD) “Hazard Risk Assessment Instrument”

“HRAI utilizes a standardized emergency management approach to identifying locally relevant hazards, assessing the probability of occurrence, and quantifying the potential impacts of maximum credible events. The instrument varies from most emergency management tools by specifically identifying impacts that are relevant to public health” (CPHD 2006). Geared toward public health planners, the HRAI relies on similar methods as the above handbook but includes a more refined analysis that provides specific estimates of impacts that can be used for planning the medical response. This planning tool consists of four steps. In the first step, the user goes through a list of possible hazards and scores the relative probability that it will affect the community. The second and third steps involve scoring the consequences of an event for each of the most likely hazard types. In the fourth step, the two results are combined into a basic risk analysis. The final table helps planners prioritize hazard types based on this quantitative risk assessment (Shoaf, Seligson, Stratton & Rottman, 2006).

5. Morrow’s “Community Vulnerability Maps”

“Examples from recent disasters, Hurricane Andrew in particular, illustrate how certain categories of people...are at greater risk throughout the disaster response process. Knowledge of

where these groups are concentrated within communities and the general nature of their circumstances is an important step towards effective emergency management” (Morrow, 1999).

6. *PACER Computer Program Helps Hospitals Prepare for Mass Casualties*

“The Electronic Mass Casualty Assessment and Planning Scenarios (EMCAPS) computer program calculates the impact of such crises as a flu epidemic, bioterrorist attack, flood, or plane crash, accounting for such elements as numbers of victims, wind direction, available medical resources, bacterial incubation periods and bomb size... [and] depends heavily on population density estimates to derive “plausible estimates” of what hospitals may expect in the first minutes or hours of a disaster” (PACER, 2009).

7. *USGS Hazard Atlas*

“The US Geological Survey (USGS) provides real-time hazard information on earthquakes, landslides, geomagnetics, and volcanoes, as well as background information on all the types of hazards” (National Atlas, 2008).

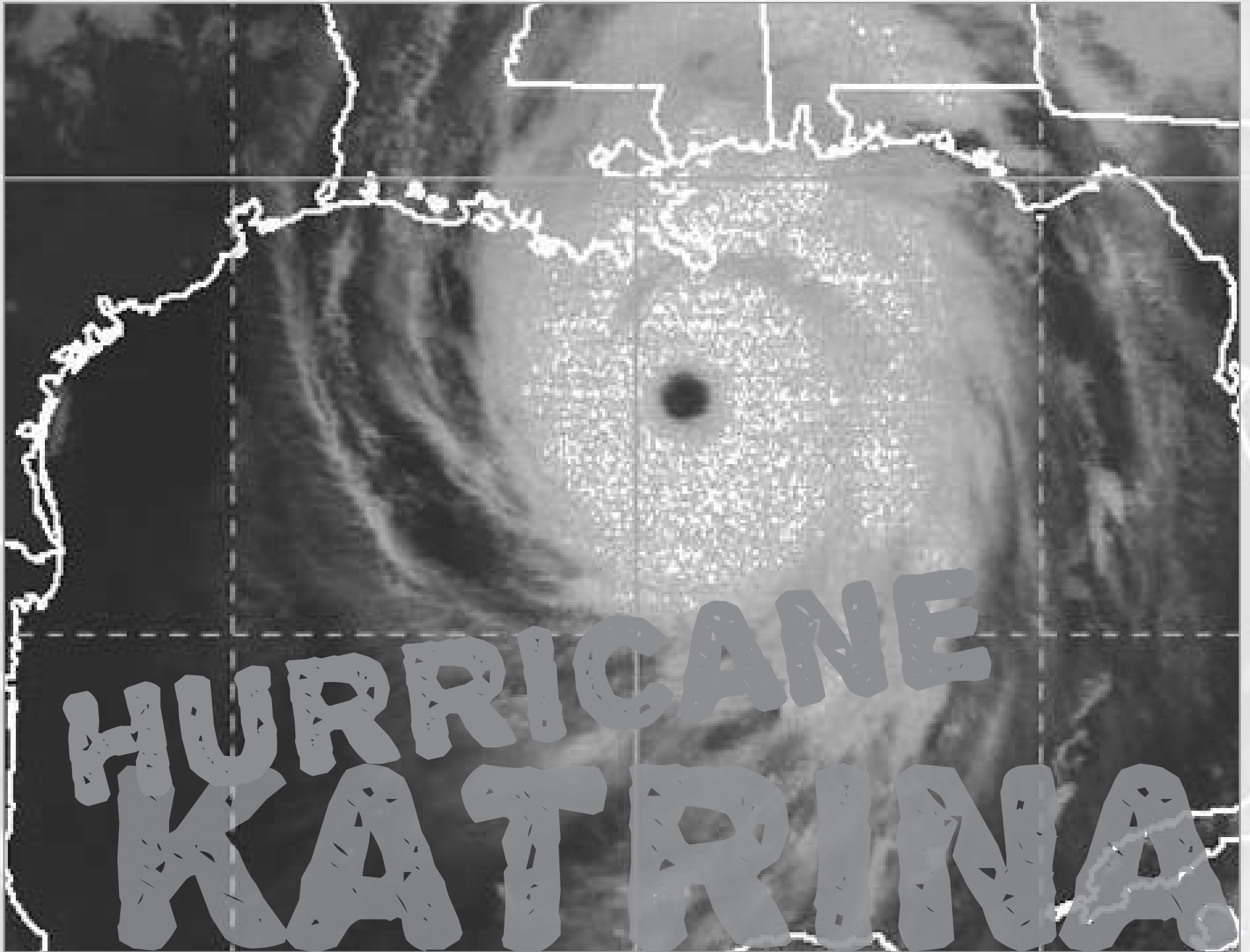
8. *World Map of Natural Hazards - Munich Re*

The reinsurance company Munich Re provides an interactive, web-enabled World Map of Natural Hazards that depicts the geographical extent of various hazards. While not a complete risk assessment tool, this map provides the user with a quick and straightforward way to iden-

tify which natural hazards (out of the range of possible types) could occur at a location. The interactive map allows the user to zoom on particular regions of the world, for example the Gulf Coast or New England, and view the major natural hazards that have affected that region. The map includes earthquakes, volcanoes, tsunami and storm surge, tropical storm and cyclones, extra tropical / winter storm, and navigational hazards. Cities that are prone to liquefaction during earthquakes are also marked (Munich Re Group, 2008).

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Hurricane Katrina: Preparation for and Impact on the Medical Community

Physical Hazards and the Vulnerability of New Orleans

There is little doubt that New Orleans is located in a region that leaves it exposed to many weather based hazards. In addition to the region's well-known experience with hurricanes, the area's humid sub tropical climate means that mid-latitude cyclonic storms and intense thunderstorms also pose a threat. Like hurricanes, these weather systems can bring heavy wind, rain, high tides, and tornados. Located on a low lying river delta and surrounded by water and wetlands, New Orleans has experienced a number of wind and flood-related disasters. Given the record of past experience, along with the widespread knowledge of the area's wetland destruction, it was known prior to Katrina that New Orleans would inevitably experience a catastrophic storm surge flood.

Opposite left:
**Satellite image of Hurricane Katrina approaching
New Orleans.**

Source: NOAA

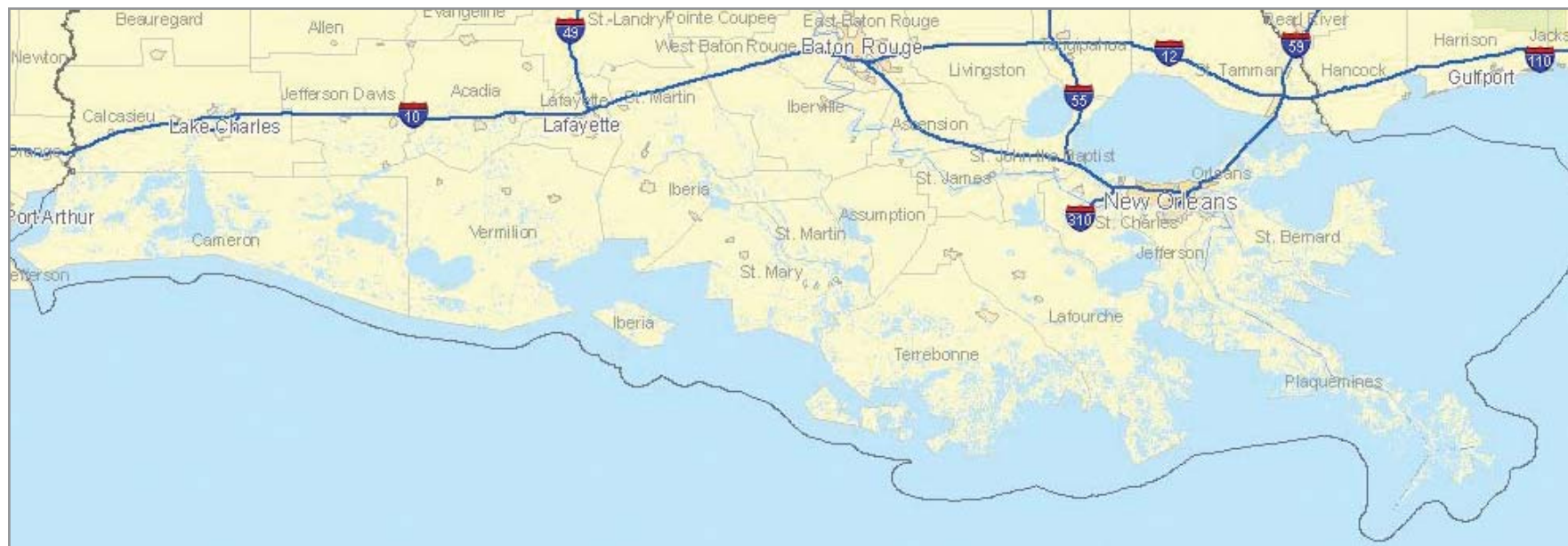


Figure 1 – Map of coastal Louisiana indicating parish locations and major cities and roads.

Source: LSU Hurricane Center

Additionally, there is irrefutable documentation that the region's population and infrastructure are highly vulnerable to disaster because of systemic poverty. For the inner city population of New Orleans, poverty, poor education, and lack of personal transportation all made preparing for a catastrophe difficult. In addition, the 2000 census counted over 150,000 persons over age 65 and over 250,000 persons with disabilities within the New Orleans Metropolitan Statistical Area (MSA), which includes heavily populated Orleans and Jefferson Parishes along with five surrounding parishes. Figures 1 and 2 show the geography of coastal Louisiana and the Greater New Orleans area, respectively.

In addition to the vulnerability of the population, the infrastructure in the region also contributed to New Orleans' catastrophic risk. The drainage system, which is one of the world's most complex, was frequently overwhelmed by heavy precipitation prior to Katrina. It was common for a neighborhood to experience street level flooding during normal rain storms. As an example, in May 1995, a two-day rainstorm dropped 20 inches of rain on the region, flooding 56,000 homes and businesses, and causing six deaths. It was common knowledge that, if a May storm could cause this much damage, then a hurricane could create catastrophic damage.

Other aspects of the region's flood protection also contributed to the risk level. Approximately 150 years ago, southeast Louisiana was comprised of a large expanse of marshes, swamps, and bayous. New Orleans and the surrounding communities were somewhat protected by these coastal wetlands from hurricane and storm surges. However, in the 1850's, federal engineers decided to pursue a "levees only" policy for maintaining the Mississippi River for navigation. This decision meant that the many distributaries of the Mississippi would be blocked. These distributaries delivered the fresh water and nutrients that sustained the coastal wetlands protecting New Orleans. With these distributaries

blocked, the coastal wetlands were starved of the freshwater and nutrients and slowly began to die.

In years that followed, many other decisions and actions contributed to the destruction of the coastal wetlands. Following the 1927 Mississippi River flood, federal engineers continued to strengthen the “levees only” policy. Over the years, many new navigation canals were dug throughout the region, including the Inner Harbor Navigational Canal, the Intracoastal Waterway, the Mississippi River Gulf Outlet, and the Harvey Canal. These are all examples of large-scale, human made navigational canals dug through the wetlands surrounding New Orleans. Additionally, hundreds of smaller navigational canals also tear through the wetlands. Other contributors to wetland loss include regional subsidence, global sea level rise, and polluted agricultural runoff. For decades, coastal scientists have worked on plans to restore the wetlands, but little meaningful restoration has taken place. As the destruction of the wetlands continued, emergency managers and others became increasingly aware that the risk of a storm surge flood disaster increased with each passing year.

Given the known threat, plans were developed at a variety of levels to prepare for the “Big One” that would “fill the bowl” (referring to the unique geography of New Orleans). Within the state and local governments, large-scale evacuation in the face of a threatening hurricane was



Figure 2 – Map of southeast Louisiana – Greater New Orleans Area.

Source: LSU Hurricane Center

seen as the best strategy to preserve life. However, the limitations of this approach were apparent. Limited highway capacity was one of the major problems with this approach. Access to the urban core of New Orleans, where the majority of the evacuating population lives, is

limited to four highways and five secondary roads. Additionally, access to some of the outlying coastal communities is limited to only a single, low-lying, two lane road that tends to flood early when hurricanes approach.

Limited access to personal transportation also complicated planning for large-scale evacuation. The 2000 Census revealed that approximately 51,000 households (27.2% of the total number) in Orleans Parish lacked access to a personal vehicle. In surrounding Jefferson, St. Bernard and Plaquemines Parishes, approximately 10% of households lacked personal transportation. Many of these same households contained elderly persons and persons with physical and mental disabilities, resulting in difficulties convincing them to leave and then helping them leave. For these reasons and other similar reasons, New Orleans had earned a place near the top of FEMA's list of possible catastrophes within the US.

The medical community in New Orleans was also known to be vulnerable to hurricane damage. In particular, it was recognized that many hospitals, which were expected to serve as havens during a disaster, would have their own problems during a hurricane or flood. For many, though not all, backup generators were located on ground levels, backup water supplies did not exist and stockpiling emergency supplies was constrained by tight budgets and was often considered waste when another hurricane season passed without major incident.

Planning for Catastrophe

Planning for the inevitable hurricane striking the New Orleans region was an important priority in the years leading up to the Katrina disaster.

In the realm of risk management and planning, these activities were described as planning for a low-probability, high-consequence event. Although hard to measure exactly, it was well recognized that the annual probability of an intense storm striking close enough to cause massive overtopping of the levee system was low. At the same time, it was also recognized that the occurrence of such an event would have devastating consequences, particularly in terms of lives, homes, and businesses lost. Assessing risk and making risk-based decisions within such a situation is difficult and far from an exact science. On the one hand, directing resources to planning for an event that is unlikely to occur appears to divert time and resources away from other important objectives that would have more immediate and definitive benefits. On the other hand, it is recognized that insufficient planning and mitigation makes heavy losses all the more likely.

Even in a static risk environment, planning for a low-probability, high-consequence event is difficult. This task is made even more difficult when the hazard profile changes with time, as was the case for the New Orleans region. In this particular context, two important environmental processes meant that the risk faced by the region was not static but highly dynamic. Locally, coastal land loss was one of these processes. The destruction of Louisiana's coastal wetlands, the region's natural storm surge buffer, had been studied for nearly half a century when Katrina

struck. One year prior to Katrina, Hurricane Ivan dealt a passing blow to the region but still caused significant destruction to the Chandeleur Islands, a chain of barrier islands that served as an ever shrinking obstacle to hurricanes and storm surges. The damages caused by Ivan meant that subsequent hurricanes would be able to push their surges further inland and closer to the inhabitants and infrastructure, including hospitals and health clinics of the Greater New Orleans region.



Destruction of Chandeleur Islands from 2001 (top) to 2005 (bottom) due to Katrina and other storms. Yellow arrows in both pictures indicate the same water feature.

Photo Credit: USGS

In addition to regional landscape changes, global climate patterns were another dynamic factor that impacted the hazard profile for the region. The North Atlantic Oscillation had recently been recognized as an Atlantic Ocean current pattern that influenced the strength and trajectory of hurricanes within the Atlantic Basin. Additionally, many climate scientists believed that global warming would result in conditions conducive to more frequent and more intense hurricanes. Regardless of the impact of global warming, global sea level rise, along with the disappearing coastal wetlands, simply meant higher storm surges.

Developing and implementing risk-based policies is a difficult task even for the experts. Assessing risk in the context of low-probability, high-consequence events is even more difficult. When regional and global environmental changes result in a changing hazard profile, this task becomes extremely challenging. In the New Orleans area, both hospital administrators and average citizens faced a difficult task when trying to assess their risk and make decisions related to this assessment.

In spite of these limitations in assessing the hurricane risk for the region, a variety of officials and agencies were engaged in planning activities. At the state level, improving the hurricane evacuation plan was a big priority. After experiencing major problems with the evacuation of New Orleans during the 2004 near miss of Hur-

ricane Ivan, the state Southeast and Southwest Louisiana Hurricane Evacuation Taskforces, comprised of state and local transportation, law enforcement, and emergency planning officials, worked diligently to develop and distribute a regional, phased contraflow evacuation plan before the start of the 2005 hurricane season. With this plan in place, over one million people within the “at risk” areas were able to evacuate before Katrina, making the vehicular evacuation plan one of the few successes in this hurricane. Most people, who had access to an automobile and desired to leave, were able to evacuate. Traffic on the major evacuation routes had cleared out before the storm arrived.

In addition to this coordinated effort to evacuate as many people with access to cars as efficiently as possible, numerous local governments started to look into ways to assist those without personal transportation or other mobility limitations. Some parishes had attained relative success in their efforts to provide evacuation assistance to those who needed it and others were still developing these plans and capabilities when Katrina struck.

For those involved in planning, it was recognized that the limitations of evacuation meant that an untold number of people would stay behind, creating widespread human suffering and necessitating a large-scale emergency response. Although evacuation planning was difficult, planning the emergency response was even more

complex and challenging. No one had definitive answers for important questions, such as: How many people would not evacuate? Where would they be? What types of hazards would they experience? How would they be transported to safety? And, what would their medical need be? To address these issues, numerous planning exercises had taken place. Many of these exercises involved individual agencies or jurisdictions, and others involved collaborative efforts between agencies and jurisdictions.

In June 2004, however, the Hurricane Pam exercise brought together people from all the major agencies at the local, state, and federal level, along with non-profit organizations and key corporate entities. During a week of intense planning, over 250 people considered the Hurricane Pam scenario, which was a strong Category 3 hurricane passing just south of the city on a northwesterly track. Computer models predicted that such a storm would flood most of the Greater New Orleans area and include over 100,000 people that needed rescue and medical care. Using this scenario, the group worked through the details of responding to this overwhelming emergency. This exercise produced the backbone of the Southeast Louisiana Catastrophic Hurricane Response Plan. The plan, while still a work in progress during the summer of 2005, nevertheless provided a solid framework for the response to Katrina.



The day before landfall - residents lining up to get into the Superdome; this was opened as a hurricane shelter.

Photo Credit: FEMA / Marty Bahamonde

Hurricane Katrina's Physical Hazards

Southeast Louisiana first began to feel the effects of Hurricane Katrina on the afternoon of Sunday, August 28, 2005. The storm had intensified to a Category 5 hurricane on the Saffir Simpson scale earlier that morning, even though it was still located several hundred miles south of Louisiana (see Figure 3). That afternoon, the storm surge started to push inland and shortly after 2 p.m. surge waters started to flood Highway 1, the only evacuation route for coastal communities, such as Port Fourchon and Grand Isle. The coastal region had completed their

preparations and evacuations by this time and sixty miles to the north in New Orleans, preparations were starting to wind down. Contraflow continued and westbound traffic along Interstate 10 flowed at a rate of about 2,500 vehicles per hour, which had been the rate for most of that day. In addition, thousands of people seeking refuge lined up outside the Superdome. By around 4 p.m., the outer rain bands of Hurricane Katrina reached New Orleans, soaking those waiting to enter the Superdome. Contraflow was terminated at 5 p.m. due to deteriorating weather conditions. Nearly 450,000 vehicles were counted leaving the region, carry-

ing over 1 million evacuees. As evening approached and conditions worsened, nearly 12,000 people found refuge in the Superdome and an estimated 130,000 people rode out the storm in their homes, their businesses, or with nearby friends and family.

The eye of Hurricane Katrina made landfall near Buras, Louisiana, around 6:00 a.m. on August 29, with wind speeds in the Category 2 range. In the ensuing hours, the storm tracked nearly due north, passing about 20 miles east of New Orleans around 10:00 a.m. Shortly thereafter, the storm made final landfall near the Louisiana-

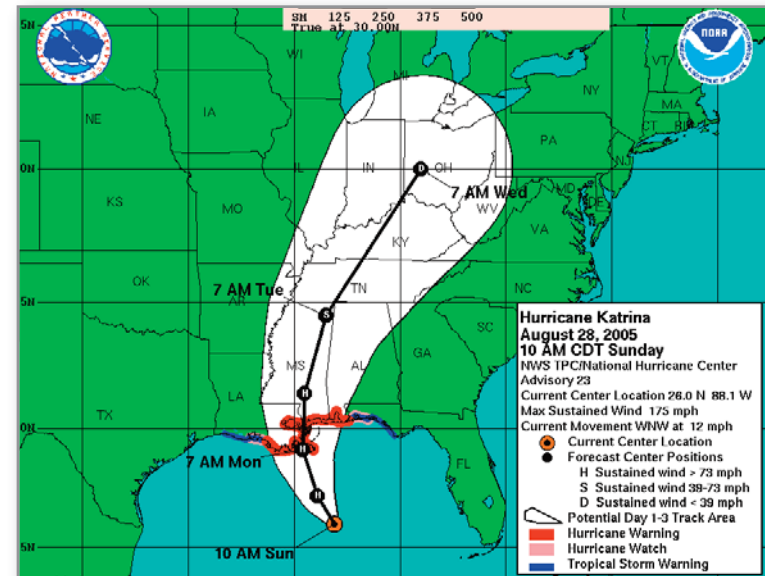


Figure 3 – Hurricane Katrina current conditions and forecast track on Sunday morning, August 28 (one day before landfall).

Source: National Hurricane Center

Mississippi state line, very close to the predicted track shown in Figure 3. The worst had passed southeast Louisiana, but Katrina continued to pound Mississippi with wind and rain throughout the day.

The hurricane had weakened significantly in the hours before landfall. Officially, the National Hurricane Center designated Katrina as a Category 3 hurricane when it made first landfall along the Gulf Coast. However, ground-based wind measurements do not generally substantiate this classification and the hurricane was most likely a Category 2, with maximum sustained winds of around 105 mph at landfall. For a storm to be designated Category 3, its maximum sustained wind speeds must be greater than 110 mph. Some of the suburban and rural

areas south and east of New Orleans experienced winds in the 90 – 95 mph range, but none of the urban areas experienced winds greater than about 85 mph, as seen in Figure 4.

Rainfall in southeast Louisiana due to Hurricane Katrina was moderate but not intense. The National Hurricane Center estimates that 10-12 inches of rain fell over the region (as shown in Figure 5), with 11.63 inches measured at a National Weather Service office in Slidell. This amount of rainfall was about half of the amount that fell during the May 1995 flood, yet is similar to a 1978 rainstorm that dropped 10 inches on New Orleans and caused five deaths. The National Hurricane Center attributes 43 tornadoes to Hurricane Katrina, but none of them occurred in Louisiana.

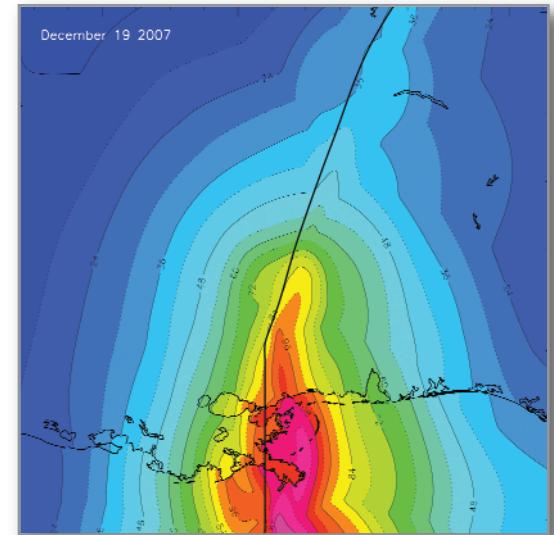


Figure 4 – Maximum sustained surface wind contours during Hurricane Katrina (in mph).
Source: NOAA Hurricane Research Division



Petrochemical facility near Katrina landfall location that experienced serious wind and flooding damage, releasing petroleum products into the environment.

Photo Credit: LSU Hurricane Center/ Marc Levitan

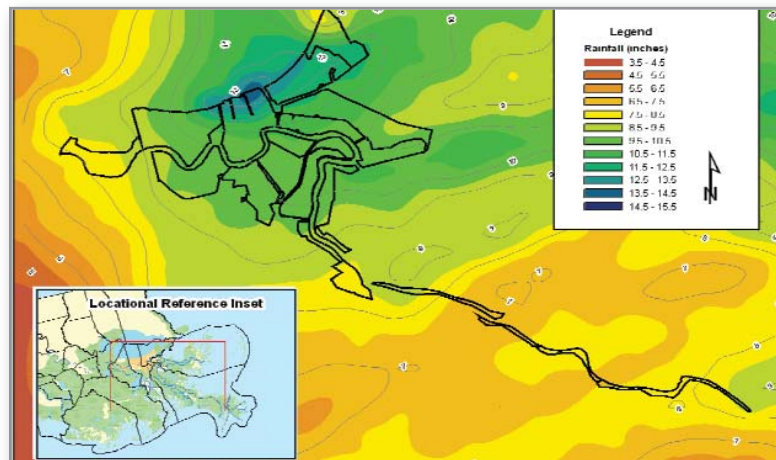


Figure 5 – Hurricane Katrina current conditions and forecast track on Sunday morning, August 28 (one day before landfall).
Source: National Hurricane Center

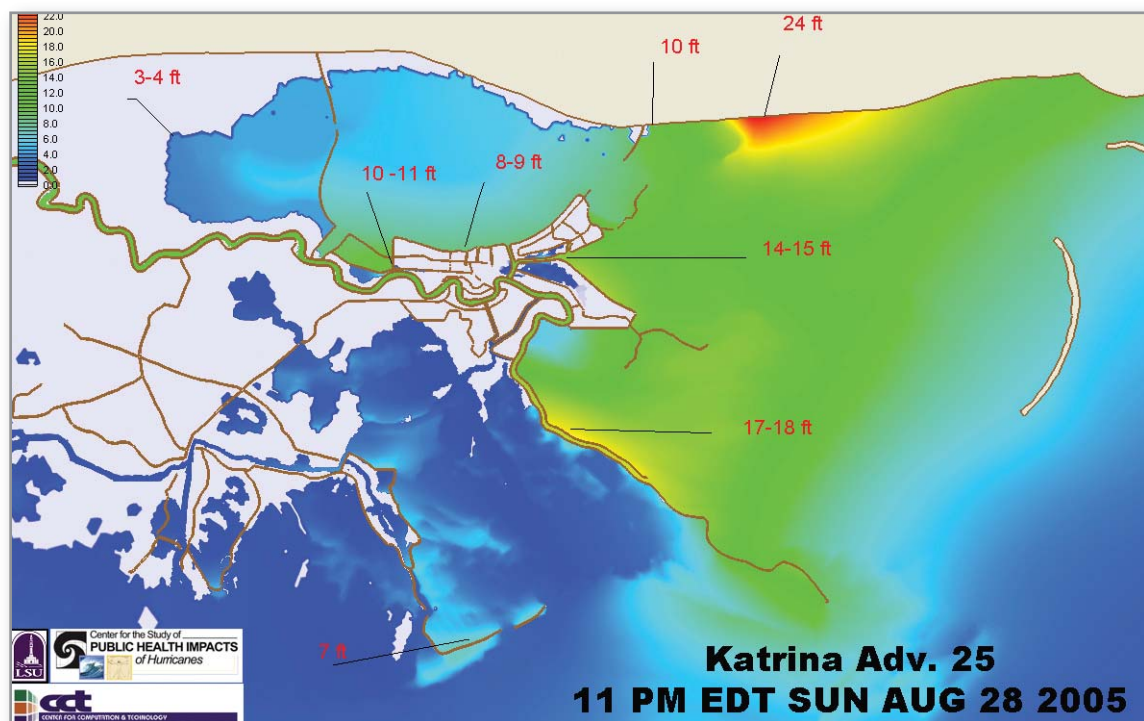


Figure 6 – Predicted storm surge elevations, above normal sea level, based on the Sunday night forecast several hours before landfall of Hurricane Katrina.

Source: LSU Center for the Study of Public Health Impacts of Hurricanes

Hurricane Katrina's storm surge was massive, very destructive, and deadly. Computer models predicted water elevations as high as 24 feet above normal based on the National Hurricane Center's forecast on Sunday evening (Figure 6). Although the hurricane's wind speeds dropped as Katrina approached the coast, lessening wind damage, the storm surge did not similarly decrease due to the inertia of the water. As the

storm made landfall along the Gulf Coast, its storm surge stretched from LaPlace, Louisiana, to Pensacola, Florida. Nearly 350 miles of coastline was inundated. The entire Mississippi Gulf Coast experienced surge levels of at least 17 feet, with a surge of over 24 feet inundating a 20 mile swath of the Mississippi coast. A peak surge height of nearly 28 feet was measured near Bay St. Louis, Mississippi.

In Louisiana, a 17-foot surge inundated coastal wetlands southeast of New Orleans (in St. Bernard and Plaquemines Parishes). To the north of New Orleans, surge levels reached 9 feet in Lake Pontchartrain and to the east of the city, Lake Borgne filled with a 15-foot surge. Because of the configuration of levees along the Gulf Intracoastal Waterway and the Mississippi River-Gulf Outlet that skirts Lake Borgne, an artificial storm surge funnel created a high-velocity surge pushing towards New Orleans. Surge waters moved at a speed of approximately 8 feet per second along this surge superhighway, where they entered the Inner Harbor Navigational Canal and quickly overwhelmed levees.

Hurricane Katrina's storm surge inundated numerous Gulf Coast communities without levee protection and caused limited overtopping of levees around New Orleans. Although flood waters caused by overtopping and rainfall would have caused damage to neighborhoods in New Orleans, most of the floodwaters and the ensuing tragedy resulted from numerous breaches in the levee system. Along the southern shore of Lake Borgne, an earthen levee largely eroded away before it was overtopped. Closer to the urban population of New Orleans, concrete floodwalls along the Inner Harbor Navigational Canal, the 17th Street Canal and the London Avenue Outfall Canal gave way in numerous locations. For days after Katrina had passed through, floodwaters in New Orleans continued to rise as water flowed through these breaches.

In all, much of southeast Louisiana flooded either directly because of the surge, because of levee failures, or other causes. Southeast of New Orleans, Plaquemines Parish suffered the most catastrophic flooding as surge waters overtopped and breached levees on the east bank of the Mississippi, then crossed the river to overtop and breach levees on the west bank. To the east of New Orleans, St. Bernard Parish, along with the adjacent lower Ninth Ward, suffered a two-fronted assault. Surge waters breached levees and entered these areas both from Lake Borgne

to the North and the Inner Harbor Navigational Canal to the east. North of St. Bernard Parish, New Orleans East suffered moderate flooding, as the surge overtopped levees at various points. On the north shore of Lake Pontchartrain, the towns of Slidell, LaCombe, Mandeville, and Madisonville all suffered flooding directly from the surge in Lake Pontchartrain. To the west of New Orleans, suburban Metairie and Kenner flooded due to rainfall and backflow through their drainage pipes. Finally, central New Orleans flooded from numerous breaches in its

floodwalls. Figure 7 shows the estimated depth of flooding in the New Orleans area, along with locations of the major levees, where they breached, and recovery locations for deceased victims.



Canal Street in New Orleans lives up to its name. Mode of transportation is still by boat nine days after Katrina.

Photo Credit: LSU Hurricane Center / Paul Kemp



Remains of a home near breached floodwall in New Orleans. The high velocity water completely gutted the home.

Photo Credit: LSU Hurricane Center / Ezra Boyd

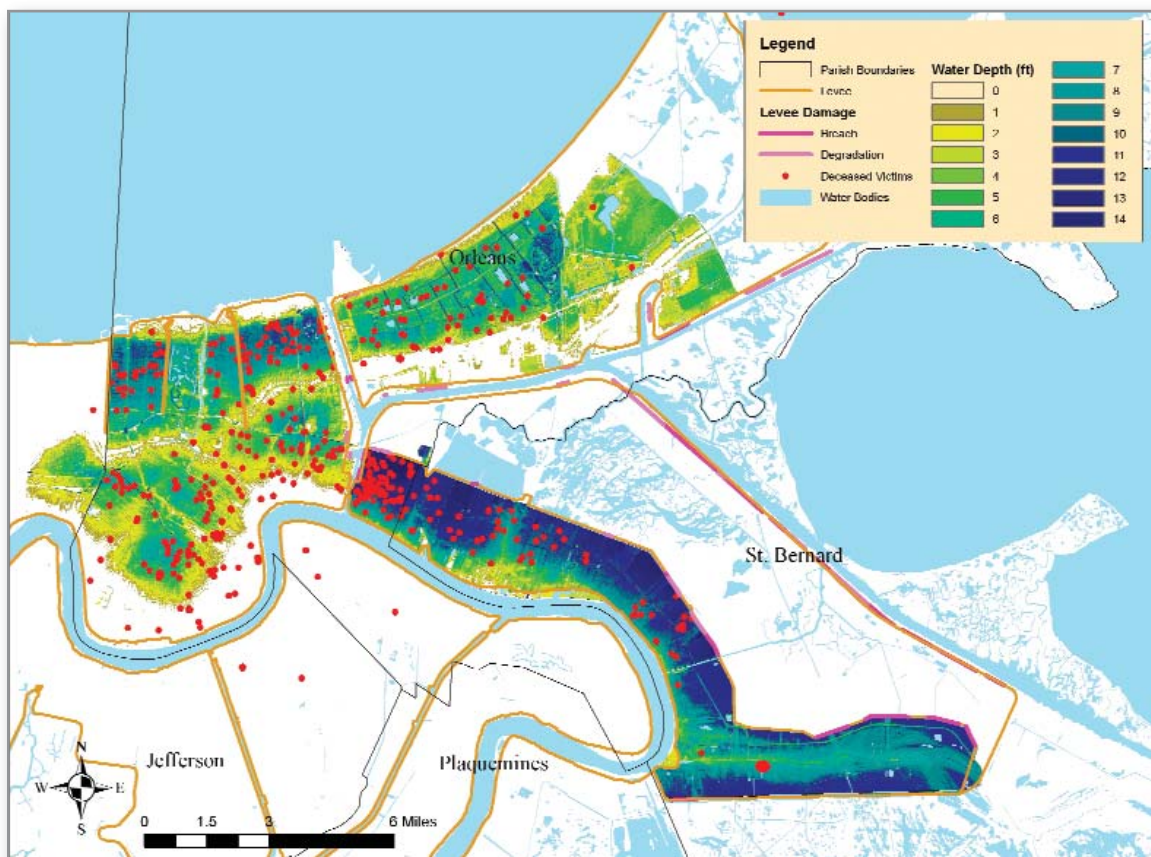


Figure 7 – Observed flood depths for the Greater New Orleans region. Map also shows locations of major levees, levee breaches, and deceased victim recovery locations. Note the concentration of victims in areas of deeper flooding (darker blue).

Source: LSU Hurricane Center / Ezra Boyd

Impact on the General Population

Hurricane Katrina and the failures in the levee system caused considerable damage and disruption to the people and infrastructure of south-east Louisiana. Before landfall, over 1 million

people in the region evacuated their homes, and over 60,000 people moved to the numerous public shelters outside of the region. In spite of the successes of the pre-storm evacuation, an estimated 130,000 people remained in soon-to-be devastated Orleans, Jefferson, St. Bernard, and

Plaquemines Parishes. Some of the people who stayed chose to stay behind, while others encountered insurmountable obstacles to leaving.

Of the 130,000 that remained, approximately 65,000 had to be rescued from floodwaters. For many of these people, the initial rescue and transport to the nearest high ground was only a first step in the journey to safety. An untold number of people spent days and nights on highway overpasses and other locations, which, while above the floodwaters, still left people exposed to the elements and with limited food, water, and medical supplies. In the next rescue phase, many people were brought to crowded collection points at the Superdome, the Convention Center, the Louis Armstrong Airport, or the I-10/ Causeway Cloverleaf. An estimated



Search and rescue crews cut through thousands of roofs looking for survivors, and later, storm casualties.

Photo Credit: LSU Hurricane Center / Ezra Boyd



Top: New Orleans on August 31, 2005 - Local residents arrive at ramp to the Superdome after being rescued from their homes. New Orleans is being evacuated due to flooding caused by Hurricane Katrina.

Photo Credit: FEMA / Jocelyn Augustino

Right: People standing on the overpasses and bridges to keep out of the New Orleans flood waters.

Photo Credit: FEMA / Marty Bahamonde

100,000 people passed through these chaotic collection points before being evacuated out of the region. An estimated 178,084 homes in southeast Louisiana suffered flood damage, and over 500,000 people were displaced from their homes for many months. By August 2008, an estimated 160,000 pre-Katrina residents of New Orleans had not returned.

Clearly, the human suffering was greatest where the flood conditions were worse; however, the area also suffered from a regional emergency that extended well beyond the flooded areas. Power and communications were destroyed across

much of southeast Louisiana. Downed trees and power lines blocked roads throughout the region, making delivery of essential commodities difficult. Many hospitals in the areas were closed and/or severely damaged, while those that remained open suffered from a surge of patients and a lack of staff. Businesses, both family-owned and corporate, were shut down. And, many essential public services, including water and sewerage, were unavailable. Numerous fires raged through New Orleans and firefighters had very little water pressure to adequately control them.





Aerial view of extensive flooding in the Lower 9th Ward after Katrina.

Photo Credit: LSU Hurricane Center / Ivor van Heerden

Impact on the Medical Community

Like the general population, the medical community suffered from a wide range of overwhelming consequences because of Hurricane Katrina and the many failures in the flood protection system. These consequences began with preparations for the storm, and they continue long into the recovery. This section describes some of these impacts.

During the roughly 42 hours between the first forecast that predicted landfall near New Orleans and the onset of hazard conditions throughout the region, hospitals, clinics, nursing homes, physicians, and pharmacies all took

steps to prepare. Most of these facilities simply closed and encouraged employees to evacuate. However, some facilities, specifically hospitals and nursing homes, faced more complex preparedness plans and decisions.

One of the most complex decisions faced by administrators in these facilities was the extent to which they should shut down and evacuate patients or residents. Nursing homes were faced with the seemingly straightforward option of either sheltering-in-place or evacuating. Some nursing home residents evacuated with their families. Although the options were simple, the logistical challenges and risks involved were highly complex. In comparison, hospital administrators faced a more complex set of possible options. What patients should they discharge? What patients should be evacuated? What patients can shelter-in-place? When does the hospital quit accepting new patients? Can the hospital remain functional throughout the passage of the hurricane? Or, should it shut down and implement a complete evacuation? What should be done to protect medical records, diagnostic equipment, and data servers? Given this situation, these medical facilities implemented a wide range of preparedness plans.

In total, one hospital in the region evacuated all of its patients before landfall, as did 21 nursing homes. It is worth noting that patients from the evacuated hospital did not reach their destination before the hurricane reached the region.

The direct and immediate physical hazards of Katrina included wind, rain, and storm surge. Like much of the city, health professionals on storm duty around the city experienced initial relief when the city and their facility escaped the direct impact of the storm with minimal damage and disruption. However, relief soon turned to dismay as flood waters rose around town and news of levee breaches spread. Soon, many hospitals and nursing homes would become overwhelmed, requiring immediate aid and rescue. Three hospitals in the region did remain open, a result of both previous mitigation efforts and pure luck.

As floodwaters surrounded these institutions, power went out, supplies ran short, and calls for rescue were sent. Inside the facilities, human misery and suffering began. In numerous hospitals, doctors, nurses, and others worked valiantly to protect patients without access to life-saving and life-sustaining health care equipment. Hand-operated bags replaced machine ventilators. Sadly, hours and days would pass before their calls for rescue were answered.

Outside of these flooded hospitals, human misery and suffering was widespread. An estimated 65,000 people were trapped in flooded homes and neighborhoods. Search and rescue teams clearly were overwhelmed by the numbers and simply not equipped to handle the medical concerns of people who had been rescued from floodwaters. During this time of unprecedented

need for medical services, many hospitals were unable to accept patients.

Approximately 43 days after the passage of Hurricane Katrina, the floodwaters had receded, leaving the region and its healthcare system in shambles. Most of the hospitals that closed faced many difficulties in reopening. In addition to substantial damage to facilities, key personnel and essential services were not available. Doctors, nurses, technicians, and other support personnel were no longer available in the Greater New Orleans area. Similarly, electricity, natural gas, sewerage and water, and other public services were interrupted.



Flooding persists in New Orleans 10 days after Katrina.

Photo Credit: FEMA / Michael Rieger



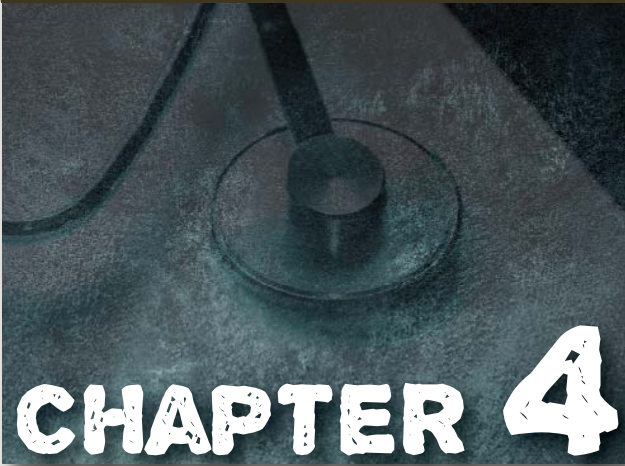
A resident is transported by a FEMA Urban Search and Rescue Team away from her house, which she was unable to vacate due to Hurricane Katrina.

Photo Credit: FEMA / Jocelyn Augustino

In the months that followed, the availability of health care services would remain an important issue impacting recovery. As people returned to rebuild, doctors did not return. Few hospital beds were available. Various clinics run by government agencies, non-profits, and private corporations filled some of this void, but much of

the burden fell on the emergency departments of the three hospitals that remained open. This burden proved to be overwhelming. For many months, the demand at the three emergency departments exceeded the capabilities of these facilities with a detrimental impact on service.





Hurricane Katrina: Health Outcomes and the Medical Response

The health outcomes associated with Hurricane Katrina's impact on Louisiana spread across both space and time. The negative health outcomes are concentrated greatest in the most heavily impacted regions and during the first days after the passage of the hurricane. However, adverse outcomes have been observed many miles and months away from the extreme hurricane winds and the catastrophic flood waters. The first part of this chapter divides health outcomes into four categories: 1) direct morbidity and mortality, 2) morbidity and mortality associated with displacement, 3) disruption of medical services, and 4) emergent effects associated with exposure to various hazards. A second section of the chapter will describe the medical response.

Opposit left:

One of the thousands of elderly residents evacuated from the city, being wheeled from the evacuation helicopter to the triage area set up inside the New Orleans Airport.

Photo Credit: FEMA / Win Henderson



As Katrina's floodwaters climbed higher, residents of one story structures were forced to retreat into attics, where many died from exposure.

Photo Credit: LSU Hurricane Center / Ezra Boyd

Direct Morbidity and Mortality

Morbidity and mortality information associated with Katrina over a period of 4-6 weeks after landfall are used to explain the storm's direct effects (See statistical data in Appendix A). Many people died or suffered injuries from exposure to wind, water, windborne debris, and waterborne debris. Geographically speaking, significant wind damage occurred throughout southeast Louisiana and flooding was widespread but restricted to particular areas. While the winds died down quickly, some areas remained flooded for over five weeks after the passage of Hurricane Katrina. Many ongoing hazards resulted from the extensive wind and flood damage. Cleaning up the debris was a hazardous activity, including all of the debris strewn across roads that created traffic hazards. Numerous tree limbs were left dangling, some of which would later fall on residents and relief workers causing both injuries and deaths. Rusty and contaminated flood debris caused infections in both residents and relief workers.

In addition to the physical hazards resulting from the storm's wind, flood waters and debris, Katrina left in its wake a regional public health emergency along with widespread breakdowns in the public safety infrastructure. This situation would cause deaths and injuries during the days and weeks after the windstorm had passed. In the four parish region around New Orleans, a general population of 130,000 experienced a

lack of safe drinking water, lack of medical services, breakdown of law and order, and many other consequences of this regional emergency. In addition, an estimated 2,500 patients remained in hospitals that had lost power, lacked supplies and staff, while flood waters and anarchy surrounded their facilities. Additionally dispersed among the 130,000 people were numerous independently living persons with special needs, such as dialysis, oxygen, mental health, and heart medications, in addition to medical needs resulting from injuries or illness from the wind and water. Throughout the region, the public health situation deteriorated drastically, causing various types of morbidity and mortality.



Search and rescue markings indicate one body found in this New Orleans house after Katrina.

Photo credit: LSU Hurricane Center/Ezra Boyd

Approximately ten days after Hurricane Katrina passed, nearly all of the general population and all endangered hospitals had been evacuated, and the regional emergency moved into the cleanup and initial recovery phase. There were a number of the identified hazards still present, but the exposed population was smaller and qualitatively different since most of the residents were gone. At the completion of the evacuation operations, an estimated 10,000 people remained in Orleans Parish, a combination of essential city workers and emergency response officials from the state and federal government, private and government relief workers, and a handful of diehard residents who disobeyed mandatory evacuation orders. By the end of September, residents of some zip codes in Orleans Parish were allowed to return, though cleanup and initial recovery activities continued around them. Throughout the clean-up period, deaths and injuries occurred as a result of wind, water, debris, and destruction.

In Louisiana, the State Medical Examiner's Office (SMEO) was responsible for the mission of recovering, examining, and identifying the deceased, along with providing information on the deceased to the public. Operationally, a deceased person was considered hurricane related if they died between August 28 and October 1, 2005, and the circumstances of death were considered related to the hurricane's impact on Louisiana (as determined by the SMEO). Officially, 1,464 victims met these criteria (CDC,



People sitting on a roof waiting to be rescued as flood water surround their New Orleans home.

Photo Credit: FEMA / Jocelyn Augustino

MMWR, 2006). Of these, it is estimated that approximately 500 persons died as a result of exposure to floodwaters, while an additional 500 people died of circumstances related to the widespread public health emergency that followed the hurricane and flooding.

As part of its medical response to the catastrophe, the Centers for Disease Control (CDC) worked with state health agencies, hospitals, and emergency response teams to implement numerous morbidity and mortality surveillance systems. These surveillance systems provided various types of information on the morbidity and mortality associated with Hurricane Katrina (see Appendix A, Morbidity and Mortality Outcomes from Hurricane Katrina).

Displacement from Home, Social Network, Providers and Medical History

The first three deaths associated with Hurricane Katrina's impact on Louisiana were three nursing home patients who died due to circumstances related to displacement from their residence. These individuals evacuated with fellow residents and their social support network, along with health providers and the residents' medical histories. For these three elderly residents, simple displacement from their residences proved deadly.

An estimated 1 million people evacuated and were displaced from their homes for at least a few days. For an estimated 500,000 residents,



Thousands of patient medical records were damaged or destroyed.

Photo Credit: Floyd A. Buras, MD



Many medical offices were destroyed, leaving patients to find new providers in unknown environments.

Photo Credit: Floyd A. Buras, MD

damage to their home and/or parish meant that the temporary evacuation would be followed by extended displacement. As noted above, some residents of Orleans and Jefferson Parishes were allowed to return home by the end of September. However, for many hundreds of thousands, displacement would last many months and years.

In general, displacement involved setting up a new life in an unknown environment. Many people set about the basic tasks of finding housing, employment, and schooling for children.

For some, even these tasks coupled with the new living environment and housing situation created conditions conducive to injury and death. In Houston, one toddler drowned in the bathroom of the family's FEMA sponsored hotel room. Although not a direct impact of Hurricane Katrina, the circumstances of this death are clearly linked with displacement due to the disaster.

Other displaced residents faced more daunting tasks as so many people evacuated without their medical records, lost contact with their medical

providers and were forced to identify new providers who had to construct new medical histories. Previously managed chronic conditions became unmanageable when individuals became displaced from their medical providers, their pharmacies, and their health records.

Among the victims considered hurricane related by the SMEO, an estimated 500 deaths occurred after the person had evacuated from the hurricane impacted area. Approximately 150 of these deaths occurred inside Louisiana and 350 occurred outside of the state.

Disruption of Medical Services

The widespread and catastrophic disruption of medical services also resulted in numerous adverse health outcomes linked to the disaster. Healthcare facilities suffered damage that ranged from minor wind damage to flood waters that destroyed any equipment located below the flood line. Regardless of the level of damage, all hospitals in the heavily impacted region lost municipal services such as water and electricity. Many faced disrupted delivery of key medications and supplies. Communication lines went down. Medical facilities lost staff and were unable to locate others to come into work. Over the short-term, blocked roads, poor communication, and gas shortages kept doctors and nurses from reporting to work. Over the long term, the lack of housing along with the generally dismal prospects for the region's future

prompted many health care professionals to relocate permanently from the area. The shortage of medical professionals has become an ongoing recovery challenge.

Many hospitals faced an additional loss as centralized computer servers were completely unworkable. Over the short term, this loss left doctors and nurses largely in the dark while trying to treat remaining patients. Over the long term, the lost computer systems resulted in hospitals facing numerous challenges in restoring services. Hospitals that lost their centralized systems were unable to reopen quickly.

Emergent Effects of Exposure to Hazards

As the acute emergency gave way to long term recovery, a number of health issues and concerns emerged. A large population suffered from the stress and trauma of the event and their personal losses. Rescue and recovery activities, which were inherently dangerous, also involved exposure to persistent toxic substances. Numerous adverse health outcomes unfolded and will continue to unfold for many years.

At the very least, the pre-storm evacuation was a stressful experience for the over 1 million people that evacuated. For a lucky few, actual hurricane damage was minimal to their residence and community, and they were able to quickly return home, experiencing only limited stress, with a quick return to normalcy. However, for

most of the population, hurricane damage to their parish and possibly their home was catastrophic. Their evacuation became short-term displacement. Their stress intensified as they worried about their homes, processed the limited, often inaccurate information that became available, and contemplated the uncertain future.

Of the estimated 130,000 people who did not leave Greater New Orleans before Katrina, approximately 65,000 experienced exposure to flood waters, followed by rescue. Many tens of thousands of people spent the night on highways and bridges, and another 100,000 people experienced horrible conditions in the four emergency shelters. For this large population that directly experienced the storm and its aftermath, stress and trauma was most certainly a prevalent health concern.

For the displaced population, returning home was a process that occurred in stages and spanned many months. Some were able to begin this process quickly, while others would have to wait months. Jefferson Parish, which suffered only moderate flood damage, was allowed back in for a “look and leave” about one week post-Katrina. This policy allowed residents to make day visits to assess damage and secure their property. Many residents in Jefferson Parish were allowed to re-inhabit their homes within a few weeks. In contrast, weeks would pass before residents of the most devastated parts

of the Lower Ninth Ward were even allowed to see their homes. When they did, they found a destroyed neighborhood with debris everywhere, cars, boats, and homes tossed around yards and streets, and a thick layer of dried flood muck covering the first floors of their homes. An estimated 400,000 individuals returned to flood damaged residences in the three years that have followed. Even though the return process occurred in stages and spanned many months, with varying individual responses, this initial assessment of their flood damaged homes and communities was undoubtedly a traumatic experience that was repeated by hundreds of thousands of people.



A resident of Chalmette, Louisiana, walks through the front of her damaged home. There is mold growing on all the walls and furniture. She and her family were trying to salvage personal items from their home which was flooded during Hurricane Katrina six weeks earlier.

Photo Credit: FEMA / Patsy Lynch



Flooded gas station next to the Medical School. Most of the many gas stations that flooded were nearly out of fuel due to pre-storm evacuation traffic, reducing contamination of floodwaters.

Photo Credit: LSU Hurricane Center / Marc Levitan



Some New Orleans residents were still out foraging through floodwaters for supplies a week and a half after the hurricane.

Photo Credit: LSU Hurricane Center / Marc Levitan

In addition to this stress and trauma, residents and relief workers experienced exposure to a variety of environmental health concerns. Rashes and other symptoms were observed on thousands of residents and rescue workers that swam and waded through contaminated flood waters. In some places, emergency response teams identified locations where unknown chemicals had mixed with flood waters. LSU researchers conducted extensive testing for chemical and microbiological contaminants in the flood waters in different regions of New Orleans. A report of this seminal work is summarized by Pardue et al. (2005). In many areas, chemical and pathogen concentrations were similar to those typically found in urban storm water runoff, because the larger amounts of contaminants were offset by the sheer volume of water.

In the immediate aftermath, water quality and food safety were crucial concerns. Damages to municipal water and sewerage networks were catastrophic. Once the waters receded, mold-infested structures posed a threat to individuals engaged in clean-up activities.

As the recovery went forward, soil samples found arsenic, lead, and various other contaminants throughout the flood impacted area. In St. Bernard Parish, petroleum oil mixed with flood waters after a pipe on a storage tank ruptured. Homes in this neighborhood suffered additional pollution from oil mixed with water, which contaminated the buildings and the soil.

As part of the federal response to the housing crisis created by Hurricane Katrina, FEMA provided an estimated 50,000 travel trailers as temporary housing to impacted residents in Louisiana. Initially considered a blessing to residents who had endured cramped shelters, these trailers eventually caused many health concerns over the long term. Some of the trailer models relied on propane gas for heating and cooking. Propane explosions resulted in deaths among hurricane survivors. Some of the trailers were set up in group sites, often resulting in survivors living in isolated locations where they lacked access to education, employment, health care, and social services. Finally, after FEMA initially denied reports on concerns related to formaldehyde in travel trailers, congressional hearings in September 2007 revealed that many residents experienced formaldehyde exposure over an extended period of time. The exact health effects of formaldehyde exposure are unknown, but many tens of thousands may face increased cancer risks due to the exposure.

The New Orleans health department estimated 2,300 excess deaths among the residents of the New Orleans during the first six months of 2006 based on their review of obituaries from *The Times-Picayune*. Data from the first months of 2004 was used as a baseline.



Researchers from the Louisiana Water Resources Research Institute and LSU Hurricane Center sampling and testing floodwaters for contaminants in the medical district, under the watchful eye of LSU Police, which provided security.

Photo Credit: LSU Hurricane Center / Marc Levitan

Medical Response

The National Hurricane Center's Advisory #15, released on Friday, August 26th at 10:00 p.m. local time, marks the start of the medical response to Hurricane Katrina. Less than 45 hours later, hazard conditions started to impact the region. Across the region identified by Advisory #15, health related facilities implemented their preparedness plans. Most pharmacies, tu-

berculosis clinics, dialysis centers, outpatient clinics, and related health care facilities simply canceled services, secured the facility, updated emergency contact lists, and encouraged employees to evacuate. Hospitals and nursing homes, with extremely vulnerable persons under their care, faced more difficult decisions. In general, the practice was for hospitals to remain open and for nursing homes to evacuate only as a last resort.

To prepare for the storm, hospitals cancelled elective surgeries and discharged the patients that could leave. They called staff for storm duty, checked their supplies, and prepared to shelter on site. One hospital did evacuate from the New Orleans area. However, they did not reach their destination before the storm arrived and the patients rode out the storm while in transit. Another hospital, hoping for the best but anticipating the worst, began planning for a possible post-hurricane evacuation. Nursing homes discharged residents who could evacuate with family, then faced the complex choice of evacuating the facility or sheltering on site. Nineteen nursing homes evacuated before the storm and 34 did not.



Black mud residue on the ground in St. Bernard Parish, after oil contaminated floodwaters receded. The flood depth in this neighborhood was slightly higher than the roof eave height. The cars floated in the flood, and then the wind pushed them back up against the houses. As the water receded, the cars got hung up on roofs and fences.

Photo Credit: LSU Hurricane Center / Marc Levitan



Baton Rouge, Louisiana, on September 3, 2005 -- Cots at the LSU Field House await evacuees of Hurricane Katrina. This is a special needs shelter for those with disabilities, senior citizens, and people seeking medical attention.

Photo Credit: FEMA / Liz Roll

For these facilities, the evacuation decision was complex and lacked clear solutions. Nursing homes, with a relatively homogenous population, were faced with the seemingly straightforward options of either sheltering-in-place or evacuating. The options appeared simple and evacuation appeared to be the straightforward choice, but the logistical challenges and risks involved in evacuating elderly and frail residents were highly complex. This prompted many nursing home administrators to make the decision to shelter on site and prepare to care for their residents through the passage of the hurricane.

In comparison, hospital administrators faced a more complex set of possible options. Canceling all elective surgeries was one simple solution. But, what patients could be discharged? What patients should the hospital evacuate out of the region? What patients could shelter-in-place? When does the hospital quit accepting new patients? Can the hospital remain functional throughout the passage of the hurricane? Or, should it shut down and implement a complete evacuation? What should be done to protect medical records, diagnostic equipment, and data servers? Given this situation and the lack of standardized guidelines, it should be no surprise that a wide range of preparedness plans were observed.

In an attempt to prepare for the coming crisis, the Louisiana Hospital Association (LHA) and the Louisiana Nursing Home Association (LNHA) canvassed their member institutions in the region for a status check, including information about generators, fuel supplies, medical supplies, and water sources. Once gathered, this information was passed on to the Department of Health and Hospitals (DHH) and the state emergency operations center.

As hospitals and nursing homes addressed their problems, local and state health departments began setting up special-needs shelters for persons among the general, non-institutionalized population that would require medical attention during the passage of the hurricane. In Orleans

Parish, the health department established a special-needs shelter in the Superdome and the regional transit agency dispatched buses to pick-up points throughout Orleans Parish. Similarly, local health departments throughout the region instituted plans to provide for special-needs residents. DHH provided assistance to the locally run special needs shelters and opened seven additional special-needs shelters throughout the state.

In general, special needs persons did not receive transportation assistance out of the region. Local governments largely used their transportation assets to move special needs persons to refuge within the parish. However, a few exceptions are noteworthy. In areas under mandatory evacuation, DHH maintained an adolescent care home, a residence for persons with developmental disorders and a mental health hospital. All of these facilities were evacuated completely by DHH before Katrina hit. In St. Bernard Parish, administrators of an inpatient, chronic care facility for elderly residents moved their residents to what they believed was the relative safety of Memorial Hospital in Orleans Parish. In Orleans Parish, city owned transit buses and state chartered ambulances were used to evacuate 500 patients from the special-needs shelter in the Superdome to the special-needs shelter at LSU in Baton Rouge. In spite of these special-needs evacuation efforts, an additional 500 patients remained in the special-needs shelter in the Superdome, and many hundreds more re-

mained in their homes, businesses, and churches throughout the region that would be hit the hardest.

Anticipating the catastrophe to come, the state began the process of obtaining external assistance during the preparatory period. On Sunday, the day before Katrina's landfall, DHH requested activation of the strategic national stockpile, a large cache of various medications maintained by CDC. The state also requested that the DHH begin staging Disaster Medical Assistance Teams (DMATs) along with other possible medical response capabilities.

Initial Response to Public Health Emergency

Hurricane Katrina reduced the local medical capabilities to nearly zero. Wind damage and the loss of crucial services affected all hospitals. Many hospitals were crippled by extensive flooding. In hospitals throughout the region, the centralized computer systems began to falter, rendering diagnostic equipment, electronic records, and telecommunications unavailable. Three hospitals remained open, but they were overwhelmed with the needs of their own patients and largely unable to provide assistance to others.

As conditions in the Superdome deteriorated, the special-needs clinic run by state and local health officials was relocated to the neighboring

New Orleans Arena. The state continued to provide services, mostly chronic disease management, to the patients that arrived before Katrina's landfall, but they also began receiving people from the growing crowd in the Superdome. Search and rescue teams provided limited first aid but were not capable of handling the variety of injuries and other illnesses that were presented. State health workers set up an aid station at the interstate I-10 /I-610 split to service flood rescues and to begin using the few available ambulances to evacuate the most severe cases to Baton Rouge. The single DMAT initially deployed to the Superdome quickly became overwhelmed.

As the patient population at the Superdome grew, additional medical emergencies developed at 25 hospitals, which collectively held 2,500 patients and 11,000 staff and family members. Some hospitals become de-facto refuges for residents flooded out of their homes. Another 34 nursing homes held hundreds of elderly residents and required emergency assistance. With the 65,000 persons requiring rescue from floodwaters, along with the growing population in emergency shelters, hospitals and nursing homes were not the priority of the available response teams.

Among the general population suffering the direct effects of the disaster were many individuals with chronic health issues. The 130,000 people scattered throughout the heavily impacted re-



Waiting for transportation at the I-10/I-610 interchange.

Photo Credit: LSU Hurricane Center / Marc Levitan

gion included thousands of diabetics and people requiring dialysis treatment, oxygen tanks, and numerous medications. Additionally, the storm and flood caused numerous injuries requiring care, including the persons suffering from stress and trauma. With medical capabilities limited and overwhelmed, the number of people with medical needs grew.

During the initial response, external medical assistance was almost non-existent. One DMAT reached the Superdome late on the evening of August 29, the day of landfall. Three others arrived days later. The strategic national stockpile of medical assistance never arrived in Louisiana. State assets were deployed, but they were completely insufficient for the magnitude of the emergency.



Thousands of victims plucked from the floodwaters left behind by Hurricane Katrina await evacuation out of the city following their rescue. Hundreds of buses worked throughout the day and night to carry these people to safe shelter.

Photo Credit: FEMA / Win Henderson

Early Aftermath

As search and rescue operations were completed, an estimated 100,000 people were spread across four emergency shelters/collection points. These locations would soon serve as evacuation hubs. A variety of health conditions, both old and new, were present among the displaced population in New Orleans. Three of these collection points

had clinics, though they were understaffed, underequipped, undersupplied, and suffered from a lack of management and support. At the Convention Center, an estimated 19,000 residents took refuge, but there was no organized medical response to serve these people. As conditions in hospitals continued to deteriorate, administrators made the decision to evacuate and began to send out calls for assistance.

On Tuesday, August 30, the day after Hurricane Katrina made landfall, federal officials activated the medical evacuation mission of the National Disaster Medical System (NDMS). The Louis Armstrong Airport, located about 10 miles west of the Superdome, was designated as the medical evacuation collection point/triage center. DMAT teams at the airport would triage patients and then load them onto Air Force aircraft that would deliver them to receiving hospitals. However, getting patients from hospitals and nursing homes to this location was difficult.

Among the 25 hospitals that evacuated post-Katrina, a variety of approaches were utilized to evacuate patients, staff, and family. The Veterans Administration Hospital, as part of the Department of Defense (DOD), was able to access DOD helicopters and other assets for evacuating patients. Tulane Hospital reached out to the Association of Air Medical Services, which was able to supply privately owned air ambulances to Tulane. Additional air evacuations were performed by Acadian Ambulance, a Louisiana ambulance company that possessed a small number of medical helicopters. However, many hospitals lacked their own capabilities to evacuate patients and had to rely on the Louisiana Department of Wildlife and Fisheries, the Louisiana National Guard, or the US Coast Guard to transport patients from the hospital to the medical evacuation point at the airport. As time went on, an estimated 3,000 persons with medical conditions along with an additional

23,000 residents without medical conditions arrived at the Superdome.

The medical evacuation component of NDMS utilized pre-selected reception hospitals that had agreed to provide open beds to patients who had been evacuated from their facilities. Once the patient arrived at the collection point, NDMS

assured their transportation and admission to the receiving hospital. In all, an estimated 3,000 medical evacuations took place at the airport.

Not everyone with medical needs was brought to this collection point. Some wound up among the general population on evacuation buses; others were evacuated directly out of the region

without assistance from NDMS. To meet the needs of these people, Temporary Medical and Operations Staging Areas (TMOSAs) and surge hospitals were set up throughout Louisiana.

Transitional Period

For the many thousands of displaced persons with medical needs, arrival at a TMOSA or the NDMS collection point marked an important transition point. Having been evacuated from the widespread public health emergency in greater New Orleans, over 4,000 patients needed a new medical care community. As noted above, NDMS relied on prearranged agreements with hospitals to supply their open beds. For others, finding their new medical care community was a much more daunting task.

Health workers at the two TMOSAs triaged an estimated 60,000 persons that had been evacuated out of New Orleans. Many of these people were deemed healthy and put back on evacuation buses that delivered them to shelters both inside and outside of Louisiana. For others, triage doctors determined whether medical conditions existed that required treatment. For these patients, available local hospital beds were utilized and when these filled up, DHH set up surge hospitals. Additionally, the TMOSA system did not detect every evacuee with medical needs, and it became necessary to setup health clinics at the shelters. The “Katrina Clinic” set up in Houston’s Reliant Arena, was the largest



Survivors of Hurricane Katrina arrive at airport where FEMA's D-MAT teams have set up a medical hospital and where people will be flown to shelters in other states.

Photo Credit: FEMA / Michael Rieger



Patients are loaded on C-130's for evacuation from the New Orleans airport on September 2, 2005.

Photo Credit: FEMA / Michael Rieger



One of the thousands of elderly residents evacuated from the city, being wheeled from the evacuation helicopter to the triage area set up inside the New Orleans airport.

Photo Credit: FEMA / Win Henderson

such clinic. At this clinic, the doctors provided basic medical treatment, including tetanus shots and prescription drugs, to an estimated 10,000 evacuees.

Whether in a traditional hospital, a surge hospital, or in a clinic at a shelter, health care providers assisting evacuees all faced a similar challenge: new patients arrived without medical records or even knowledge of their exact prescription medications. Lacking detailed medical histories, care providers reconstructed diagnosis and treatment from the information supplied by the patient.

Long-Term Recovery

For long-term recovery, the medical response involved two sets of activities. In New Orleans, the medical response focused on rebuilding the local medical capabilities. Outside of New Orleans, the medical response focused on providing health services to displaced residents.

Medicaid was a primary vehicle for providing services to residents displaced by Hurricane Katrina. In addition to arranging services for pre-enrolled beneficiaries, Louisiana health officials urged Congress to expand eligibility to include a category of temporary beneficiaries. Congress allocated \$2 billion to provide services to both existing and new beneficiaries, along with funds to pay providers for uncompensated care associated with the disaster. With both beneficiaries

and providers scattered across the country, Louisiana health officials found themselves administering a “National Medicare program.”

With most hospitals closed and the three open hospitals overwhelmed, New Orleans lacked the medical care capabilities to meet the needs of recovery workers and residents eager to cleanup and rebuild. Temporary clinics were the only solution. The LSU Health Sciences Center, the organization that administered Charity Hospital and its Level 1 Trauma Center, set up a limited emergency care clinic. In December 2005, this clinic saw over 4,500 patients. As time went on, LSU and other government agencies and non-governmental organizations would set up basic clinics.

Reopening closed hospitals was a difficult task, yet progress was made on this front over many months. By April 2006, approximately six months after Hurricane Katrina passed, six of the closed hospitals in Greater New Orleans had reopened and seven remained closed. In total, nine open facilities provided 1,678 staffed beds; 1,583 of which were constantly occupied.

At the start of 2009, over three years after Hurricane Katrina hit southeast Louisiana, a number of ongoing medical needs remain. Plans to build a new Charity Hospital, adjacent to a VA hospital, are moving forward. However, obstacles remain, and it will be some time before this facility reopens, if at all. The need to restore acute care facilities is perhaps the greatest in New Orleans



Thousands of displaced New Orleans residents were sheltered at Reliant Arena in Houston. In this photo, a volunteer from Houston helps an evacuee move her belongings.

Photo Credit: FEMA / Ed Edahl



A Medical Corps person aboard the USNS Comfort, a 1,000 bed hospital ship now docked in New Orleans to provide medical backup support to the city, prepares an oxygen delivery system for use by the next patient admitted with a respiratory ailment.

Photo Credit: FEMA / Win Henderson

East and in St. Bernard Parish. Each parish had a pre-Katrina population of approximately 60,000 residents. Each parish lost their only hospital. Now each parish has a population of approximately 40,000 people and both areas lack a hospital. Residents must rely on small clinics run out of modular buildings. Plans to reopen hospitals in these areas are just getting started. Additionally, there is still a huge need for mental health providers and medical specialists.

Exemplary Medical Service

The Katrina catastrophe has been described as both the “largest disaster in recent American history” and as a “failure of all levels of government.” During the darkest days and months after Katrina, widespread human suffering was met with bureaucratic failure. Often lacking resources and leadership, medical professionals emerged as the unsung heroes of the disaster. Throughout the ordeal, there were four particular areas where health professionals made significant contributions. First, the doctors, nurses, administrators, and other professionals who stayed behind to work disaster rotations in hospitals endured horrible conditions for extended periods. Through the dedication, determination, persistence, and inventiveness of these professionals, many lives were saved. Secondly, with health care infrastructure destroyed and in the face of widespread suffering, numerous temporary clinics provided life saving care to many people. It was not uncommon for the medical

professionals at these locations to provide care without support or supplies. Third, throughout the nation, patients arrived at hospitals and shelters with limited understanding of their diagnosis or treatment. Medical professionals at these host locations worked diligently to re-establish medical care and medical histories. Finally, for both individuals from the impacted area and individuals throughout the nation, the recovery tasks in southeast Louisiana represented a unique chance to make a difference. The many medical professionals who have endured the lack of adequate housing, the debris strewn neighborhoods, the limited services and the uncertain long-term prospects so they could remain in their communities to help re-build, continue to suffer within a disrupted medical infrastructure and continue to make a difference in the recovery of the New Orleans area.



Disinterred coffins - just one more problem to deal with after Hurricane Katrina.

Photo credit: LSU Hurricane Center / Ezra Boyd



A satellite image of Hurricane Rita, showing a large, dark, swirling cloud mass over the Gulf of Mexico. The text "CHAPTER 5" is overlaid in large, white, distressed font at the bottom right of the image.

CHAPTER 5

Hurricane Rita: Preparation, Impact, and Response of the Medical Community

Just weeks after Hurricane Katrina decimated southeast Louisiana, record setting Hurricane Rita made landfall on the southwest end of the state, causing considerable impact across the entire Louisiana coastline. In southwest Louisiana, the Lake Charles metropolitan area was heavily impacted by both the surge and wind of Hurricane Rita. In south central Louisiana, the Houma-Thibodaux region experienced considerable flooding, and even some parts of southeast Louisiana flooded a second time. Louisiana, still in the emergency response mode for Hurricane Katrina, now faced a new potential catastrophe. Thousands of residents displaced by Hurricane Katrina were now being forced to flee a hurricane once again. These evacuees added to the millions of people leaving southwest Louisiana and southeast Texas. Although, comparable to Katrina in intensity, Hurricane Rita's damage and deaths were much less than Katrina. The difference in impact from the two storms can be attributed to a number of factors, including different geographies and physical vulnerabilities, different populations, and different emergency preparedness steps or strategies.

Opposite left:
Satellite image of Hurricane Rita approaching southwest Louisiana.

Source: NOAA



An EMT takes a nap while waiting pre deployment in response to Hurricane Rita. Long and unpredictable hours at work and on call necessitate sleeping whenever possible.

Photo Credit: FEMA / Ed Edahl

Physical Hazards and the Vulnerability of Southwest Louisiana

Southwest and south central Louisiana experienced similar meteorological hazards as southeast Louisiana. In particular, both regions are exposed to hurricanes and their extreme tidal surges, waves, rains, and winds. However, geography and settlement patterns meant that the vulnerability of the population within this region of the state was much different than the vulnerability of the population impacted by Hurricane Katrina.

Southeast Louisiana sits on the deltaic plain of the Mississippi River, and the geography of southwest Louisiana consists of terrace highlands

about 30 miles from the coast, with widespread marsh truncated with Chenier Ridges toward the coast. Like the delta in southeast Louisiana, the Chenier Ridges are believed to be landforms that were created from deposited sediment. It is believed that longshore currents running parallel to the coast and toward the west carried sediment from the Mississippi and Atchafalaya Rivers to the west. Then, the Gulf waves deposited the sediment along the coastline to build new landforms. Over thousands of years, this process resulted in the Chenier Ridges, which

are sand ridges about 5 – 10 feet above sea level, surrounded by marshland, swamps, and lakes. Unlike southeast Louisiana, the landscape of southwest Louisiana did not possess the same extensive system of levees and other flood protection structures. Southwest Louisiana largely reflects the concentration of population on the terrace, relatively distant from the coastline. The result is that the southwest Louisiana population enjoys the relative safety of elevation and distance from the Gulf of Mexico. However, it lacks the levees and other flood protection means to



Figure 8 – Map of south central and southwest Louisiana and southeast Texas.

Source: LSU Hurricane Center

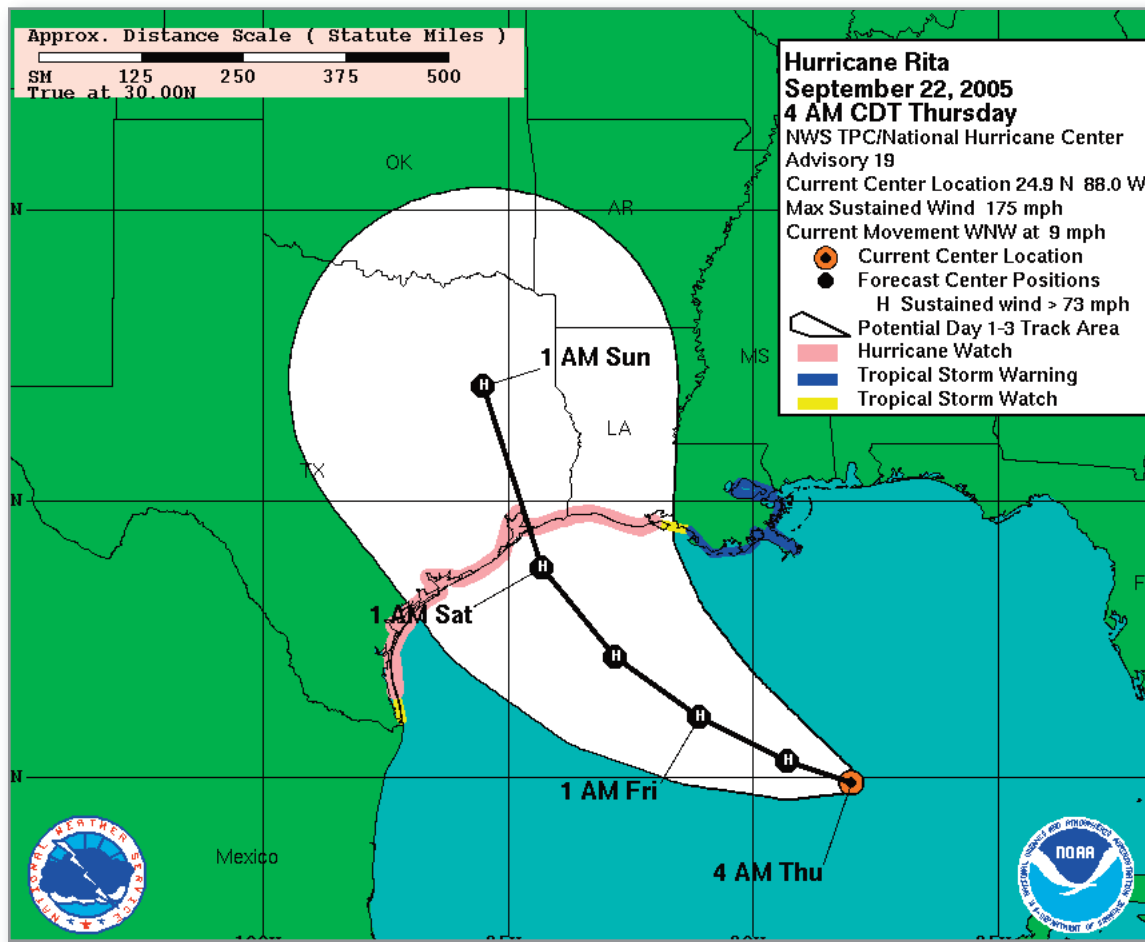


Figure 9 – Hurricane Rita current conditions and forecast track on Thursday morning, September 22. The storm made landfall two days later, east of the forecast track at the Texas/Louisiana border, placing southwest Louisiana in the most dangerous right front quadrant of the hurricane.

Source: National Hurricane Center

limit their exposure to storms with sufficient intensity to push the surge over the ridges. In 1957, Hurricane Audrey pushed a monster

storm surge over the ridges, resulting in 400 - 500 deaths and destroying nearly 90% of all buildings along the coastal area.

Population of Southwestern Louisiana

In addition to the differences in the landscape and settlement patterns, the two areas differ in terms of the vulnerability of their population. The pre-Katrina New Orleans metropolitan region included over 1.1 million people in the 2000 Census. Only 193,000 people inhabit the Lake Charles metropolitan area. The city of Lake Charles serves as the population and economic center of southwest Louisiana (see Figure 8). In 2000, an estimated 70,000 people lived in the city of Lake Charles. Another 110,000 people inhabited the rest of Calcasieu Parish, the southern edge of which is about 20 miles from the coast. Only about 10,000 people lived in the pre-Rita coastal parish of Cameron. South of the urban center of Lake Charles, the rural settlements of Creole, Cameron, and Grand Chenier exist on the narrow Chenier Ridges. Pre-Rita Holly Beach, also known as the Cajun Riviera, consisted of a small beachside community of elevated homes, many of which were vacation homes.

The population within these two areas of the state also varies in physical well-being and socioeconomic indicators. The pre-Katrina New Orleans metropolitan area was home to approximately 183,000 persons with disabilities, and the number of disabled people in the pre-Rita Lake Charles metropolitan area was only about 42,000. Similarly, the New Orleans metropolitan area contained 147,224 persons over 65, as

One difference between Hurricanes Katrina and Rita is seen in the **level of federal assistance provided** during the preparatory stage.

compared to the 22,120 persons over 65 in the Lake Charles metropolitan area. In the New Orleans area, 67,000 households lacked access to a vehicle, compared to less than 7,000 for the Lake Charles area (US Census, 2000).

Although located over 150 miles from where the eye of Rita made landfall, the coastal parishes of Terrebonne and Lafourche also experienced the impact of Hurricane Rita. Centered on the Houma-Thibodaux metropolitan region, these two parishes had a population of approximately 195,000 residents. Located southwest of New Orleans, these parishes largely consist of coastal wetlands that are part of the Mississippi deltaic plain, along with a handful of bayous accompanied by elevated ridges. For the most part, these parishes lack protection from hurricane storm surges. Within these two parishes, there were approximately 35,000 people with disabilities, nearly 25,000 people over 65 years of age, and less than 7,000 households without access to a vehicle.

Thus, the people most impacted by Hurricane Rita had fewer risk factors than those most affected by Hurricane Katrina.

Physical Impact

Hurricane Rita entered the Gulf of Mexico, due south of the Florida Keys, early in the morning of Tuesday, September 20, 2005. Initially, it was forecast to travel mostly due west and make landfall somewhere along the central Texas coast. By Wednesday morning, the National Hurricane Center Rita Advisory #16 placed southwest Louisiana within the cone of uncertainty, indicating significant probability that it would make landfall there, though the landfall was expected almost four days later. By Thursday, the predicted landfall location had moved closer to the Texas / Louisiana border and reached Category 5 status on the Saffir-Simpson scale, the most intense category (see Figure 9). Governor Blanco declared a state of emergency for Louisiana. Hurricane Rita weakened to a Category 3 hurri-

cane before making landfall along the Texas / Louisiana border with estimated sustained wind speeds of 115 mph. In terms of ground based wind measurements, the highest recorded sustained wind speed in Louisiana was 76 mph at the Lake Charles Calcasieu Parish Agriculture Center. In Lake Charles, sustained wind speeds reached 58 mph. Gusts reached 95 mph and 74 mph at those two locations respectively.

By Friday morning, mandatory evacuation orders had been enacted for Calcasieu and Cameron Parishes along with all of Jefferson Davis Parish and southern portions of Vermilion, St. Mary, Acadia, and Iberia Parishes. Nearly 10,000 displaced persons from Katrina being sheltered south of Interstate 10 joined the nearly 250,000 residents under evacuation orders because of Rita. One difference between Hurricanes Katrina and Rita is seen in the level of federal assistance provided during the preparatory stage. During the preparatory phase before Hurricane Katrina, the activities of FEMA and other federal agencies were essentially limited to pre-staging assets and commodities for quick deployment following the landfall of the hurricane. However, federal assistance was provided during the evacuation prior to Hurricane Rita. Instead of opening shelters in flood risk areas, the state provided nearly 1000 buses to assist those without access to personal transportation. In contrast to the preparations for Hurricane Katrina, shelters were not provided in the areas potentially flooded by Rita, which included everything south of Interstate

10. By the time Rita arrived, near 100% compliance with evacuation orders had been achieved for the Cameron and Calcasieu Parishes. The areas that eventually suffered the worst flooding were essentially empty.

Heavy rain from Hurricane Rita fell across most of coastal Louisiana, with most gauges in southwest Louisiana measuring over 5 inches. Rain gauges in the Lake Charles area measured rainfall amounts between 6 and 9 inches. The Baton Rouge area experienced the worst rainfall, with one station recording over 9 inches of accumulated rainfall. This rainfall amount is attributed to a “railroad” effect of rainclouds, as a feeder band of the hurricane moved across the Baton Rouge area.

The National Hurricane Center reported that there were at least 90 tornados associated with Hurricane Rita. Many of these occurred far north and east of the center of circulation, with 23 tornados occurring as far east as Alabama and 11 as far north as Arkansas. In the area around Jackson, Mississippi, 56 tornados were observed. There is no documentation indicating that any tornadoes occurred in Louisiana.

The storm surge from Rita inundated the entire coast of Louisiana. Beyond Louisiana, the Florida panhandle experienced elevated water levels in the Gulf, while Galveston Island experienced a “bay surge” due to winds from the north. Figure 10 indicates the extent of Hurri-

cane Rita’s storm surge flooding. Rita’s storm surge peaked at about 15 feet above sea level along coastal Cameron Parish. After overtopping the Chenier Ridges, the surge pushed inland across Calcasieu Lake and up the Calcasieu River, flooding parts of Lake Charles. The strong winds from the south managed to push water as far north as sections of Interstate 10 in Lake Charles, more than 30 miles from the coast. Approximately one-third of Lake Charles experienced flooding. East of Cameron Parish, the coastal parishes of Vermillion, Iberia and St. Mary all experienced flooding due to 8 – 12 foot surge levels. Moving further east, surge levels reaching 8 feet flooded parts of Terrebonne and Lafourche Parishes, both of which are located between the Atchafalaya and Mississippi Rivers. Rita’s surge also caused additional flooding in areas that had flooded due to Hurricane Katrina. In Slidell, a 5 – 6 foot flood surge pushed over highways and flooded debris left by Hurricane Katrina. In New Orleans, the surge overwhelmed emergency sandbag repairs to levees breached during Hurricane Katrina, causing additional flooding there and delaying efforts to remove water from the city after Hurricane Katrina.

Impact on the General Population

Lake Charles was the most densely populated area to be flooded by Hurricane Rita. However, rural Cameron Parish received the heaviest flooding. The southwest coastal region was al-

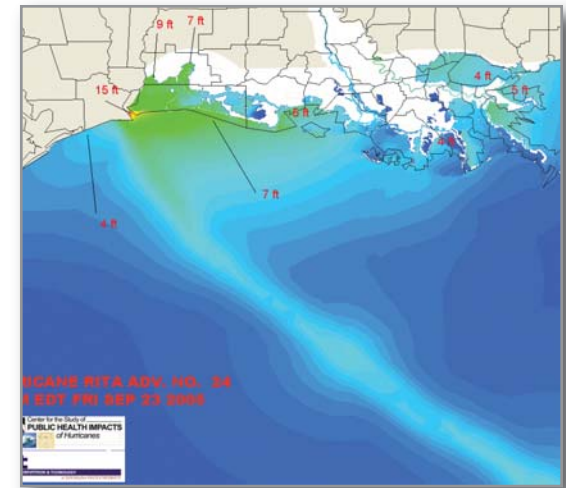


Figure 10 – Modeled storm surge flooding due to Hurricane Rita

Source: LSU Center for the Study of Public Health Impacts of Hurricanes

most entirely evacuated, and only a handful of people had to be rescued in this area. Small towns further east were caught off guard as Rita’s surge pushed further inland than expected. In Vermillion Parish, the towns of Erath and Abbeville (nearly 80 miles east of Lake Charles and 30 miles north of the coast) experienced unexpected flooding as the water pushed inland by the storm surge met rain water draining south. Approximately 1,000 people were rescued from floodwaters in this area. In addition, flooding in and around Lafitte, located about 30 miles south of New Orleans, trapped about 500 people in floodwaters.



Rescuers in Erath, Louisiana, guide a boat through shallow Hurricane Rita floodwaters with evacuees from the storm.

Photo Credit: FEMA / Win Henderson

Overall, Hurricane Rita forced nearly 3 million people from their homes, the overwhelming majority of which evacuated from the Houston region and returned home shortly after the hurricane passed. In Texas, approximately 3,000 homes suffered damage, mostly due to either wind or minor flooding. In Louisiana, over 55,000 homes suffered damage, most of which were in Calcasieu Parish, which includes Lake Charles. In Calcasieu Parish, 44,000 homes were damaged, about 38,000 of which had

minor wind damage and fewer than 1,000 had flood damage. In Vermillion Parish, nearly 7,700 homes were damaged, nearly half of which were flooded. In Cameron, a much smaller number of homes were damaged, but of the 3,200 homes, an overwhelming portion (almost 94%) suffered from severe flood damage.

Hurricane Rita's floodwaters receded quickly in most of the impacted areas. Damage to infrastructure and housing was not catastrophic and

people were able to quickly return to their homes and work toward their community's cleanup and recovery. However, flood devastated Cameron, where small communities line the Chenier Ridges, tells a much different story. Damage to housing and infrastructure was catastrophic and when the waters receded, houses, business, and health care facilities were damaged beyond repair. Electricity, telephone, natural gas, and water service were unavailable for a long time. Cameron Parish remained closed to the public until June 2006, nine months after Hurricane Rita passed.



Hurricane Rita flooded many neighborhoods and small towns across south central and southwest Louisiana.

Photo Credit: FEMA / Greg Henshall

Medical Response

The sequence of events surrounding Hurricanes Katrina and Rita are similar in many ways, with only one key detail differentiating the two disasters. Both sequence of events began with the monitoring of the storm, followed by evacuation during the days and hours preceding the arrival of hazard conditions. Next, the outer bands of the hurricane arrived, bringing wind and rain, followed by the arrival of the storm surge, which peaked as the eye made landfall. During this sequence, homes, businesses, pharmacies, doctor's offices, and hospitals flooded and suffered extensive wind damage. In the aftermath of these events, communities were left in shambles, people were rescued from floodwaters and collapsed structures, and the emergency response eventually phased into recovery. At some point, the federal emergency response teams arrived to relieve overwhelmed local and state governments along with hospitals and nursing homes. Both disasters followed this basic sequence of events.

What accounts for the different effects of the two storms is the time at which federal assistance arrived. During Katrina, federal assistance arrived only after the storm had passed; during Rita, federal assistance began before the storm. In addition to the nearly 1,000 buses provided to evacuate the general population before Rita, numerous assets, including buses, ambulances, and aircraft, were provided to evacuate hospitals, nursing homes, and other persons with medical

needs persons before the storm. This key difference in the sequence of events explains much of the difference in outcomes. Over 65,000 people had to be rescued after Katrina, fewer than 2,000 required rescue after Rita. Similarly, the dire events that occurred in dozens of nursing homes and hospitals following Katrina did not

occur in hospitals and nursing homes that received comprehensive evacuation assistance before Rita.

The arrival of Hurricane Rita was preceded by the largest emergency evacuation in US history - over 3 million people fled southeast Texas and



Veterinarians from the National Veterinarian Response Team (NVRT) examine dogs brought in to the Animal Disaster Response Facility staged in the Ford Arena outside Beaumont, Texas, following Hurricane Rita's landfall.

Photo Credit: FEMA / Bob McMillan

southwest Louisiana. In addition, hospitals and nursing homes took unprecedented steps, aided by an unprecedented level of federal emergency assistance, to evacuate their patients, residents, and staff. In Louisiana, a total of nine hospitals fully evacuated before Hurricane Rita, and four partially evacuated. In southwest Louisiana, only Lake Charles Memorial Hospital remained open with a skeleton crew operating an intensive care unit to provide emergency care in the immediate aftermath of the storm.

to evacuate patients and establish field hospitals to support 2,500 beds. Before the arrival of Hurricane Rita, DOT airlifted 4,000 special-needs patients from evacuation hubs in Beaumont, Houston, and Lake Charles. Overall, more than 500 medical response personnel and 1,350 urban search and rescue personnel were pre-staged in Texas and Louisiana.

Given the unprecedented level of federal support for evacuating residents and patients before Rita,

Katrina. Throughout most of the impacted area, the lack of intensive and pervasive flood damage meant that the initial clean-up quickly moved into long term recovery. Businesses and government offices quickly reopened, as did pharmacies, clinics, and hospitals. However, most structures in coastal Cameron Parish (including the towns of Creole, Grand Chenier, and Holly Beach) suffered catastrophic damage that included the complete destruction of all health care related facilities in the parish. The first

Because of the complete evacuation of the parish and the health care facilities, the **catastrophic damage** to these health facilities was not accompanied by the **human catastrophe** that was witnessed following Katrina.

Similar to the medical evacuation following Katrina, the full scale and complete evacuation of hospitals and nursing homes located along Texas' southeast coast and Louisiana's southwest coast required numerous transportation assets which were provided by federal emergency response teams. Working with FEMA, the US Department of Transportation (DOT) provided ambulances and buses to support medical evacuations, along with a tanker of diesel fuel. Additionally, FEMA tasked the DOT to provide helicopters

the initial response was not overwhelmed with the need to rescue thousands of flood trapped residents and evacuate dozens of disabled persons from hospitals and nursing homes. Still with millions displaced, hundreds of thousands in shelters, and a coastal landscape in shambles, medical needs were still critical during this period.

Most of the area impacted by Hurricane Rita escaped the catastrophic damage witnessed during

medical clinic in the parish did not reopen for over a year. It was nearly two and one-half years before the hospital reopened.

Health Outcomes

The direct health impacts of Rita are limited in number, certainly in comparison to Katrina. A drowning in Calcasieu Parish accounts for the only Rita related death in Louisiana. Throughout the Gulf Coast region, Rita caused seven

wind-related deaths. An estimated 700,000 homes in Louisiana lost power, but there are no known incidents of fatal carbon monoxide poisoning. In Texas, where millions were without power, 41 non-fatal cases of carbon monoxide poisoning and 10 fatal cases were observed.

By far, displacement was Hurricane Rita's biggest killer. Over 110 deaths are attributed to circumstances related to the evacuation of over 3 million people from the Houston / Galveston region. Many of the deaths were caused by heat exhaustion, as the poor evacuation planning for this area caused massive gridlock during the summer heat. During the evacuation, a vehicle transporting nursing homes patients caught fire after an oxygen tank exploded, resulting in 23 deaths. Even though this particular incident has been attributed to negligence by the transportation company, it still demonstrates the extreme risks encountered when evacuating the most vulnerable persons.

In general, damage to medical facilities was isolated and limited, with Cameron Parish being the one exception. Every medical facility in this coastal Louisiana parish was severely damaged by Rita. The damage from the wind and surge left this area without any medical care capabilities. Because of the complete evacuation of the parish and the health care facilities, the catastrophic damage to these health facilities was not accompanied by the human catastrophe that was witnessed following Katrina. Cameron Parish

experienced the large-scale and extended loss of medical capabilities following Rita; however, all of the other hospitals in the impacted area returned to full capacity once electricity was restored and staff returned. Few patients experienced sustained disruption of their treatment programs or displacement from their providers and medical records.

In regard to the health effects of various toxic exposures due to Rita, one might expect some of the same outcomes witnessed following Katrina. In many ways, the similar circumstances of the two events resulted in similar toxic exposures. For example, one would expect the same household chemicals that mixed with floodwaters in New Orleans to be found in the kitchens and garbage areas flooded by Rita. Similarly, industrial facilities located in both of the impacted regions suffered wind damage and the release of materials. Finally, the same formaldehyde-laden trailers were used to house residents impacted by disasters. However, due to minimal research conducted on the health outcomes related to possible toxic exposure from Rita, these health outcomes are not well known.

The long-term physical devastation resulting from Hurricane Rita was much less dramatic than that resulting from Hurricane Katrina. As discussed above, the timing of evacuation and federal assistance was critical to the improved outcome. Additionally, the breach of the levee system in the New Orleans area was a major fac-

tor in the differential. Even though the absence of a levee system in the southwestern part of the state left those areas more vulnerable to storm surge, particularly in Cameron Parish, a catastrophe was averted because of an effective evacuation system. Getting people out of harm's way can be credited for the fact that there was only one drowning.

The physician interviews described in Part II of the report point out, repeatedly, that the legacy of Hurricane Rita is greatly tempered by the leadership of the mayor of Lake Charles and those involved in disaster preparedness in southwest Louisiana. Calcasieu Parish, including the medical community, provided a model of local initiative and accountability that should serve as a refreshing inspiration to the leaders, medical professionals, and citizens of our state.



Cameron Memorial Hospital was severely damaged from Hurricane Rita's tidal surge and had to be demolished and rebuilt. Demolition and debris removal was funded by FEMA.

Photo Credit: FEMA / Marvin Nauman





Summary of Reports and Official Records on Hurricanes Katrina and Rita

In assessing the impact of Hurricanes Katrina and Rita on the Louisiana medical community, this report combines quantitative information from official reports, media coverage, and academic literature, with more qualitative information from direct involvement with the medical community. In the three and one-half years following the storms, there has been a great deal of research conducted on the impact of the storms on Louisiana, particularly south Louisiana. Much of this information was collected and has been summarized in the various sections discussed in this chapter. Official reports and records were used to substantiate the amount of damage and the circumstances to which the medical community had to respond. The purpose of this chapter is to describe information about the impact of the storms, in order to provide a context for the situation within which the medical community was placed. Without knowing the extent of impact, it is difficult to place physician interviews in context, as their stories are intricately involved with the official accounts of what took place.

Opposite left:

Fully portable fully self contained DMAT (Disaster Medical Assistance Team) centers play a vital role in providing needed disaster services after Katrina.

Photo Credit: FEMA / Marvin Nauman

Chapters 3-5 provide an in depth examination of all aspects of the impact of Katrina and Rita. Part II of this report is specifically dedicated to the physicians who worked in the various situations created by the storms, ranging from sheltering-on-site in a hospital to working long hours in a shelter or special-needs temporary facility. Additionally, the physicians have discussed what happened to their practices, where they live now, and the struggles they have had with recovery and restoration. As indicated above, the focus in this chapter is to describe, in detail, the conditions under which the healthcare community tried to function. Categories have been developed highlighting the primary issues, barriers, and problems that critically impacted the operation of physicians and the health care community. The main issues identified through data collection efforts as well as the plethora of research that has been released in the three years after the storm, includes transportation problems, communication, sanitation, consumable supplies, utilities, medical records, and barriers to physician efforts to assist.

General Findings

- 1. During the same year that Katrina and Rita hit (2005), natural disasters affected over 1 billion people worldwide. Of those affected, nearly 100,000 died;**
- 2. The US is becoming more vulnerable to natural hazards mostly because of changes in the population and in the national wealth density, in which infrastructure and people have become concentrated in disaster prone areas. In New Orleans, the vulnerable population is generally comprised of the poor and elderly, although Katrina impacted all ages, incomes, and educational levels;**
- 3. Hurricanes Katrina and Rita displaced 2.5 million residents and killed at least 1,800 along the US Gulf Coast;**
- 4. As a result of Katrina, 90,000 square miles of the Gulf Coast region were destroyed;**
- 5. After Katrina, 80% of New Orleans was under water after storm surges overtopped levees and caused breaches;**
- 6. As a result of the levee failures, 400,000 New Orleans residents were displaced;**
- 7. In New Orleans, more than 1,300 people lost their lives during Katrina and in the flooding that followed;**
- 8. All nine acute care hospitals in the Greater New Orleans area were rendered inoperable, and it became necessary to evacuate all patients and staff. Flood waters damaged generators and rising flood water made supplying the hospitals impossible.**

Other information that has been documented from a variety of sources includes the following:

Transportation

In the past, approximately 60% of the population would leave or have the capability to leave the area before a disaster strikes. This was certainly the case with Katrina, as it is estimated that 200,000 to 300,000 residents did not have access to reliable transportation, which would have taken them out of the storm impacted area. The elderly population was greatly affected because those who were immobile or ill simply could not evacuate.

Emergency response personnel with transportation are usually the designated responders to deal with the evacuation of the elderly. However, in the case of Katrina, the New Orleans flooding happened so quickly that the emergency personnel could not get to vulnerable populations in time. The emergency personnel in the Lake Charles area were much more effective in their response to Rita because of effective prior planning and significant time to evacuate prior to Rita's approach.

After Katrina hit and the levees broke, hospitals faced the overwhelming task of finding transportation. By the time they realized everyone would be trapped in the rising flood waters, it was impossible to get transportation into the area and even harder to communicate the need for transportation to those outside the area.

Many people drowned especially the elderly, disabled, and poor, due to the lack of accessible transportation and the inability of vehicles to enter areas where they lived.

Communication

Almost the entire communications infrastructure was destroyed by Katrina. The system was minimally restored before Rita hit several weeks later.

The widespread effects of this failure can be seen by:

1. More than 3 million customer telephone lines were down in Louisiana, Mississippi, and Alabama after Katrina;
2. New Orleans lost two primary communication tower sites;

3. New Orleans police and fire communication sites were evacuated because of rising waters;

4. Thirty-eight 911 call centers were destroyed in the Orleans region after Katrina

5. Over 2,000 New Orleans police and firemen had to communicate on a single channel after Katrina;

6. Local wireless connections were seriously damaged, with up to 2,000 cell phone sites out of service after Katrina hit;

7. Over 20 million calls did not go through the day after Katrina because of destroyed connections, the impossibility of recharging phones, and overload of the entire system;

8. Thirty-seven of 41 radio stations in the Orleans area were knocked off the air;



A mobile home lies across the road blocking two lanes of traffic near Empire, Louisiana, after Hurricane Katrina.

Photo Credit: FEMA / Robert Kaufmann

Secondary effects of this situation caused much of the chaos and confusion that occurred as Katrina hit and in the subsequent flooding. For example, since the media could not verify reports from various residents and officials, inaccurate information was rampant and resulted in a host of additional problems. One of the most chaotic situations took place when Jefferson Parish officials were advised that a band of looters were attempting to gain entry into the parish. This information was based on what was reported to them from other law enforcement officials. As it turned out, those headed toward Jefferson Parish (west of New Orleans) were evacuees looking for shelter. The lack of communication made it impossible for well-meaning officials to know the truth.

In the Superdome evacuation site, the public address system did not work, so officials tried to maintain order among hysterical evacuees with bullhorns. FEMA dispatched amateur radio operators to hospitals, evacuation centers, and parish emergency operations centers in an attempt to restore some communication, but it was too late in most cases, especially for the hospitals that were completely inaccessible.

Sanitation

Hurricane Katrina destroyed major water mains and water treatment facilities in south Louisiana. There was great concern among the medical community about the effect of bacteria seeping into south Louisiana's water supply. Thus, water supplies were completely cut off within two days

after Katrina passed. In the days that followed, conditions such as those listed below existed:

1. The EPA determined that 159 of 683 water facilities and 36 of 86 wastewater treatment plants serving 2.8 million people in south Louisiana were either completely inoperable or their status was unknown;
2. There were so many dead bodies floating in the water in New Orleans, most of the water was completely unusable;
3. Within two days of the passing of Katrina, all New Orleans hospitals were without power and water;
4. The lack of water rendered conditions in hospitals unlivable because of the lack of plumbing, personal hygiene supplies, and fresh water for patients;
5. In addition to the problems posed by the lack of bacteria-free water, the flood water attracted mosquitoes, which increased concern about the spread of West Nile Virus;
6. Many evacuation sites were unable to determine if their water supply was safe, thus running the risk of spreading illness among this huge post-storm population;
7. There was a general lack of understanding within the community as to how to determine if water was safe.

Consumables

With the entire medical community disrupted, the shortage of medicine and medical supplies quickly became a crisis. In particular, insulin and tetanus vaccine were in great demand and there was not enough of either of these drugs. The lack of medical supplies and consumables was a huge problem during Katrina. In the month that followed, it was even worse as the few physicians who were left in town and those who were able to return were left with the task of providing tetanus and other shots to workers who were coming back into the area to help with recovery. An additional barrier was the lack of postal services and the fact that all entrances to New Orleans were blocked by the National Guard. Lack of mail services prevented delivery of medicine to the health care community when it was needed the most. Specific examples of the problems with consumables include:

1. Physicians found it necessary to break into hospital pharmacies for essential supplies, such as water, food, and medicine;
2. Urgent requests for pain medication, IV lines, catheters, and other equipment were delayed for days because of the breakdown in communication, disorganized response, and lack of access to funds;
3. Physicians also reported that the lack of satellite phones affected their ability to get help.

Utilities

Over one million customers lost power for days, weeks and months after Katrina. Three and one-half years after Katrina hit, there are still entire neighborhoods in New Orleans and the surrounding parishes that are uninhabitable. The lack of utilities had an overwhelming effect on the health care providers and the patients who remained in the hospitals as Katrina approached.

1. Nearly 800 staff and 1,600 patients were trapped in hospitals with no power;
2. Generators initially provided power to the hospitals after the electricity went out but were eventually lost to the flood waters, because so many of the hospital generators were on the first floor of buildings;
3. Even if the generators were in operation, the hospitals quickly ran out of fuel;
4. It has been estimated that the hospitals needed about 200 gallons of fuel per hour to keep the emergency generators in operation;
5. Lack of power and water severely compromised the health of critically ill patients, most of whom were exposed to temperatures over 100 degrees in the sweltering hospitals;
6. The Department of Agriculture used civilian and military 4-wheel-drive vehicles in their attempts to deliver fuel to the hospitals;



Hurricane Rita blew down trees and power poles all across Lake Charles, Louisiana, blocking roads and leaving the area residents and businesses without electricity.

Photo Credit: FEMA / Greg Henshall

7. The Centers for Disease Control (CDC) surveyed evacuation centers after Katrina and Rita and found that 5 of the 6 illnesses affecting the evacuees were related to chronic diseases, including medication refills and oral problems that often affect vulnerable populations, such as the elderly, disabled, and poor. The leading conditions were hypertension, cardiovascular disease, diabetes, and psychiatric disorders;
8. Other post-Katrina and Rita surveys indicated that 41% of the evacuees had at least one chronic health problem.

Medical Records

Inaccessible medical records likely had one of the biggest effects on the health care community and the patients they served. All across the Gulf Coast and into Texas, Georgia, and other areas where many of the evacuees were being housed, shelter care workers, volunteer physicians, and hospitals were at a complete loss as to how to deal with the medical needs of persons from the Gulf Coast, particularly residents of south Louisiana and southern Mississippi.

1. The medical files of more than one million people along the Gulf Coast were lost or destroyed during Katrina;
2. Up to 250,000 evacuees housed in shelters required some sort of medical attention post-Katrina;
3. Approximately 8,000 people were in critical care shelters post-Katrina;
4. The Orleans area had 7,600 participants in experimental medical trials, whose progress was either halted or disrupted;
5. Nearly 8,000 people being treated for HIV/AIDS were displaced by Katrina;
6. Healthcare providers in the Astrodome reported major problems with vulnerable evacuees who could not say what medicine they were on, but who were clearly showing a variety of symptoms;



Veterinary services were available at the New Orleans airport staging area for stray animals and pets of the victims of Hurricane Katrina. This dog waits for his turn under his owner's cot.

Photo Credit: FEMA / Liz Roll

7. Displaced persons with mental and behavioral disabilities caused a huge strain on numerous entities in communities where they evacuated. Baton Rouge, Houston, and other north Louisiana cities reported major difficulties in homeless shelters, local jails, and emergency rooms.

Barriers to Physician Efforts to Assist

There are a number of other miscellaneous types of problems that the health care community faced that can be resolved and are being resolved through policy and procedural changes. Unfortunately, it has taken a major disaster for practitioners and policymakers to identify the many barriers faced when trying to provide help to communities in need of disaster assistance.

1. The lack of coordination, and often the lack of cooperation, among local, state, and federal agencies posed a number of problems for physicians: blocking volunteer doctors from coming into the area, the refusal of medication from outside the state, and the failure to accept help from others if not licensed in Louisiana;
2. Hundreds of doctors and other health care professionals attempted to try to help in Louisiana and were turned away because of licensing issues, liability concerns and poor coordination among officials;
3. Medical equipment and supplies that were flown into Louisiana could not get to their destination because there was no process set up to receive supplies, and the delivery trucks were blocked from high-impact areas;
4. Policies prohibited evacuees from taking their pets with them; thus, many persons stayed behind or tried to get through the waters to the Superdome with their pets. Snakebites were also a big problem following Katrina;

5. Physicians who stayed behind often had to do so either at the price of separating from their families or bringing their families and pets into the medical facility. The reported stress and fear among family members was significant;

6. There was a great deal of concern among physicians about liability as there were no policies in place to protect them in situations such as having to administer medication without having a patient's medical file or history;

7. There were numerous problems with Medicaid regulations affecting patients who were from out of state, resulting in the inability of patients to get medication and failure to qualify for services because of missing documentation.

8. Medicaid regulations did not allow physicians to move patients from their current nursing homes and in-patient facilities to other outside facilities without prior government approval;

9. Nursing homes were not required to evacuate; thus, many sick residents remained in these facilities. Many of them died in these facilities because of poor conditions;

10. Many hospitals did not have helicopter landing pads, thus rendering late evacuation impossible;

11. There were no policies or procedures in place to set up portable or field hospitals to sup-

port existing facilities; thus, many of the federal medical teams who came in had no place to practice medicine;

12. Facilities that remained open were not prepared for looters and snipers who targeted several facilities in south Louisiana (snipers were shooting at helicopters arriving at a Jefferson Parish Hospital);

13. Much of the health care infrastructure and medical equipment was lost or destroyed throughout the hurricane impacted areas of southeast and southwest Louisiana. Evacuees that left the Orleans area [southeast Louisiana] to go to the Lake Charles area [southwest Louisiana] because of Katrina had to evacuate this area, along with Texas evacuees, in order to escape the path of Rita.

This information has been obtained through published accounts of the conditions that impacted medical care and is well supported in the data collected in this research. The focus groups and face-to-face interviews yielded much of the same information, but in greater detail and with more poignant descriptions from physicians who experienced Katrina and Rita.

Findings and Recommendations from Selected Official Documents

Given the catastrophic level of destruction and unprecedented level of response, the 2005 Hurricane Season provided an important opportunity to assess the national, state, and local level of preparedness and response. Many papers, reports, and books were published by academic researchers, government agencies, advocacy groups, and others. Given the magnitude of Katrina's impact, along with the perception that preparation and response were lacking for this storm, most research efforts were directed towards Katrina, as opposed to Rita.

Key points concerning the medical community and health care are summarized from selected literature. Although most literature addresses Katrina issues, other storms are included if the information seemed to be useful. There is an additional listing of reports by official government or corporate organizations at the end of this chapter.

1. The White House. *The Federal Response to Hurricane Katrina: Lessons Learned* (2006)

This document presents the White House's comprehensive review of the disaster and the federal response. The narrative description of the disaster is split between two chapters, one that covers the pre-landfall preparations and another that covers the post-hurricane response. This report also includes a number of lessons learned

and a broad ranging list of 125 specific recommendations, which are organized around a handful of critical challenges.

In the report, “Public Health and Medical Support” is recognized as a critical challenge with the following lesson learned:

- In coordination with the Department of Homeland Security and other homeland security partners, the Department of Health and Human Services (HHS) should strengthen the Federal government’s capability to provide public health and medical support during a crisis. This will require the improvement of command and control of public health resources, the development of deliberate plans, an additional investment in deployable operational resources, and an acceleration of the initiative to foster the widespread use of interoperable electronic health records systems.

Toward improving public health and medical support during disasters, the White House recommends the following policy actions:

- HHS should lead a unified and strengthened public health and medical command for federal disaster response;
- HHS should ensure coordination and oversight of emergency, bioterrorism, and ongoing public health preparedness needs;

- The Surgeon General should routinely provide and communicate public health, as well as individual and community preparedness guidance to the general population;
- Create and maintain a dedicated, full time, and equipped response team composed of Commissioned Corps officers of the US Public Health Service;
- DHS and HHS should look for the means to increase the capabilities of local and State health infrastructures;
- Accelerate the HHS initiative to foster widespread use of interoperable electronic health records (EHR) systems, to achieve development and certification of systems for emergency responders within the next 12 months.

Many of these recommendations are related to policies at the federal level; however, they are policies that will trickle down to impact state, local, and private organizations involved in health care.

2. Senate Committee on Homeland Security and Government Affairs, *Hurricane Katrina A Nation Still Unprepared* (2006)

Based on 22 committee hearings, along with witness interviews and a review of internal documentation from many agencies, this document



Fully portable fully self contained DMAT (Disaster Medical Assistance Team) centers play a vital role in providing needed disaster services after Katrina.

Photo Credit: FEMA / Marvin Nauman

includes a broad-based review of the preparations and response by all levels of government. This report is organized along different themes, including a chapter devoted to “Medical Assistance.” The report then provides a summary list of “Conclusions and Findings” before presenting a list of seven foundational recommendations, which are supported by additional tactical recommendations.

Among the “Conclusions and Findings,” the Senate report includes:

Federal Problems

- While both FEMA and the Department of Health and Human Services made efforts to activate the federal emergency health capabilities of the National Disaster Medical System (NDMS) and the US Public Health Service, only a limited number of federal medical teams were actually in position prior to landfall to deploy into the affected area. Only one such team was in a position to provide immediate medical care in the aftermath of the storm;
- The federal government's medical response suffered from a lack of planning, coordination, and cooperation, particularly between the US Health and Human Services and the Department of Homeland Security;
- Despite its lead role as the primary agency in charge of coordinating the federal medical response, the Department of Health and Human Services did not deploy its on-scene response-coordination teams as rapidly as it should have, and the agency lacked adequate emergency-coordination staff and resources;
- The federal agencies involved in providing medical assistance did not have adequate resources or the right type or mix of medical capabilities to fully meet the medical needs arising from Katrina, such as meeting the needs of large evacuee populations, and were forced to use improvised and unproven techniques to meet those needs;

- Unlike Disaster Medical Assistance Teams, the US Public Health Service is not organized or equipped to serve as medical first responders and have no pre-established, readily deployable teams, personnel practices, transportation and, other logistical difficulties;

- Although FEMA eventually deployed virtually all of its National Disaster Medical System resources, having started with only a single team, there was a greater need for such teams than could be filled, and those teams that did deploy experienced difficulties in obtaining necessary logistical, communications, security, and management support;

- Despite efforts by both FEMA and HHS to activate federal emergency-health capabilities of the National Disaster Medical System (NDMS) and the US Public Health Service as Katrina approached the Gulf Coast, only a limited number of federal medical teams were actually in position prior to landfall to deploy into the affected area, only one of which (the Oklahoma – 1 Disaster Medical Assistance Team) was in a position to provide immediate medical care in the aftermath of the storm;

- Although a shipment of medical supplies was dispatched from the Strategic National Stockpile to Louisiana late on Sunday, August 28, in response to a last-minute request from the City of New Orleans, it was not possible to get it to Louisiana before landfall, and no other federal

medical supplies were pre positioned in the Gulf region.

Louisiana Problems

- The State of Louisiana failed to ensure that nursing homes and hospitals were incorporated into the State's emergency-planning process, and as a result failed to ensure that they had effective evacuation plans or were genuinely prepared to shelter their critical care patients in place, causing loss of life and avoidable suffering;

- Louisiana failed to plan for known emergency medical-response needs, such as post-storm evacuation of patients from hospitals or moving large numbers of patients to medical treatment facilities;

- Louisiana State University [Hospital System-Charity Hospitals] failed to carry out its responsibilities under the state emergency-operations plan to ensure adequate emergency preparedness for [its] health care facilities;

- The Louisiana Office of Homeland Security and Emergency Preparedness failed to ensure that its functions were implemented.

Additional recommendations, specifically related to medical care include:

Federal Level

- The scope of Emergency Support Function (ESF-8, Public Health and Medical Services), as defined in the National Response Plan (NRP), should be expanded to clearly include the public health and medical needs not only of victims of an emergency, but also those of evacuees, special-needs populations, and the general population who may be impacted by the event or may need to be evacuated or sheltered-in-place. The NRP should also clarify that responsibility for all mortuary activities, including collection of victims, resides with ESF-8. Appropriate mass fatality plans and capabilities should also be developed;
- DHS and HHS should improve their coordination;
- DHS should ensure that all federal emergency response personnel from federal departments and agencies with responsibilities under the NRP have a standard credential that details the emergency management positions for which the person is qualified based on measurable criteria, performance, objectives, and standards so that they may easily integrate into emergency response operations (Red Card System). DHS should coordinate with state governments to en-

sure that all state emergency response personnel from departments and agencies with responsibilities under the state emergency response plan, and volunteers, also have a standard credential based on the same credentialing system;

- HHS, in conjunction with DHS, should lead a federal, state, and local initiative to roster and credential, in a centralized or linked manner, medical personnel and volunteers (National Disaster Medical System, Medical Reserve Corps, US Public Health Service, etc.) to ensure that, in the case of national emergencies, properly qualified medical providers are quickly identified and able to gain appropriate access to the affected area;
- Private sector telecommunications, utilities, critical infrastructure, and other private entities should be included in emergency response planning and be assured appropriate access to disaster areas to repair critical infrastructure and restore essential services. DHS should coordinate with federal, state, local, and other emergency management officials to develop a standardized national credential that would allow emergency management professionals, first responders, and other response personnel from the private sector access to disaster areas, as appropriate;
- DHS should ensure and direct that all federal departments and agencies with responsibilities under the NRP, including the ESFs, take into

consideration the special needs of persons with physical, mental and other disabilities, the most vulnerable, and those least able to help themselves, in their response and recovery plans. DHS should coordinate with state and local governments to ensure that their response and recovery plans also address persons with special needs;

- DHS should coordinate with the private sector and non-governmental organizations (NGOs), including the American Red Cross, to ensure that the response and recovery plans of those participating in emergency preparedness and response operations take into consideration the special needs of persons with physical, mental, and other disabilities.

State and Local Preparations

- States should ensure that effective communications lines and information sharing systems exist between the state emergency operations centers and all facilities, or mobile units that provide medical care or other assistance to victims of a catastrophic event;
- State agencies responsible for licensing of hospitals and nursing homes should ensure those facilities have evacuation plans and audit them annually, including an evaluation of the availability of transportation resources, to verify that they are viable;

- State agencies responsible for special-needs shelters, working with local counterparts and emergency support organizations, should consider developing and maintaining a voluntary database of special-needs persons residing in the area.

3. Government Accountability Office, *Hurricane Katrina: Allocation and Use of \$2 Billion for Medicaid and Other Health Care Needs*, 2007.

In addition to looking at the emergency preparations and response to Hurricane Katrina, the GAO has also looked at a number of issues related to long-term recovery. Two reports by the GAO examine the medical aspects of recovery. This report assessed the use of \$2 billion in Congressional appropriations for Medicaid costs associated with the impacts of Hurricanes Katrina and Rita. This review looked at how the funds were allocated to the states, how the states have used the funds, and whether states anticipated additional funding needs. The GAO found that the biggest portion of the money (\$1.5 billion) went to existing beneficiaries from the impacted states; that the majority of the claims were concentrated in nursing facilities, inpatient hospital care, and prescription drugs; and that both Louisiana and Texas raised concerns that additional funds might be needed. Also of note, is that this report describes what is termed a “national Medicaid program” administrated by Louisiana for enrolled individuals and providers that were displaced and living in different states.



Cooks aboard the Texas Clipper II prepare a meal for displaced government workers who are being housed on board. This ship is a Texas A & M training ship docked at the Port of Lake Charles. Due to the severe housing shortage, FEMA provides housing for local government workers displaced by Hurricane Rita who are needed to keep local government running.

Photo Credit: FEMA / Marvin Nauman



Jefferson Parish emergency communications tower collapsed during Hurricane Katrina, and crushed a building where it fell.

Photo Credit: LSU Hurricane Center/ Marc Levitan

4. Government Accountability Office, *Hurricane Katrina: Status of the Health Care System in New Orleans and Difficult Decisions Related to Efforts to Rebuild It Approximately 6 Months after Hurricane Katrina, 2006.*

In March 2006, the GAO assessed the recovery of health care in the New Orleans areas six months after Hurricane Katrina. Among its findings, the GAO states that:

- The health care infrastructure was significantly damaged;
- The number of staffed hospital beds in the City of New Orleans was about 80 percent less in February 2006 than before Hurricane Katrina;
- Increased demand has been reported at the open emergency departments and has led to the slower unloading of patients from ambulances and to patients being housed in the emergency department because hospital beds were not available;
- More than three-fourths of the safety net clinics in the New Orleans area were closed, and many of those that were open had limited capacity.

There are a number of additional reports that provide recommendations for the federal, state, and local governments as well as the medical profession and health care community. These include:

- The Select Bipartisan Committee to Investigate the Preparation for and Response to Hurricane Katrina. (2006). *A Failure of Initiative* (Publication no. 23950 PDF). Washington, DC. Government Printing Office. Retrieved February 5, 2009, from <http://www.gpoaccess.gov/katrinareport/mainreport.pdf>.
- Government Accountability Office. (2006). *Disaster Preparedness: Limitations in Federal Evacuation Assistance for Health Facilities Should be Addressed* (Publication no. GAO-06-826). Washington, DC. Retrieved February 5, 2009, from <http://www.gao.gov/new.items/d06826.pdf>.
- Government Accountability Office. (2006). *Hurricane Katrina: Status of Hospital Inpatient and Emergency Departments in the Greater New Orleans Area* (Publication no. GAO-06-1003). Washington, DC. Retrieved February 5, 2009, from <http://www.gao.gov/new.items/d061003.pdf>.
- Emergency Management Assistance Compact (EMAC), 2005 Hurricane Season Response After-Action Report.
- Joint Commission on Accreditation of Healthcare Organizations. (2006). *Surge Hospitals: Providing Safe Care in Emergencies*. Retrieved February 5, 2009, from http://www.jointcommission.org/NR/rdonlyres/802E9DA4-AE80-4584-A205-48989C5BD684/0/surge_hospital.pdf.
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- Arendt, L. A. & Hess, D. B. (2006). Hospital Decision Making in the Wake of Katrina: The Case of New Orleans. In, *Engineering and Organizational Issues Before, During and After Hurricane Katrina: Vol. 1. Hurricane Katrina: Emergency Response*. MCEER. Retrieved February 5, 2009, from http://www.prevention-web.net/files/1960_VL206317.pdf.
- Federal Emergency Management Agency. (2006). *DHS/FEMA Initial Response Hotwash: Hurricane Katrina in Louisiana*. (Publication no. DR-1063-LA). FEMA: Baton Rouge, LA.
- American College of Emergency Physicians. (2006). *Emergency Medicine One Year after Katrina*. Retrieved February 5, 2009, from <http://www.acep.org/Default.aspx>
- Emergency Management Assistance Compact. *2005 Hurricane Season Response After-Action Report*. Retrieved February 5, 2009, from <http://www.emacweb.org/>.

From the number of reports, official documents and, now, the words of those in the medical community, every state has the information to avoid another Katrina failure. and response” (CPM, 2008).





CHAPTER 7

Comparison of Hurricanes Gustav and Ike to Hurricanes Katrina and Rita

The experiences of Hurricanes Katrina and Rita led to powerful “lessons learned” changes across the entire tiered system of local, state, and federal government, public and private agencies, and all medically related entities. In the ongoing aftermath of Katrina and Rita, it has never been more apparent that all responders must work together from the planning process to emergency preparation, response, and recovery. If any level of the government is not working effectively, the medical community cannot work well either. When communications are down, hospitals and health care professionals cannot interact to provide care for their patients and those in need of medical assistance. Alternatively, if the medical community has a poor response to a disaster, it leaves public officials, police, and citizens in a difficult situation because of unmet medical needs, and/or their inability to provide support to first responders and others.

Opposite left:

A resident is transported by a FEMA Urban Search and Rescue Team away from her house, which she was unable to vacate due to Hurricane Katrina.

Photo Credit: FEMA / Jocelyn Augustino

Dr. John Fleming, a nationally recognized expert on emergency preparedness, described the comparison between the response to Katrina and Gustav as:

“A largely unorganized and dysfunctional [response] at all levels of government,” compared to “a highly coordinated and collaborative effort where ensuring the life safety and the well being of those living in impacted areas became the ‘mission’ driving all aspects of the preparation and response” (CPM, 2008).

Although Hurricanes Gustav and Ike did not make a direct hit in the New Orleans area, the damage and potential for greater damage across most of the state of Louisiana was quite significant. The threat of a New Orleans hit provided the opportunity for the implementation of the revised emergency plans across all parts of the system, especially the hospitals. The devastating effects of wind damage throughout most of south Louisiana, especially the hard hit areas of Baton Rouge and its neighbors to the immediate southeast, resulted in the implementation of emergency plans and recovery efforts. With Hurricane Ike following on the footsteps of Gustav, southwest Louisiana once again had to face the flooding and wind damage from another storm. Gustav produced a substantial rain event through much of central and north Louisiana. Ike caused severe flooding all along the Louisiana coast. Most of Louisiana was impacted by one or both hurricanes, either directly

or indirectly, with evacuation of populations and recovery processes.

Even though the greater New Orleans area was spared direct impact by Gustav, the entire area was placed under mandatory evacuation orders. Gustav hit the southeast Louisiana town of Cocodrie, in Terrebonne Parish, on the morning of September 1, 2008. In the days before it hit, the following activities had taken place:

- 450 special-needs patients were evacuated to the LSU Pete Maravich Assembly Center;
- 700 buses were moved to New Orleans to evacuate persons without transportation;
- 500-600 hospital and home based medical patients were moved out of state;
- 8,200 nursing home patients were moved from 92 nursing homes;
- Department of Defense airlifted 1,000 patients to safety;
- An estimated 2 million people left south Louisiana before Gustav hit;
- Shelters were opened at numerous sites throughout Louisiana.

Comparatively, Katrina caused flooding problems and Gustav caused wind related problems. Almost all of Louisiana’s 64 parishes were affected with some type of power outage during Gustav. Ike caused severe flooding all along Louisiana’s coast, from the Texas/Louisiana border to the beleaguered coastal point at Grand



Red Cross volunteers discuss a floor plan to make the best use of the space in the abandoned mall that housed nearly 1,000 Houston residents after Hurricane Ike.

Photo Credit: FEMA / Greg Henshall

Isle. In the hard hit areas of Gustav, power was not restored to some homes for 3-4 weeks. In the capital city, Baton Rouge, power was out in many parts of the city for days, with some residents without power for almost two weeks. Traffic signals did not work, and the operation of the city was compromised. Martial law was enacted in most of the towns and cities in south Louisiana, with Baton Rouge experiencing an 8:00 p.m. to 6:00 a.m. curfew for almost a week. The economic impact of the power outage was tremendous, with property damage estimated to be \$15 billion, compared to Katrina and Rita’s combined cost of \$100 billion. The Louisiana Office of Economic Development estimated that losses to the state’s gross national product were as high as \$250 million a day following Gustav.

In spite of this catastrophic event, Louisiana fared much better during Gustav and Ike than it did during Katrina and Rita. Clearly, the track of the storms influenced the outcomes in 2008, when compared to 2005. However, the reorganization of preparedness and response protocols, in addition to improved local, state, and federal leadership across all systems, was largely responsible for the collaborative efforts and better outcomes. There was no place where this was more evident than in the medical community, which again, underscores the fact that when one part of the emergency response system fails, it causes failure among the other entities.

Major Problems Affecting the Medical Community during Katrina and Rita

Obviously, the overall problem was the rapid flooding from the breach in levees that no one had anticipated. However, the devastating effects could have been greatly reduced if other components had been in place, such as communications, adequate preparation of consumables and supplies, leadership, and the three-tiered government response. Communication capability completely collapsed. Pre-storm preparation for supplies (water, food, medical necessities) and alternative power sources was totally inadequate. Leadership, at every level, was lacking from local, state, and federal officials, as well as within the medical community. The leadership that emerged from the medical community during the crisis was responsible for the

care that hundreds of people were able to obtain, as well as the prevention of a number of additional deaths. The deficiency in government assistance at all levels is well documented and accounts for the inability of the medical community to get outside help when their internal processes and procedures failed.

Communication

Specifically, what happened with the communication system during Katrina was unpredictable and, in reality, unbelievable. There is little doubt that the communication failure was the biggest contributor to the horrific situation that developed within the medical response. No one had anticipated that cell phones, land lines, and the internet, would have all been compromised by the impact of the storm and the ensuing chaos and confusion. To make matters worse, few radio stations were operating, so there was no central location for public service announcements and no way to get information to the public. Even if hospitals and medical facilities had access to satellite phones, there was no one to call for help. Thus, the hospitals became completely isolated from any type of assistance and in fact ultimately received help in bizarre ways, such as by text messaging family members out-of-state, who contacted hospital branches or emergency personnel in out of state locations.

Staffing became impossible as no one could reach employees and employees could not call



Power lines throughout Louisiana become entangled in trees from Hurricane Gustav's powerful winds and rain, disrupting power throughout much of the state.

Photo Credit: FEMA / Jacinta Quesada

in to report their situations or see if they were needed. The medical community was widely dispersed by the flooding and the chaos. Following Katrina, operational radio stations could have been one of the most important factors in quelling the rampant rumors that caused so much turmoil. Accurate news accounts would



Medical personnel from the Air Force National Guard prepare for the arrival of special needs patients who are going to be evacuated from hospitals and nursing homes in the Corpus Christi, Texas, area in anticipation of Hurricane Ike's landfall.

Photo Credit: FEMA / Patsy Lynch

have greatly aided emergency response. In short, no one was prepared for the rapid flooding. Medical facilities were simply cut off from the rest of the system as well as from each other. They were isolated with the backup plan for government assistance, an unanticipated failure.

Preparedness

The medical community, emergency organizations, and the three-tiered level of the government were all ill prepared for a catastrophic event. Public officials really did not know the

conditions of the hospitals during Katrina and were unable to provide any help. In reality, public officials did not know the conditions surrounding them because they were unable to communicate. To add to this chaos, as patients were evacuated, there was minimal transfer of medical records and poor tracking of who was going where. The elderly and newborn babies were evacuated without family members, creating additional chaos, as family members tried to determine where their evacuated family members were located.

In an interview with an older woman who became separated from her family in the flood waters, she described her eventual air transport to a shelter in west Texas. She had a stroke while at the shelter and eventually her family members were located at a shelter in Ft. Worth, where she was moved so she could have family support during her recovery.

Another young woman delivered her baby at a private hospital in New Orleans the day before Katrina hit and was not allowed to evacuate by air with her baby, as only neonatal unit babies were given the precious air medical support. The distraught family eventually found the baby, safe, in a Dallas hospital. These were not isolated incidents.

Those patients who could be evacuated when air support was available were removed from the hospitals and taken to other locations. Some pa-

tients were too ill to move or could not be transported without equipment. The medical personnel that remained with them primarily did so on a voluntary basis, or because they were unable or unwilling to evacuate. If a process existed for assigning medical personnel to the facilities, it did not work during Katrina. To make matters worse, even if employees wanted to get to their jobs at the medical facilities, it is doubtful that they could have reached their destination because of flooding, and later looting, followed by marshal law. Transportation, access to gas, and dealing with their own family needs were just a few of the problems that hampered medical support after Katrina. The situation was compounded in New Orleans because of the flooding and the lack of communication within the medical community.

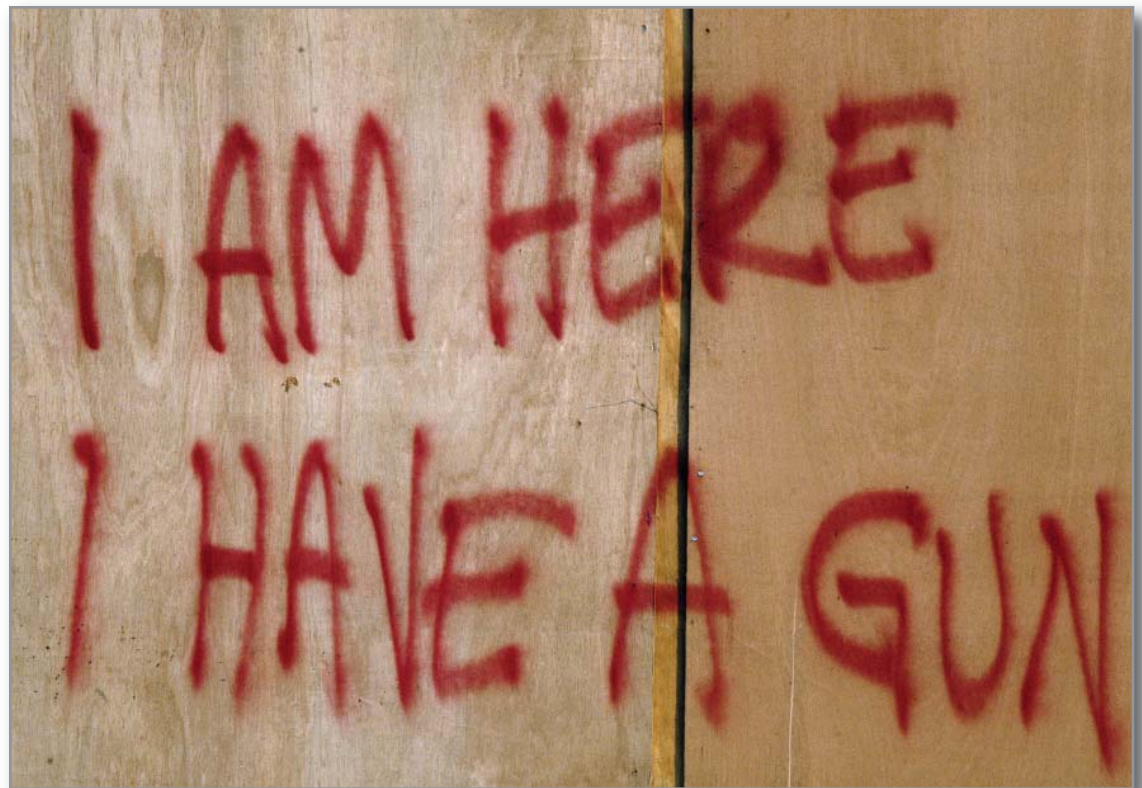
For those who remained in medical facilities, a lack of supplies became a serious problem. Water and food did not last long. Without power, the heat was sweltering, and eventually the plumbing went out. In many cases, generators had been placed on the first floor of the facility and they quickly became nonfunctional because of the flood waters. Medical supplies for the patients did not last and physicians reported having to break into hospital pharmacies to look for medicine and supplies. The sanitary conditions could not have been much worse.

Of the 15 acute care hospitals that existed in the greater New Orleans area in 2005, six suffered

extensive damage, five suffered limited damage, two experienced moderate damage, and only two hospitals had no damage (Tulane Lakeside and Meadowcrest). Since Katrina, two hospitals have been demolished, three have been closed, and the other 10 have remained open, with some under new ownership. This has had a huge impact on the provision of medical care in the

area, particularly for the low income and medically needy population. The debate continues among state officials, DHH, and the LSU Health Sciences Center as to how services are going to be provided to the indigent population.

The situation in southwest Louisiana after Rita was also catastrophic, but the response was



On Magazine Street in New Orleans, a warning to potential looters.

Photo credit: FEMA / Liz Roll

much more effective. According to post-Katrina and Rita interviews and surveys, the medical community in southwest Louisiana had a collaborative network in place that functioned when everything else failed. The communication problems were not as bad, but dealing with huge numbers of evacuees, first from southeast Louisiana during Katrina, and then from Texas during Rita, placed a huge burden upon the entire medical community in southwest Louisiana. The coastal towns in southwest Louisiana were almost destroyed by flood waters in Rita, adding to the number of people with serious problems moving to the more urban environment of Lake Charles. With the majority of the government and media response focused on New Orleans, southwest Louisiana was fairly isolated. The local-level organization and leadership was a huge asset to this community during the crises, and provides a good model for other communities in preparation and planning efforts.

Leadership

The importance of local, state, and national leadership from government officials and emergency organizations, as well as from the medical community, cannot be emphasized enough. In this type of catastrophic event, someone has to be in charge and the organization and reporting hierarchy has to be clear for all responding personnel and for citizens. In Katrina and Rita, this organization was lacking at all levels. Ideally preparation, response, and restoration would

begin and remain centralized at the local level; those in command would know who to contact at the state level, and where to go for assistance at the federal level. In Katrina and Rita, none of this took place, except at the local level in southwest Louisiana and in isolated medical facilities throughout south Louisiana. It was often unclear as to who was in charge locally. Options included the local mayor, the National Guard, the governor, FEMA, and other organizations, such as the Red Cross and DHH. There is ample documentation of the New Orleans mayor, Ray Nagin, on television, outside of south Louisiana, begging for help from anyone after the local response had totally collapsed. State officials were overwhelmed as their response failed, causing them to seek help from the federal government. State and local law enforcement and the military struggled over who was in charge. Their efforts were hampered because of the lack of policy governing such issues and the feeble communication capability.

Several days after Hurricane Katrina, state and local officials were able to convince President Bush and the federal government that there was a real emergency in Louisiana, and how local and state resources were unable to deal with the level of destruction and need. As resources poured into the state, the lack of leadership, organization and planning became even more evident. Social service providers did not know who was in charge of making decisions. Was it the local mental health authority, or the state

mental health organization? What was the role of the Red Cross and other organizations in response to the disaster? To whom would these organizations report? How could supplies be delivered into the greater New Orleans area with martial law in place and entrances to the city totally blocked?

Issues of leadership and organization emerged throughout all phases of the disaster- preparation, response, recovery, and restoration. It literally has taken the years since Katrina and Rita to establish the hierarchical relationships and organizational leadership that must exist to be able to effectively deal with any disaster and, certainly, a catastrophic event. This has also been a critical development in the medical community and within the facilities that will be affected by future severe weather events in Louisiana. In surveys and interviews with medical personnel and physicians for this report, examples of organizational leadership, or the lack of such a role, entered into almost every description of effective or failed responses during and after the storms.

Government Failure

Throughout the previous discussions, the undisputed failure of all three levels of government is evident. When local systems cannot respond to an emergency, the federal government should be able to step in to support the local structure. As a part of the local system, when the medical

community cannot effectively address disaster needs, it should be able to rely on local, state, and federal assistance. For all of the reasons discussed, this did not happen with Katrina. Communication problems, the lack of resources, the leadership void, poor planning, overwhelming and rapid effects of flooding, and internal disorganization all hampered the government and medical community response. In Louisiana, these problems were exacerbated by the large percentage of persons living in poverty that either made poor decisions or were unable to provide for themselves during a catastrophic event.

Outside of Louisiana, commentators and analysts have remained puzzled over why people did not leave pre-Katrina New Orleans, as they did when Gustav approached. It did not occur to these analysts that poor and disabled citizens did not have transportation, and that government assistance checks, upon which many citizens rely, did not arrive until the day after Katrina hit. Because of the local-level disorganization, public officials were unaware of the hundreds of school buses that were available to transport people, or the offers from the local train station and air service providers to whom they could have applied for assistance in getting people to safety. FEMA promised hundreds of buses that never appeared. Evidence of multi-level failures can be provided for many parts of the response. At the same time, evidence of effectiveness and leadership in some aspects of Katrina and Rita were seen through the efforts of the Coast



Thousands of people waiting for buses at highway pickup point in New Orleans, four days after Katrina.

Photo Credit: LSU Hurricane Center / Marc Levitan

Guard, among others, who made the decision to save lives and address policy issues later.

As Gustav approached on September 1, 2008, a preemptive state of emergency had been declared and there were 700 buses in New Orleans ready to transport the poor and disabled out of harm's way. The government assistance checks

had been delivered the Friday before because of the Labor Day holiday falling on the 1st, which was a Monday. Additionally, policies had been changed that allowed persons to evacuate with their pets, which had caused untold tragedy during Katrina and Rita. These are just a few examples of actions that were taken prior to Gustav that resulted in a more effective response.



Dogs displaced by Hurricane Ike are sheltered at the local center on Galveston Island, Texas, set up by the Humane Society.

Photo Credit: FEMA / Jocelyn Augustino

Post-Katrina and Rita Changes that Were Made for Gustav and Ike

New Orleans residents clinging to their roofs and houses, begging to be saved from the flood waters, has become the national face of Katrina. Media coverage of dead bodies of people and animals swirling in the raging waters will never be forgotten. The other national story was the plight of patients and medical personnel struggling in the sweltering heat in flooded hospitals, medical facilities, and nursing homes. The ongoing saga of the medical professionals who remained to take care of patients can also never be forgotten. Dr. Anna Pou, who has finally been cleared of legal charges for staying to help critically ill patients, will face civil suits for a long time. The medical community in south Louisiana has been irrevocably impacted by the devastation caused by Katrina and Rita, with physicians struggling to maintain practices and hospitals dealing with severe shortages of personnel.

However, the changes that were made within the medical community post-Katrina and Rita have clearly shown that adversity can be overcome, and that recovery can be the catalyst for the changes that must take place in order for the medical response to be effective in a disaster. These are not just lessons for south Louisiana but for every community in the US. As discussed in Chapter 2, hurricanes and floods are not the only disasters that will continue to

plague the country, and there is no community that can assume it is not “at risk” for a disaster and possibly for a catastrophic event.

In the form of a post-Gustav National Science Foundation and Multidisciplinary Center for Earthquake Engineering Research (MCEER) study (Arendt & Hess, 2008), many of the changes that have taken place within the New Orleans hospitals and medical community are described through categorical themes that evolved out of extensive post-Katrina research. MCEER is located at the University at Buffalo, State University of New York. The themes of change MCEER describe include: (1) Constructing Resilient Building Systems; (2) Planning to be Self Sufficient; (3) Networking; (4) Staffing; (5) Communicating Emergency Plans; (6) Communicating in the Wake of Disaster and (7) Leading Effectively.

An overall theme that has continuously been discussed is the need for hospitals and medical facilities to be able to function independently of government assistance. For the medically related entities that must rely on the government or emergency organizations for assistance, such as the nursing homes and charity hospitals, the officials in charge of these facilities must ensure that they have been a viable part of the overall state planning process. This includes a detailed plan for identifying those patients who must be evacuated, if everyone in the facility does not have to be transported out of a potential impact

area. It must be clear who will assist with transportation, when this will take place, and where the patients will be moved. Further, family members of all patients should be knowledgeable of the evacuation plan, so they will know how and where their family member will be transported. There must be a clear line of decision making and authority within the facilities that cannot act independently, so that evacuation can take place in an efficient manner. Facility administrators must be held accountable for participation in all regional disaster planning sessions and communication of plans to all personnel.

If all patients will not be evacuated, the facility administrators must also ensure that they can function independently with all of the patients and personnel who remain behind. This includes structural resiliency, maintenance of a sufficient supply of consumables, proper staffing and training of staff, and communication/reporting processes. For the hospitals and medical facilities that plan on achieving self sufficiency, and for disaster operations that are not dependent upon outside assistance, they must take the steps that many of the New Orleans hospitals have taken or are in the process of taking.

Resiliency

During Gustav, New Orleans and the southwest part of Louisiana did not suffer from the extreme flooding experienced in Katrina and Rita, yet;

the medical community had to be prepared for that possibility. Thus, plans for maintaining good medical care within the New Orleans hospitals were put into effect as it became apparent that Gustav was heading toward the Gulf Coast. Because the structural rebuilding is not complete in New Orleans and the soundness of the levees is simply unknown, hospitals and medical facilities evacuated fragile patients and reduced the number of in-patients as much as possible. Extensive planning went into ensuring that generators were available and not placed in areas prone to flooding. New Orleans hospitals had contractual arrangements to have portable generators delivered as Gustav headed toward Louisiana.

Of course, Gustav took a much slower path to Louisiana than did Katrina, so there was more time to put plans into action, but plans have been made to deal with the need for fast decision making. Additionally, New Orleans is not taking a chance with the levee system again. The entire area surrounding New Orleans was placed under mandatory evacuation orders and all non-essential medical personnel were asked to evacuate. Medical personnel that stayed in New Orleans to work were advised to evacuate their families and pets, and avoid bringing people or pets to the hospital (which had been a problem during Katrina).

Several New Orleans hospitals have dug their own water wells to ensure an adequate water

supply during disasters. Like the generators, contractual arrangements were made to have portable water storage delivered as the storm entered the Gulf. Another change that the hospitals made was to have air conditioning systems connected to emergency power sources. The high temperatures after Katrina and Rita caused one of the biggest problems medical personnel had to face.

Interestingly, while the New Orleans hospitals fared well, the hospitals and medical facilities 75 miles away in Baton Rouge faced huge obstacles. These hospitals had taken the same steps as the New Orleans hospitals in regard to generators, water, medical supplies, and staffing but had seriously underestimated the amount of time that they would be without electricity. All of the Baton Rouge hospitals lost power and some hospitals had to function off of generators for 5-7 days. The situation in Baton Rouge would have been a disaster near the scope of Katrina medical problems if communication, networking, good decision making, and leadership had not prevailed.

Woman's Hospital in Baton Rouge is the largest provider of medical and health services to pregnant women and babies. It has the best neonatal clinic in the area and provides care to babies who are born in need of extremely complicated medical care. In fact, most of the New Orleans babies were evacuated to Woman's Hospital after Katrina, until it reached capacity. Baton Rouge

also houses Earl K. Long Hospital, which is a large public hospital that provides care to the indigent population. The power was out for so long after Gustav that Earl K. Long had to close down completely and send patients to other area hospitals. This put a burden on the other hospitals, who were already maintaining patients longer than the length-of-stay guidelines because of their reluctance to release sick patients to homes with no power. Additionally, with the extreme power outages, calling in additional staff and medical personnel became problematic but not nearly as bad as it had been during Katrina. Most hospitals established text messaging processes to notify medical personnel. After Earl K. Long closed, a regional hospital outside of Baton Rouge also closed because of power outages and ironically evacuated its patients to New Orleans. The generator situation was greatly exacerbated by the lack of access to gasoline and, of course, the cost of gas at that time.

One of the biggest advantages that Baton Rouge maintained during Gustav was an effective radio broadcast that was on air continuously to provide public announcements, communicate about various conditions, and provide briefings during the day from the governor, the mayor, and the necessary entities, such as energy companies, FEMA, and the Red Cross. Although the medical situation was greatly improved, there is little doubt that a major post-Gustav change will be related to upgrading generators, which imposes a huge cost on the hospitals. For exam-

ple, the Baton Rouge General Hospital anticipates the cost to be in the range of \$10 million for their system and Our Lady of the Lake Hospital in Baton Rouge estimates a cost of \$15 million.

Self Sufficiency

For the medical professionals serving hospitals as well as the hospital administration, self sufficiency throughout the medical community became a very important goal after Hurricanes Katrina and Rita in 2005. To reach this goal, a great deal of detailed planning has had to take place across all parts of the medical community, including private practitioners, hospital staff, non-physician medical staff, medical associations, and facility administrators. All of the difficulties have not been resolved or even identified yet, but south Louisiana's experiences with Gustav and Ike certainly indicated a vast improvement. Medical professionals and hospital administrators have had to determine what their responsibilities are in a disaster and at what point the government or emergency systems must step in. Once the boundaries become less blurred, the medical community can take appropriate steps to ensure self sufficiency, while becoming a full participant in local, regional, and state planning with all of the necessary partners for effective disaster collaboration.

Hospitals have the responsibility to maintain enough supplies and consumables, organize ad-

equating staffing, implement an infallible communication system, maintain a power supply that will work during a disaster, maintain a safe and strong building structure, and hire security to protect inhabitants of the hospital/medical facility. These responsibilities create a self-sufficient environment, until there is a disaster-related intersection with problems outside of their control. For example, during Katrina, there was not a hospital administrator who planned for, or had control over, a breach in the levee system. After Rita, Calcasieu Parish officials were left to deal with the complete destruction of at least one coastal parish, resulting in an immediate population increase at a time when flooding and wind damage was requiring all of the parish's attention. After Gustav, hospital administrators were not prepared to deal with power outages for more than a few days, but unfortunately, it took much longer to restore power. These are points in time where procedures must be in place to interact with the three tiers of government, as well as emergency organizations and outside entities who can help.

In Katrina, as was clearly seen, there were no processes in place to get help. There was no help for the hospitals, medical practitioners, medical personnel, and, in many cases, their families. Eventually, private citizens and the military were able to get everyone to safety, but it was not a planned or orderly process, and lives were lost or traumatized because of this. Since Katrina, most New Orleans hospitals have installed helipads to evacuate patients if necessary.



National Guard unloads commodities from a Chinook helicopter at the newly formed distribution center in Franklin, Louisiana, six days after Hurricane Katrina.

Photo Credit: FEMA / Jacinta Quesada

During and after Rita, the southwest Louisiana medical community had a process in place, as well as local leadership that enabled them to deal with most problems more effectively. Obviously, they did not have the flooding and the huge population that New Orleans had, but they certainly had problems with the sheer number of evacuees and the physical destruction in the area.

After Gustav, hospital officials had to depend on government intervention to help get additional generators and access to gas in order to maintain power. Several hospitals that had planned well in advance, maintained a huge surplus of gas for their employees' cars, and other necessary medical transportation.

Hospitals in Baton Rouge will have to depend on outside assistance to resolve some of the financial issues that evolved out of Gustav. Payment for the indigent population that was transferred to area hospitals when Earl K. Long had to close, reimbursement waivers for patients who exceeded length-of-stay requirements because of power outages, and government assistance to help pay for the expensive upgrades to hospital generators, are just three examples of appropriate reliance on the government.

well as they did is because of an active and ongoing association of medical community representatives. Because of proactive leadership in the mayor's office, teams of people met regularly in Calcasieu Parish so that there was an understanding of each person/profession's role if a disaster occurred. Interestingly, Calcasieu Parish had developed a disaster plan for pandemic flu, and that process also worked for Katrina and Rita. As one physician pointed out, "If you meet with all of the partners needed in disaster planning, everyone gets to know each other and

nicate with the medical community from a safe place.

In pre-Gustav Baton Rouge, the signs of ineffective regional and national network planning were evident. The evacuation of nursing home residents was repeatedly stalled because of confusion with planes not arriving that were supposed to and ambulances being unavailable for services because of failure to receive clear instructions on which patients to pick up or prioritize. As Gustav approached, the neediest

One of the **first changes** made within the greater New Orleans area after Katrina was the **establishment of active relationships** among the different parts of the medical community.

Networking

Although a variation of several themes has been discussed, one lesson that the New Orleans medical community learned is that there has to be a strong, dependable network with local, state, and national sources of assistance, beginning within the medical community itself. From interviews with physicians, one of the reasons the southwest medical community performed as

trusting relationships develop." When a disaster hits, it is much easier to operationalize the plan if all of the players know each other.

It should be noted that the networking within the medical community in Calcasieu Parish also involved relationships with the Louisiana State Medical Society. In fact, one member's role is to remove important documents and contact information out of the disaster area and commu-

patients were finally air lifted out by helicopters, which had not been in the original plan. The important element in this example is that effective leadership can avoid making things worse, particularly when the person in charge knows all options available to move patients and makes a timely decision to call on others for assistance when the initial plan does not work.

One of the first changes made within the greater New Orleans area after Katrina was the establishment of active relationships among the different parts of the medical community. All hospitals belong to the Metro Hospital Council of New Orleans, which is affiliated with the Louisiana Hospital Association (LHA). Through this group, emergency preparedness planning is undertaken so that all hospitals can collaborate to have effective outcomes after a disaster. Many of the difficulties that happened during Katrina are being addressed, such as methods for patient tracking and automated prescription information.

Staffing

Most of the staffing problems that have been previously discussed clearly revolve around issues such as inability to communicate, transportation problems because of flooding, no access to gas, concern about family members, and overwhelming job responsibilities for workers in shelters because there is so little staff. Numerous changes have been made to address these problems. The most significant change has been the organizational planning around team efforts with very specific functions.

Most of the facilities, whether a hospital, nursing home, or emergency medical shelter, now have assigned teams to deal with disasters. There is generally one team responsible for the early preparations and evacuation; another team is as-

signed to work during the crisis, with a support team on hold in case the effects of the disaster continue for a long time. Finally, a post-storm followup/cleanup crew is assigned. Disaster teams are asked to evacuate their families and pets prior to a hurricane moving onto shore. In some of the major New Orleans hospitals, a centralized location has been established through which all disaster functions are administered and where all communications are located. After Gustav, hospitals in Baton Rouge reported difficulties in being able to locate staff since phones were down and power was out. They plan to implement one of the text messaging systems before next hurricane season.

Emergency Planning Before Disaster Strikes

Realistic planning efforts are the key to effectively dealing with any type of disaster, whether a pandemic flu, a terrorist attack, or a weather event. There are numerous accounts of pre planning in Louisiana prior to Katrina, but many of the plans were not tested, were outdated, or simply not well conceived. Complacency also sets in when plans are not drilled on a regular basis. Two bizarre examples of poor or unrealistic planning that took place during Katrina involved generators and satellite phones. Since the existing plan said generators had to be available if the power went out, all of the hospitals had generators, but many of them were located on the first floor of buildings. Thus, they were flooded when the levees broke. The rapidity with which

the flooding happened did not allow time to move the generators. Also, most of the hospitals had satellite phones, but employees had not been trained in how to use them. Additionally, batteries were not available for the phones at some hospitals.

In post-Katrina New Orleans, all emergency planning is based upon the theme, "Plan for the worst and make sure everyone knows their role." All emergency plans have been revised and all staff/medical personnel receive annual training at a minimum, especially before hurricane season. In addition, the hierarchy of decision making has been clearly established in most medical facilities within south Louisiana.

Communication During the Disaster

Regardless of the disaster type, communication breakdowns should be anticipated and a plan developed to address the issue. Even with the changes made in south Louisiana after Katrina and Rita, there were still problems during Gustav and Ike. Communication within the medical community and among the three tiers of government must be clear prior to the disaster striking.

Some of the changes that have been made in south Louisiana include:

- Updated satellite phones, with training of all employees;
- The purchase of numerous cell phones with out-of-state area codes;
- The purchase of 800MH radios;
- Housing of internet servers outside of the potential disaster area;
- The establishment of 1-800 numbers for employees;
- The establishment of a text messaging system;
- Designation of a Regional Coordinator through whom communication would flow by phones or EMS technology.

Obviously, communications systems should be implemented consistent with the likely type of disaster within each community: such as fires, floods, tornados, hurricanes, earthquakes, or terrorist attacks.

Effective Leadership

This particular theme may be the most important one of all, as the lack of decisive leadership at all levels during Katrina and Rita exacerbated what was already a horrific situation. Effective leaders and decision makers can find solutions in the wake of a disaster, but without that leadership throughout the medical community, as well as the government, chaos and confusion can cause insurmountable damage. There are nu-

merous examples of leadership voids and leadership “heroes” throughout all four of the severe storms that have impacted Louisiana since 2005. There are also examples of good leaders who could not lead because they were blocked by higher level officials or existing policies.

With the crisis taking place in south Louisiana as Katrina hit and the levees burst, it remains unbelievable that local and state officials were unable to get assistance in a timely manner from the federal government. That situation contributed significantly to the number of lost lives, the physical damage, and the mental health problems that exist very prominently in south Louisiana today. The fear of that scenario happening again, however unlikely, continues to have an impact on recovery efforts.

In no place have we seen the impact of failed leadership more than within the medical community. Fortunately, there were plenty of leaders and heroes that emerged out of the medical community during the storms and the recovery. However, the failed government leadership during Katrina has no doubt led to physicians’ reluctance to return to Louisiana, or their inability to rebuild their practices in New Orleans and coastal parishes. The failure to reopen and fund the medical schools in a timely manner, to decide what to do about Charity Hospital in New Orleans, and to increase the rate at which recovery is taking place, does not really make south Louisiana an attractive place for physicians and other health care professionals to locate.

If the failures of leadership during Katrina and Rita were made spectacularly visible to the nation, the changes and the improvements in the functioning of all levels of the government, medical facilities, and emergency organizations were equally evident as Gustav and Ike struck most of Louisiana and part of Texas. While the destruction of Louisiana communities was once again made visible, the absence of the chaos and confusion demonstrated vast improvements in preparation and emergency response. There were glitches in the evacuation processes, problems at several shelters in north Louisiana, critical issues with power outages in the capital area of Baton Rouge and surrounding parishes, but all were overcome within a reasonable amount of time, with the exception of extreme damage to the power systems in the hardest hit areas.

In examining some of the improved outcomes, organizational effectiveness and leadership can explain many of the changes. The amount of planning that had taken place across the state helped local and state officials deal with the problems that arose. People in charge knew that having a “Plan A” was not enough and that contingencies must be developed for every possible scenario. The contingencies included knowing how to access assistance from other agencies, volunteers, and emergency organizations.

Nearly two million people were evacuated from coastal Louisiana in an orderly manner before Gustav hit, primarily because of the planning and staggered approach to getting everyone out

of harm's way. Pets and other animals were evacuated first to designated sites across the state, followed by evacuation of critically ill patients and frail nursing home residents. Finally, when it was known that Gustav would hit the south Louisiana coast, residents were placed under mandatory evacuation orders and martial law was implemented in deserted cities and towns. The governor had issued a preemptive state of emergency so the military was able to move rapidly to areas in and around New Orleans. Federal emergency organizations were in the state long before Gustav hit. There was a strong partnership among the three tiers of the government and everyone knew what they were supposed to do.

Examples of Leadership and Organizational Effectiveness in Gustav and Ike

- When the planned planes and ambulances that were supposed to evacuate nursing home residents did not appear or were inaccessible, the head of DHH located helicopters to start moving residents out of south Louisiana. This was possible because of access to emergency officials who knew where the resources were;
- The local human services authority had the LSU PMAC shelter in Baton Rouge ready and staffed for critically ill patients by noon on the Friday before the storm hit on Monday. The first patients started arriving that afternoon. All volunteers and medical staff had been pre-certified and trained to work in the shelter;

The failed government leadership during Katrina has no doubt led to physicians' reluctance to return to Louisiana, or their inability to rebuild their practices in New Orleans and coastal parishes.

- 700 buses were in New Orleans at pre-advertised staging sites to get residents out of New Orleans. There were several glitches, which were resolved quickly because of the organization and flexibility to give up "Plan A" and move to "Plan B";
- There were problems with the delivery of generators from FEMA and the governor authorized a \$20 million dollar expenditure from the state budget to get generators to meet critical needs;
- Local radio stations were able to stay on air and coordinated public service announcements and daily reports from the governor and mayors, as well as taking calls from citizens about problems and information needs;
- When hospitals had to close because of power outages, the evacuation process for patients was timely and orderly;

- The loss of life was minimal; fewer than 50 people died as a result of Gustav, compared to over 2,000 people in Louisiana from Katrina.

There are still many changes that need to be made and a number of new "lessons learned" from Gustav and Ike that need to be implemented. Comparatively, Louisiana fared much better in Gustav and Ike than in Katrina and Rita because of the planning that has taken place and the changes that have been made by the entities impacted by hurricanes. Huge and costly problems, such as upgraded generators for medical facilities, complete electronic automation of all medical records, and the development of non-coastal nursing homes, will all take time and require assistance from government sources. The government, emergency organizations and the medical community are critical to the effectiveness with which disasters are handled. Hopefully, some of the hard lessons Louisiana has learned can be used to help other states and communities prepare for effective disaster response.





Opposite left:

This Mobile Medical Unit is set up as a clinic, which includes 575 sq. ft. of patient treatment area with diagnostic x-ray, clinical laboratory, pharmacy and minor surgery suite. FEMA provided this transportable facility and several others like it to parishes affected by Hurricanes Katrina and Rita in Louisiana.

Photo Credit: FEMA / Robert Kaufmann

Lessons Learned and Best Practice Recommendations

Through an extensive examination of information from academic literature and from the medical communities that have experienced Hurricanes Katrina and Rita and their aftermath, the lessons learned have become all too clear. From the preliminary assessment of preparation and response to Hurricane Gustav (which took place three years after Katrina) it was very evident that there were vast improvements within the medical community, mainly due to the independent responsibility of physicians, healthcare personnel, and hospitals. However, vast improvements were also made because of enhanced system planning, preparation, and response. What are the primary lessons learned from the 2005 and 2008 hurricane seasons? What can local medical communities do to ensure that a Katrina response never happens in their community? No community can control the onset of a disaster, but every community can be prepared to meet whatever type of disaster they may face in the future.



The National Disaster Medical System (NDMS) set up one of the new, fully self-contained Mobile Medical Units (MMU) in Plaquemines Parish to treat persons who lost access to medical care when Hurricanes Katrina and Rita slammed the area. The MMU is a complete mini-hospital.

Photo Credit: FEMA / Greg Henshall

Throughout the information gathered, there is no doubt that leadership, coordination, and preparations are critical to effective response to disasters. This theme evolved consistently throughout the literature and through personal contact with medical personnel in south Louisiana. In the communities and isolated medical facilities that fared best in Katrina and Rita, the presence of a leader who had organized a strong and knowledgeable network of persons and agencies to plan and respond to the disasters was the most significant factor differentiating one response from another. This factor proved to be stronger as Gustav approached south Louisiana and the effects of local, state, national, and system leadership emerged.

In considering the effectiveness of the disaster responses post-Katrina and Rita, it is obvious that the levee breaches exacerbated the difficulties in New Orleans and the surrounding areas. However, the extent of preparation was a critical factor in the effectiveness of the disaster responses. Although many of the factors that hampered effective disaster response were external to the medical profession, interviews with physicians and medical personnel revealed many ideas on how to be better prepared so that a response is efficient, effective, and more within the control of physicians and hospitals.

Under the broad umbrella of leadership, coordination and preparedness are very valuable

'lessons learned' in specific areas vital to effective response. These areas are described as the issues that hampered the medical response more than others and that have required the attention of the medical community as pre-Katrina emergency plans were being redesigned. The primary areas are delineated below, with a brief description of the lessons learned and the action taken to address the issues in an effective manner.

Communication

Lessons Learned:

- Broadcast media plays a critically important role during a disaster for general communication, alerting residents of danger, and making public service announcements;
- Cell and radio towers are very vulnerable during a hurricane and cannot be the only communication source upon which to depend;
- Communication technology may vary across all systems, including first responders, hospitals, law enforcement, military, and the three tiers of government, rendering system-wide communication impossible (80% of city emergency networks were incompatible with federal agencies);
- The Internet works well for posting information at a centralized location if the disaster does not destroy utilities. It is helpful in the recovery process when power is restored, particularly for missing persons;

- Text messaging systems seem to work well;
- Hand-held radios have some difficulties in operating system wide; if used, compatibility and strength should be verified;
- Two-way radios, marine band radios and out of area cell phones are other options, considering the geographic location;
- Even when a major Internet hub and radio/television stay intact, if citizens are not educated on generator use or access to fuel and maintenance of a good portable radio with batteries, it does not help with communications;
- Mail is not delivered during a disaster and is not easily restored in high impact areas.

Best Practices to Prepare for Effective Communication:

- Local government should test and upgrade local communications systems, in conjunction with compatibility checks with state, national, and emergency systems;
- Local and state government should develop their communication plan together, ensure consistency with national and emergency organization plans, test and revise the plan annually, and have a backup plan for the worst case scenario;

- Communication methods to consider are two way radios, text messaging capabilities, satellite phones, and PDA's, all used in conjunction with staff training;
- Establishment of a 1-800 number with a designated point of contact outside the disaster area is advisable;
- Education should be undertaken with citizens and companies so that everyone will understand mail, bank services, automatic deposits, and telephones rarely work in high-impact areas. Bill payment is disrupted and can rarely be explained until power and utilities are restored. Companies should develop policies around these issues;
- State officials should consider a single radio frequency exclusively for emergencies, if one is not yet in place.

Transportation

Lessons Learned:

Even with a large-scale disaster, it is difficult to evacuate all of the citizens without well planned organization and massive government, emergency, and volunteer assistance.

- Elderly, critically ill, and disabled populations are less likely to evacuate on their own and will



Aerial of roughly 300 ambulances staged at Kelly USA, in San Antonio, Texas, on July 20, 2007, in preparation for Hurricane Dean. The EMS resources were activated to assist the state in evacuation of hospitals, nursing homes, and patients living at home with significant medical problems when the storm.

Photo Credit: HHS / Sandy Bogucki

require assistance;

- Regardless of the planning, emergency response transportation is easily overwhelmed in a disaster, particularly because of unplanned occurrences (i.e., buses flood before put into use; drivers delivering fuel cannot get through so there is no gas on the evacuation route);
- Hospitals, medical facilities, and nursing homes must be an integral part of all evacuation and emergency planning efforts;



Two years after Hurricane Rita destroyed South Cameron Memorial Hospital, it reopened its doors this time mitigated to reduce potential loss of property and medical equipment against future disasters. Having weathered Hurricane Ike, the mitigation measures of building safer, smarter, stronger proved to be invaluable, as the hospital received only minor damages.

Photo Credit: FEMA / Calvin Tolleson

- Evacuation plans must be based on the predicted amount of use of personal autos vs. the use of buses, trains, and air services. Katrina reflected the failure to serve the non-driving population, while Rita reflected the failure in planning related to the number of people using their cars to get out of harm's way;
- Evacuation planning must consider the need to evacuate critically ill, special-needs, elderly, and other vulnerable populations first;
- Evacuation planning must include people's pets or they will not leave;
- All evacuation vehicles used to transport people and pets should be tested for air circulation systems, safety, and operation under stress (long hours on highway, people boarding with large amounts of luggage);
- All evacuation plans are dependent upon the availability of fuel and the drivers who must show up for work, get through the traffic, and deliver the fuel, particularly along the evacuation route;
- The value of air transport cannot be underestimated, especially if a disaster hits without notice or with little time to respond.

Best Practices to Prepare for Effective Transportation:

- Include transportation issues in all aspects of emergency planning;
- Adopt philosophy of "Expect the best and plan for the worst scenario" when considering transportation, especially evacuation;
- Address transportation related staffing issues within separate systems, as well as system wide. Access to fuel and ability to get to work are but two major considerations for proper staffing;
- Ensure that a failsafe system is put into place to identify, contact, and evacuate vulnerable populations (Katrina lost many disabled and wheelchair bound people who drowned because no one came to get them or move them to higher ground);
- Focus on mass transit evacuation vs. personal automobiles. Buses get more people out faster; the use of cars by everyone can cause major congestion. Trains and air support remove congestion from the highways;
- Effective communication ability and transportation go hand in hand. Extensive joint planning, and testing should be undertaken;
- Major trauma centers or centralized hospital locations should have a helipad.

Sanitation

Lessons Learned:

- A large-scale disaster can render drinking water facilities and water mains inoperable;
- Drinking water may be contaminated by flooded sewerage lines;
- Water quality is a huge concern in the prevention of diseases, such as diarrheal disease, parasitic infections, typhoid fever, and epidemics;
- Standing flood waters create a breeding ground for mosquitoes in areas generally impacted by hurricanes;
- Sanitary conditions in shelters and medical facilities must be maintained.
- Water quality, airborne disease, and contamination of articles brought into shelters can cause serious illness and infection;
- Hospitals should maintain an independent water supply;
- Hospitals and shelters can have serious problems if plumbing goes out. Sanitary conditions are difficult to maintain without good water and plumbing;

- Evacuees who walk through flood waters are very susceptible to a number of illnesses and infections from unsanitary conditions;

- Delivery of necessary equipment in shelters may be delayed because of the traffic situation and delivery workers' ability to get to their workplace.

Best Practices to Prepare for Effective Sanitation Systems:

- Hospitals, shelters, and medical facilities must have supplies on hand to test water quality;
- Educate appropriate agencies, as well as the citizenship, on procedures for disinfecting water;
- Educate agencies and citizens on the risks of using or walking through flood waters;
- Develop a plan and train employees, who are placed in shelters at hospitals, and other medical facilities, on procedures to be used if water and plumbing become inoperable; make sure there is a backup plan;
- Alert citizens and shelters (human and pet) of the signs of the most likely infections that will develop as a result of unsanitary or overcrowded shelter facilities;



Flooding left behind unsanitary conditions, contaminated drinking water and mold in many medical facilities.

Photo Credit: Floyd A. Buras, MD

- Have a backup plan for shower installation in shelters;
- Develop a follow up and backup plan if necessary equipment is not delivered in a timely manner to shelters;
- Screen volunteers to ensure they have proper shots and are healthy enough to be involved with human and pet shelters because of sanitation issues.

Consumables and Supplies

Lessons Learned:

- Medical facilities that remain open and/or are temporarily being used must have stockpiles of supplies on hand from drinking water to tetanus vaccines and insulin;
- Particularly needed items include water, pain medication, catheters, and IV lines;
- Post-storm medications for workers and first responders must be deliverable within the impact area, especially if martial law has been established;
- Physicians do not have access to consumables and supplies without communication and transportation from outside of the impacted area.

Best Practices to Prepare for Consumable and Supply Shortages:

- For hospitals that have been identified as remaining open and for medical shelters to be established, detailed planning must go into the supplies and medications that will be needed during a worst case scenario. Depending on the type of disaster, hospitals, nurses, and physicians should be able to identify the medical supplies necessary to sustain themselves during a catastrophic event and have a back up communication/transportation plan in place to get supplies if needed;

- All supplies should be kept in a safe place and updated regularly or delivered in ample time pre-disaster;
- There must be an effective post-disaster plan in place to get medication and supplies into the area for first responders, emergency workers, law enforcement, and medical facilities that may have remained open, especially if the impact area is isolated and under martial law;
- Pre-arrange access to organizations/agencies that can provide four wheel drive or other emergency transport vehicles for evacuation and /or delivery of supplies.

Utilities

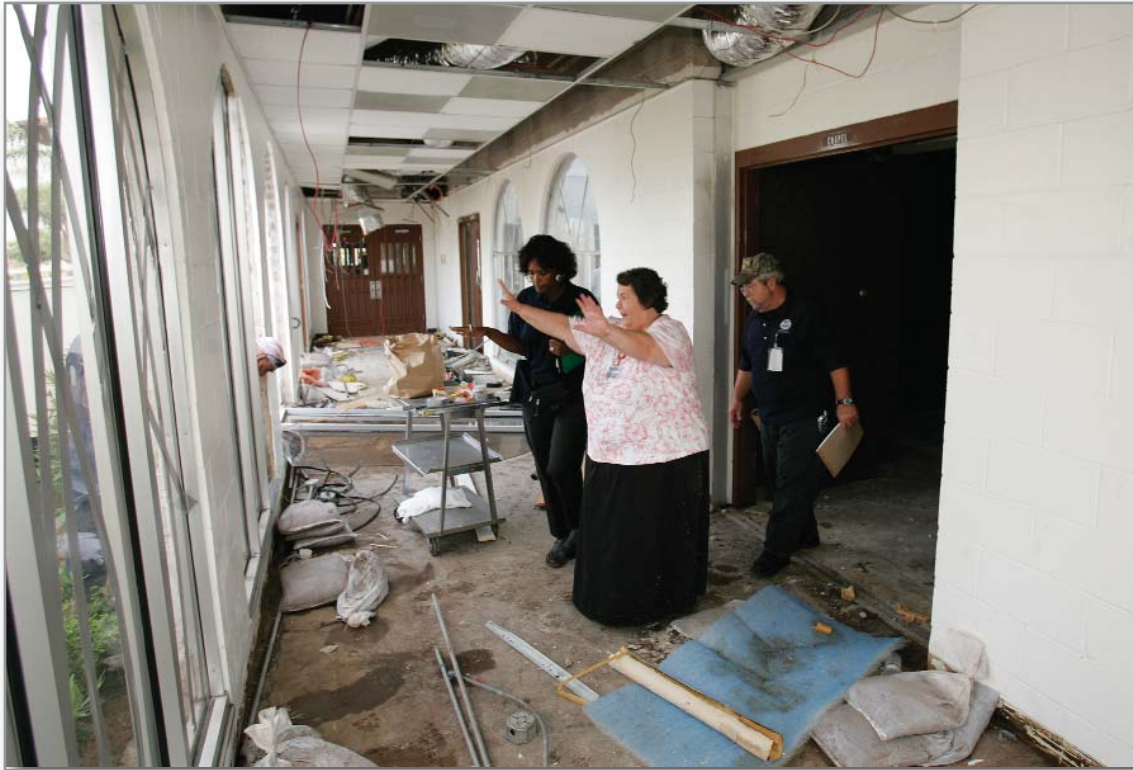
Lessons Learned:

- Lack of utilities, including water quality and availability, severely hampered medical operations in high-impact areas, and added new complications for post-disaster treatment;
- Air conditioning is not a luxury in south Louisiana; it is a necessity in the hospitals and shelters at a minimum;
- Generators fail for various reasons and without an alternative plan, the lack of utilities in hospitals and shelters can be deadly;

- More powerful generators are needed;
- Generators only work if there is access to fuel, unless it is a natural gas generator, which might also be compromised;
- Hospitals need approximately 200 gallons of fuel per hour to keep their emergency generators working;
- If air systems are not connected to the power source, when utilities return, electronic devices will overheat a room very quickly;
- Valuable data can be lost from laboratory and other high-tech facilities when power outages occur;
- Adequate utility plans must be made for the “special-needs” population in a potential disaster area, which is significant because of the countries’ aging population.

Best Practices to Prepare for Utility Maintenance and Shortages:

- Maintain a list of all equipment and utility systems that must be reset or restarted when power returns, with printed instructions clearly posted for whoever might be responsible for restarting the system;
- Hospital and other facilities must adequately plan for the amount of fuel they will need for utilities;



FEMA public assistance specialists inspect the Starr County Memorial Hospital in July 2007 with a hospital administrator to determine if the county will be eligible for federal assistance to offset expenses caused by the recent flooding.

Photo Credit: Bob McMillan/ FEMA Photo

- Ensure that generators are in safe locations, especially away from flood waters or where the exhaust can cause damage to people;
- Ensure that critical data is backed up with off-site copies and computer servers are in a safe place;
- Plan and stockpile necessary supplies in the event utilities are out for a week or two;
- Consider upgrading hospital generators.

Specific Medically Related Concerns

Lessons Learned:

- Medical Records
 - ▶ Some evacuees with medical conditions are unable to explain their diagnoses and prescriptions;
 - ▶ Physicians must determine how to treat patients in a temporary medical shelter with limited diagnostic equipment;
 - ▶ Physicians and other health care personnel have expressed great concerns about liability, although medical care was provided in the most effective way possible;
 - ▶ There was valuable time lost in the treatment of seriously injured people without any idea of their medical history; i.e., snake bites and heart attacks;
 - ▶ Most people do not evacuate with medical records and prescription information;
 - ▶ In a catastrophic disaster such as Katrina, medical records and physician practices are destroyed;
 - ▶ The Veterans Administration does have an automated records system available nationwide for participating veterans;

► The law does not adequately deal with medical record issues during a catastrophic event; nor does state policy.

- Volunteer Medical Personnel During Disasters

► Many badly needed physicians could not be utilized because of bureaucratic red tape and an inability to get requirements waived in an acceptable amount of time;

► Military personnel would not allow the Red Cross to enter into the high-impact areas because of 1) fear for the personal safety of the Red Cross workers, and 2) what might result in the unintended consequence of encouraging local residents to stay in the devastated area when evacuation of all non-essential persons was necessary and mandated;

► There was a serious problem with the organization of medically related services and assets that could be used by the medical community and individuals helping with disaster response;

► Housing availability was a problem for volunteers and was especially difficult during power outages;

► Volunteer pharmacy personnel experienced a great deal of difficulty setting up pharmacies;

► Most medical volunteers were gravely concerned about liability issues, although they performed the work that needed to be done.

- Reliance on Major Hospitals in Disaster Area

► The major trauma centers and hospitals in New Orleans were unable to function after Katrina and there were major complications from damage to the Calcasieu Parish facilities post-Rita;

► Aside from the pre-storm population of critically ill, special-needs, and vulnerable persons, there were significant medical problems requiring treatment post storm, such as asphyxiation from misuse of generators, broken limbs from falls, electrocutions from downed power lines, snakebites, and the spreading of disease due to poor sanitation;

► Few medical facilities were independently equipped to deal with the huge surge and influx of persons needing medical care.

Best Practices to Effectively Address Medically Related Issues:

- Medical records

► A national protocol for automated record keeping should be developed, with incentives for physicians to implement this expensive record keeping system;

► Citizens should be educated to keep copies of prescriptions, insurance and medical information, including maintenance of a copy with someone in another location, especially individuals with critical medical needs;

► Ensure that laws are consistent with modern medical needs;

► Ensure that physicians and other medical personnel are protected from liability concerns when treating persons during a disaster;

► Stringent policies and laws must be developed to enable appropriate medical personnel to access anyone's medical information during a disaster, while deterring inappropriate persons from violating privacy policies and laws.

- Volunteer Medical Personnel During Disaster

► Pre-certification must be accomplished prior to admittance of volunteer physicians, nurses, medical personnel, or veterinarians to any disaster sites;

- ▶ There is an abundance of outside help available from medical personnel as well as medical supplies, but it has to be organized prior to the disaster for the help to be available and effective;

- ▶ Establish new policies or laws that waive liability issues for pre-certified medical personnel during a previously defined disaster event;

- ▶ Develop a housing plan for volunteers who are on-site in a post-disaster area, especially when their assistance will be needed for weeks or months.

- Temporary Medical Facilities

- ▶ Disaster plans should include the establishment of temporary field hospitals, with functioning pharmacies included;

- ▶ There must be a more effective plan for transporting patients out of the disaster area into areas where medical services are available quickly. Air support is critical;

- ▶ Make sure that policies are set in place to waive Medicaid, Medicare, and insurance rules across a wide range of difficulties, such as transporting people from nursing and hospitals to outside facilities without getting prior approval, making prescriptions available outside the cover-

age area, and allowing pre-filling of prescriptions so people can get enough medication to last through an evacuation period;

- ▶ Setting up portable and surge hospitals with federal emergency medical teams to augment existing medical help;

- ▶ Establish mobile medical teams to help deal with medical needs during the recovery process;

- ▶ Ensure that security is considered a part of any disaster related medical facility;

- ▶ Address the issue of medical records, which most likely can only happen with electronic records.

The lessons learned from Hurricanes Katrina and Rita are numerous and complex. Some things can be easily corrected; other memories and lessons must be placed in the past. Because of the Louisiana experience, it has been the intent of the Louisiana State Medical Society to present this information in a way that will be helpful to other states and communities. In the words of one Louisiana physician:

“I think it is fair to say that no one was really prepared for Katrina. That was a shot out of the darkness that nobody, I think, in their wildest imagination really thought would happen, you know. We all talked about the Armageddon scenario, the right hurricane coming right up the mouth of the river, blah, blah, blah. But, I don’t think anyone really thought that it would happen.”

“

I think it is fair to say that **no one was really prepared for Katrina.** We all talked about the Armageddon scenario, the right hurricane coming right up the mouth of the river, blah, blah, blah. But, I don’t think anyone really thought that it would happen.

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APPENDICES

1. Morbidity and Mortality Outcomes from Hurricane Katrina

The appendix summarizes results from health surveillance systems published in the CDC, Morbidity and Mortality Weekly Reports [*MMWR*]; *MMWR* 2005:54#35; *MMWR* 2006:55#2; *MMWR* 2006:56#9.

2. References

3. Photo and Figure Credits

4. Interview List

Health Outcomes

A) Direct morbidity and mortality: Outcome associated with direct storm effects & immediate aftermath

- Disease Surveillance, Louisiana and Mississippi, Aug 29 – Sept 11: 22 cases of vibrio illness in Louisiana and Mississippi between August 29 and September 11.
- Admissions to CO poisoning treatment facilities in Louisiana, Alabama, and Mississippi: 51 total cases, 16 cases on non-fatal CO poisoning and five fatal cases in Louisiana
- An active surveillance system of functions emergency treatment locations including open hospitals and emergency clinics in Orleans, Jefferson, Plaquemines, and St. Bernard Parishes between Sept 8 – 25, 2005 reported 7,508 total health related incidents:
 - o 4,168 (56%) were for illnesses
 - o 2,018 (27%) were for injuries
 - o 1,321 (17.5%) were for non-acute complaints, including medication refills, wound checks, cast removals.
 - o 14 cases of CO poisoning and 27 cases of exposure to toxic substances were found.
 - o For the 6,167 cases where disposition was known, five died and 552 were admitted to hospitals.

- o 1,037 of the events were for relief workers, 2,567 were for residents, and for the remaining 3,904 status was unknown.

- The above described active surveillance program was interrupted by Hurricane Rita, but reestablished on Sept 25, which corresponds to repopulation. Between Sept. 25 and Oct. 15, it recorded 17,446 visits to participating facilities:
 - o 8,997 (52%) for illness
 - o 4,579 (26%) for injury
 - o 3,870 (22%) for non-acute or undetermined reasons
 - o For the 13,717 for which disposition was known, 11,169 were discharged, 1,500 were admitted to a hospital, 537 left without medical advice or treatment, 486 were transferred to another facility, and 25 died.
 - o 1,235 visits by relief workers were reported, 5,437 were among residents, and 6,904 were unknown status.
 - o Of the patients admitted to a hospital, 27% had heart conditions, 12% had nondiarrheal gastrointestinal illness, 7% had a mental health condition, and 6 had heat related illness.
 - o Of the 25 patient deaths, 23 had illnesses while 2 died of injuries.

- Illness surveillance and rapid needs assessment of evacuee evacuation centers in Colorado, Sept 1 - 23:

- o Sept 7 – 21: 3,600 evacuees arrive at Lowry Evacuation Center, Clinic at Lowry has 509 evacuee visits. 10 cases of vomiting or diarrhea, 10 cases of acute cough and fever, 15 cases of wound infection or cellulitis, 17 mental health concerns. Majority of visit were for medication refills (not counted). No outbreaks of infectious disease were identified.

- Health hazard evaluation of New Orleans police and fire, Oct 17 – 28 and Nov 30 – Dec 5 included 912 police officers (~70% of the current force) and 525 (77% of the current number of firefighters):

- o 51% of firefighters and 30% of police reported floodwater contact with nose, mouth, or eye. 52% of police and 63% of firefighters reported rescuing citizens from flooded areas.
- o 69% of police officers and 59% of firefighters reported that they were not living with family
- o 28% of police and 31% of firefighters reported upper respiratory symptoms. 21% of police and 23% of firefighters reported cough. 54 of police and 49% of firefighters reported rash.

- o Numerous police and fire reported lacerations, sprains/strains, falls, and animal bites/stings.
- o 19% of police and 22% of firefighters reported symptoms of PTSD, 25% of police and 27% of firefighters reported major depressive symptoms.

- Morbidity surveillance of emergency clinics (ECs) and health-care facilities (HCFs) that served Katrina affected population in Arkansas, Louisiana, Mississippi, and Texas, Sept 1 – 22:

- o EC surveillance, Sept 1 – 22: 14,531 visits. 33% for chronic illnesses, 27% for GI illnesses, 20% for respiratory illnesses, 18% for rashes, < 6% for injury and mental illnesses
- o HCF surveillance, Sept 5 – 22: 9,772 visits, 58% for injury, 16% for respiratory illness, < 10% GI, rash, chronic conditions and mental illnesses combined

B) Displacement from home, social network, providers, & medical history.

- Surveillance of evacuation centers during the first 3 weeks after the Hurricane:
 - o One case of norovirus at an evacuee center in Texas.
 - o A cluster of 30 cases of MRSA at an evacuee center in Texas.

- o Approximately 20 clusters of diarrheal illness in shelters in Louisiana, and 1,000 cases of diarrhea and vomiting in shelters in Texas and Mississippi.

- Clinic at Reliant Park, Sept 2 – 12: 1,169 persons who reported symptoms of acute gastroenteritis at the Reliant Park evacuation center in Houston. This number corresponds to 18% of persons treated at the health clinic there. Medical personnel, police and volunteers also report symptoms. No deaths reported.

- State wide daily syndromic surveillance from Sept 8 – Oct 26 at approximately 500 evacuation shelters in Louisiana sheltering over 50,000 persons recorded 39,217 patient encounters:

- o Including influenza like illness and rash along with cases of skin infection.
- o Chronic conditions, which accounted for 31% of encounters.
- o Mental health conditions accounted for 9% of patient encounters.

- Illness surveillance and rapid needs assessment of evacuee evacuation centers in Colorado, Sept 1 - 23:
 - o Sept 1 – 23: 124 evacuees visits to Colorado Hospital EDs. 20% for pain or headache, 13% for

medication refill, 11% chronic disease, 11% for respiratory illness, 15% other reasons including dizziness, allergic reaction, sore throat. 23% were admitted to the hospital. One died of pneumonia after refusing hospital admission

- Morbidity surveillance of emergency clinics (ECs) and health-care facilities (HCFs) that served Katrina affected population in Arkansas, Louisiana, Mississippi, and Texas, Sept 1 – 22:

- o EC surveillance, Sept 1 – 22: 14,531 visits. 33% for chronic illnesses, 27% for GI illnesses, 20% for respiratory illnesses, 18% for rashes, < 6% for injury and mental illnesses
- o HCF surveillance, Sept 5 – 22: 9,772 visits, 58% for injury, 16% for respiratory illness, < 10% GI, rash, chronic conditions and mental illnesses combined

C) Disruption of Medical Service

- A Rapid Health Needs assessment of 1,360 displaced heads of households in evacuation centers in San Antonio, TX found, 91% are from Orleans Parish:

- o 42% reported household member with chronic medical condition, 28% with physical or mental disability,

20% with someone needing counseling

-Illness surveillance and rapid needs assessment of evacuee evacuation centers in Colorado, Sept 1 - 23:

- o Sept 4 – 9: Rapid needs assessment of 106 heads of households at the Lowry. Nearly all report member of household with common acute medical condition, 34% report thirst/dehydration, 22% report dizziness/lightheadedness, 19% report problem breathing, 17% report cough, 12% report diarrhea/vomiting, 12% report skin rashes. Many also reported members with chronic medication conditions, 28% report hypertension, 23% depression or other psychiatric illness, 21% asthma or chronic lung disease, 18% report cardiovascular disease, and 14% report diabetes. 60% of households report one or more member requiring prescription medications, of which 39% were lacking them at the time, and 435 had gone without them as result of Katrina.

- Morbidity surveillance of emergency clinics (ECs) and health-care facilities (HCFs) that served Katrina affected population in Arkansas, Louisiana, Mississippi, and Texas, Sept 1 – 22:

- o EC surveillance, Sept 1 – 22: 14,531 visits. 33% for chronic illnesses, 27% for GI illnesses, 20% for respiratory illnesses, 18% for rashes, < 6% for injury and mental illnesses
- o HCF surveillance, Sept 5 – 22: 9,772 visits, 58% for injury, 16% for respiratory illness, < 10% GI, rash, chronic conditions and mental illnesses combined

D) Emergent Effects of Exposure to Hazards

- During Oct 17 – 22, CDC teams surveyed residents that had returned to Orleans and Jefferson Parishes:
 - o Housing Units: 22% lacked water, 25% lacked electricity, 43% lack tele phone.
 - o 50% of adults exhibited emotional distress
 - o 56% of homes included at least on member with a preexisting chronic health condition, 53% of homes included a person that had been ill in the 7 -8 weeks since Hurricane Katrina. 23% of household reported problems obtaining health care, only 9% reported problems obtaining prescriptions.
 - o Emotional concerns reported: 43% report feeling isolated, 26% of households contain one or more members need counseling, 50% measure possible need to mental

health services on the SPRINT-E assessment, 33% indicate probable need on SPRINT-E

- A survey of 112 occupied homes in areas of four parish region where residents were permitted entry found:

- o Flood levels are > 6 ft in 19%, 3 – 6 ft in 17%, 0 - 3 ft in 25%, and zero in 39%. 68% of homes had water leaking through roof damage.
- o Visible mold growth was found in 46% of homes, 17% displayed mold coverage > 50% on interior wall in most affected room
- o Participants reported an average of 13 hrs heavy cleaning and 15 hrs light cleaning since the hurricane. 61% of participants stated that they had inhabited their homes overnight, 25 hrs average number of nights inhabited

- A convenience sample of 159 residents and 76 remediation workers with potential mold exposure:

- o Residents: 42% had cleaned up mold of which 69% did not always use appropriate respirators
- o Workers: 91% had cleaned up mold of which 35% did not always use appropriate respirators

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PHOTO AND FIGURE CREDITS

Photographs, Aerial and Satellite Images

FEMA and HHS photographs were obtained from the Federal Emergency Management Agency Photo Library, retrieved February 9, 2009, from <http://www.photolibrary.fema.gov/photolibrary/index.jsp>.

NOAA satellite images of hurricanes Katrina and Rita were obtained from the National Oceanic and Atmospheric Administration's Satellite Services Division hurricane archives, retrieved February 12, 2009, from <http://www.ssd.noaa.gov/GOES/2005/Katrina/gmex/vis-l.jpg> and <http://www.ssd.noaa.gov/GOES/2005/Rita/gmex/vis.jpg> respectively.

USGS images of the destruction of Chandelour Islands were obtained from the United States Geological Survey's Coastal Change Hazards web site, retrieved February 9, 2009, from <http://coastal.er.usgs.gov/hurricanes/katrina/photo-comparisons/chandeleur.html>

Figures

Figures 1, 2, and 8: Cartography by S. Ahmet Binselam, LSU Hurricane Center. Data sources: US base map vector data layers extracted from ESRI Data & Maps 2006 dataset, and Louisiana vector data layers from The Louisiana GIS Digital Map - May 2007 Compilation DVD Set.

Figure 3: National Hurricane Center (2005). Retrieved February 9, 2009, from http://www.nhc.noaa.gov/archive/2005/KATRINA_graphics.shtml

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Figure 6: LSU Center for the Study of Public Health Impacts of Hurricanes (2005). Retrieved February 9, 2009, from http://hurricane.lsu.edu/floodprediction/katrina25/images/Katrina25_LA_MS.jpg

Figure 7: Cartography by Ezra Boyd, LSU Hurricane Center. Data sources Ezra Boyd, LSU Hurricane Center, and LSU Natural Systems Lab.

Figure 9: National Hurricane Center (2005). Retrieved February 12, 2009, from http://www.nhc.noaa.gov/archive/2005/RITA_graphics.shtml

Figure 10: LSU Center for the Study of Public Health Impacts of Hurricanes (2005). Retrieved February 9, 2009, from http://hurricane.lsu.edu/floodprediction/rita24/images/adv24_SurgeTX_LA.jpg

INTERVIEW REFERENCE LIST

Personal interviews were conducted by Linda Robinson with the following individuals on the dates noted:

Dr. Albert Barrocas (March 20, 2008)
Ms. Charlene Baudier (March 12, 2008)
Dr. Floyd Buras (November 17, 2008)
Dr. William Cassidy (April 17, 2008)
Dr. Kevin Contreary (May 6, 2008)
Ms. Susan Dantoni (February 28, 2008)
Dr. Peter Deblieux (June 12, 2008)
Dr. Karen DeSalvo (June 14, 2008)
Dr. Phillip Gardner (April 15, 2008)
Dr. Lenworth Jacobs (June 17, 2008)
Dr. Kevin Jordan (June 16, 2008)
Captain Joe Leonard (May 13, 2008)

Dr. Ken Mattox (May 8, 2008)
Dr. Louis Minsky (April 18, 2008)
Dr. Melanie McKnight (April 23, 2008)
Dr. Norman McSwain (July 7, 2008)
Dr. Kate Rathbun (March 28, 2008)
Dr. Kevin Stephens (April 17, 2008)
Dr. Mark Townsend (June 16, 2008)
Dr. Louis Trachtman (March 26, 2008)
Dr. John Van Hoose (May 14, 2008)
Dr. John Wales (May 8, 2008)
Ms. Linda Wranosky (May 14, 2008)
Mr. Fred Young (May 26, 2008)

