Hurricane Katrina and the Healthcare Infrastructure: A Focus on Disaster Preparedness, Response, and Resiliency

HAVIDÁN RODRÍGUEZ, PH.D., AND
BENIGNO E. AGUIRRE, PH.D.

SUMMARY • The aftermath of Hurricane Katrina provides a window of opportunity to address a frail and failing healthcare system. Katrina was the rare incident that disrupted the external systems supplying hospitals with key services and resources needed for the organizations to function; increased the number of patients, both present and expected, that required medical care; and affected directly the physical plants of the hospitals, challenging their functionality. Sorting through and gleaning useful lessons to increase the resilience of hospitals for this type of catastrophic incident will take time and will require system-wide public health planning and intervention. In this article, the authors focus on how hospitals prepared for, responded to, and coped with Katrina. They also provide a brief overview of the current situation and the healthcare crisis confronting hospitals and communities in the region affected by Katrina and discuss the impending need to develop disaster-resilient medical and healthcare systems. Planning, access to adequate resources, networking, effective communication and coordination, and training and education of doctors, nurses, technicians, and medical staff are essential in the development of a resilient healthcare infrastructure that will be able to provide the much needed services to populations affected by future disasters.

Havidán Rodríguez, Ph.D., is director of the Disaster Research Center and professor in the department of sociology and criminal justice; and Benigno E. Aguirre, Ph.D., is a core faculty member of the Disaster Research Center and professor in the department of sociology and criminal justice at the University of Delaware.

HURRICANE KATRINA was a catastrophic event (Quarantelli 2006). In its report "The Federal Response to Hurricane Katrina," the White House (2006) indicates that this has been "the most destructive natural disaster in U.S. history." Hurricane Katrina resulted in the displacement of over one million people, leaving "refugees" scattered throughout the continental United States; destroying about 350,000 houses; resulting in a death toll estimated at about 1,300[1]; and displacing over 200,000 persons to evacuation centers in at least 18 states. Although the total economic impact of Katrina fluctuates from one source to another, it is estimated that it will surpass $100 billion.[2]

The aftermath of Hurricane Katrina was exacerbated by the breach in the levee system in New Orleans, resulting in extensive flooding. Several hours after the hurricane, many people and organizations in New Orleans were actually celebrating, given that the impact of Katrina was not as devastating as predicted (Rodríguez, Trainor, and Quarantelli 2006). However, shortly thereafter the flood waters started rising, resulting in widespread destruction of property and the extensive loss of life. Hospitals and other medical units were particularly hard hit by the floods, resulting in significant problems for health institutions with previous experience managing and responding to disaster events. The healthcare infrastructure and healthcare services of the area, already ranked as among the poorest in the nation, were all but decimated by Hurricane Katrina. In the following sections, we focus on the impact of this devastating event on the healthcare system and its infrastructure and how hospitals prepared for, responded to, and coped with this disaster. We also provide a brief overview of the current situation and the healthcare crisis confronting hospitals and communities in the affected region, primarily focusing on New Orleans. We conclude this article with a discussion regarding the impending need to develop disaster-resilient medical and healthcare systems.

PREPARING AND RESPONDING TO KATRINA

Rodríguez, Trainor, and Quarantelli (2006) summarize how hospitals prepared for and responded to Hurricane Katrina:

> *[T]he initial response of hospitals was to react as they had done in the past. They activated their disaster teams of specially designated physicians, nurses, and other key staff members. Less critically ill patients were discharged. Extra supplies of water, food, blood, and medical supplies were stored on scene....When the hurricane hit the area, the buildings as a whole suffered little physical damage. The electric power did fail, but this had been anticipated. In most hospitals, the expectation was that normal operations would soon be resumed.... It appeared for a few hours that the traditional planning had worked. Within less than 24 hours, however, the floodwater from the levee breaks created a new kind of crisis. Basements with stored food, water, and fuel, as well as morgues for dead bodies were inundated; in some hospitals, activities on the first floor had to be moved to higher floors. Telephone systems were erratic at best. As emergency generators ran out of fuel, the water, sewage, and air conditioning systems failed. Patients who died in the hospitals had to be temporarily stored in stairwells. Eventually, waste of all kinds littered almost everywhere. The rising temperatures made most diagnostic equipment inoperable.... Regular hospital procedures simply stopped, but per-*

sonnel improvised to try to provide at least minimum healthcare. (89–90)

Hospitals in the New Orleans area have extensive experience in preparing for and responding to disasters. Moreover, hospitals are required by the Centers for Medicare and Medicaid Services to have an emergency plan. Further, the Joint Commission on Accreditation of Healthcare Organizations requires that these facilities have emergency plans that include an evacuation plan. Hospitals in the region appeared to be prepared for a short-duration event, but they anticipated that in several days they would be back to their "normal" operations. Many hospitals appeared to have had enough supplies, materials, and generator power to be self-sufficient for about three to five days. However, many used their basements as storage space. As a result of the levee breach in New Orleans, basements were flooded by the rising waters; medications, food, equipment, and supplies were partially or completely lost; and the mechanical, plumbing, and electrical systems were all but destroyed. Hospitals ran out of fuel to power their generators. For many hospitals there was no electricity and no running water, the sewage system was inoperable, and communication systems were rendered useless. Further, many hospitals had to ration food for their patients, hospital staff, and others who had converged at their facilities.

Consequently, as discussed by Rodríguez, Trainor, and Quarantelli (2006), many hospitals were ovewhelmed by the aftermath of Hurricane Katrina. This situation was aggravated not only by the number of patients for which hospitals had to provide healthcare but by other individuals that were seeking temporary shelter. Rodríguez and colleagues (2006) point out that, in Charity Hospital alone, over 1,200 staff members, relatives of hospital patients, and others sought shelter.[3] As indicated by Dr. Bryant King (a physician at Memorial Medical Center in New Orleans):

We weren't really functioning as a hospital but as a shelter ... we had no electricity. There was no water. It was hot. People were dying.[4] We thought it was as bad as it could get. Why weren't we being evacuated? (Johnston 2006)

Evacuation problems also emerged as a critical issue for hospitals, particularly for those with very few resources. Recent reports indicate that about 6 hospitals and 13 nursing homes were under investigation by the Louisiana Attorney General, which eventuated in the arrest of a doctor and two nurses accused of using lethal injections in a New Orleans hospital in the aftermath of Katrina.

Hospitals in the vicinity of New Orleans, particularly in Northern Louisiana and Baton Rouge, although not necessarily directly impacted by the hurricane and the levee breach, were nevertheless impacted by the number of patients that were being transferred from hospitals that had been all but destroyed by Hurricane Katrina and the emerging floods. These hospitals also had to make the necessary arrangements to cope with the increasing number of patients, which exceeded their normal carrying capacity.[5]

The report "The Federal Response to Hurricane Katrina" highlights some of the problems and challenges confronted by the public health and medical sectors following this catastrophic event:

Hurricane Katrina created enormous public health and medical challenges, especially in Louisiana and Mississippi—states with public health infrastructures that ranked 49th and 50th in the nation, respectively. But it was the subsequent flooding of New Orleans that imposed catastrophic public health conditions on the people of Southern Louisiana.... Tens of thousands of people required medical care. Over 200,000 people with chronic medical conditions, displaced by the storm and isolated by flooding, found themselves without access to their usual medications and sources of medical care. Several large hospitals were totally destroyed and many others were rendered inoperable. Nearly all smaller healthcare facilities were shut down.... [T]he region's healthcare infrastructure sustained extraordinary damage. (The White House 2006, 58)

The aforementioned report indicates that as a consequence of the extensive impact on the healthcare infrastructure, there was an "unprecedented mobilization of federal public health and medical assets" to the region. For example, in Gulfport, Mississippi, a makeshift medical unit or a portable hospital was set up to provide medical services to the general public. Administered by the National Institutes of Health, this was part of the federal response to provide medical assistance to the communities in the areas affected by Katrina. However, despite such efforts, the federal government itself recognized that "the coordination of federal assets within and across agencies was poor" (2006, 58), thus exacerbating the healthcare crisis in the region.

Katrina magnified the problems and deficiencies of an already ailing and compromised healthcare system.

In its report on the evacuation process of hospitals and nursing homes following Katrina, the U.S. Government Accountability Office (U.S. GAO 2006) indicates that the National Disaster Medical System[6] (NDMS) was used to help in the evacuation process of patients during the aftermath of Hurricane Katrina. However, hospitals and nursing homes were not on the priority list of personnel in charge of the rescue process in New Orleans (The White House 2006). This problem was exacerbated by the fact that most hospitals did not have the resources to evacuate their patients. Moreover, some evacuation attempts were abandoned when air transportation never came to fruition.

Hospitals are essentially designed to shelter in place (U.S. GAO 2006) during these types of emergencies. Therefore, hospital administrators would evacuate their patients if no other viable alternatives existed to provide adequate care and support to them. As Quarantelli (1997) argues, hospital evacuation plans rarely deal with having to evacuate facilities following a disaster. However, during the aftermath of Katrina, it appeared that some of the hospitals that did decide to evacuate their patients did not have the necessary resources to do so, and the federal response was extremely slow, thus endangering the lives of hundreds if not thousands of patients and hospital staff. As mentioned previously, the problems that hospitals confronted with relatively large populations in their facilities were complicated by the fact that many of them ran out of supplies, materials, and food several days after Hurricane Katrina. Furthermore, the U.S. GAO (2006, 14) indicates that

[D]uring Hurricane Katrina, the destruction of communications systems left hospital and nursing home administrators unable to receive basic information, such as when assistance would arrive.

Hospitals and Healthcare Facilities in a Post-Katrina Environment

As a consequence of Hurricane Katrina and the massive flooding that ensued, many of the hospitals in New Orleans were put out of commission. Two of the major hospitals that served the New Orleans area, and provided medical care to over 500,000 patients each year, are beyond repair and, apparently, must be demolished. Charity Hospital (a 270-year-old institution and the flagship teaching institution in New Orleans) functioned as a makeshift operation in the New Orleans Convention Center, a location that it abandoned in April 2006. It is now relocated in three different buildings in New Orleans and Jefferson Parish. In his article titled "New Orleans' Uninsured Get Primitive Care," Callimachi (2006) describes the operations of Charity Hospital in the Convention Center:

> *In the same concrete structure where thousands of fleeing families waited in vain for food and water, they now wait for medical care, dispensed by a skeletal staff of doctors working out of military tents. Inside their plastic and canvas walls, the doctors can only offer the most rudimentary care: They can x-ray bones, but not set them. They can draw blood and diagnose an ailment, but not treat it beyond prescribing pills. And with no capacity to operate, they can't do much more than stabilize trauma patients before sending them by ambulance elsewhere, often far away.*

Callimachi (2006) also indicates that, as a consequence of Hurricane Katrina and its catastrophic floods, 8 of the 16 hospitals in the New Orleans area were closed, some permanently, and about 2,000 (57 percent) of the 3,500 practicing doctors were displaced. The shutdown of Charity Hospital due to its "compromised" infrastructure and "safety issues" will negatively impact thousands of residents, primarily poor individuals, and access to healthcare will be significantly limited. Consequently, other hospitals in the region that are slowly reopening (but remain understaffed) have experienced a significant increase in the number of poor and uninsured patients,[7] thus increasing the financial strains and compromising much of the resources of already ailing medical institutions.

The healthcare system in New Orleans is fragile at best, and the health resources and services that are available are insufficient to cope with the medical and healthcare needs and demands of the current population, not to mention the pre-Katrina population in the region. The region also suffers a shortage of doctors, nurses, technicians, and other support staff. For example, an estimated 4,500 doctors evacuated New Orleans as a consequence of Hurricane Katrina, and about 1,200 have returned. As Darcé (2006) indicates, "Katrina shooed scores of physicians from the city, and the ones who come back face a healthcare climate that's running on life support."

Hurricane Katrina magnified the healthcare problems and deficiencies of an already ailing and compromised healthcare system in Louisiana and the other regions impacted by this catastrophic event. The 2006 report of the Health and Social Services Committee of the New Orleans Commission indicates that prior to Katrina, Louisiana was characterized by "some of the poorest healthcare statistics in the nation [and that] large disparities in health statuses existed for minorities."

Developing Resilient Medical and Healthcare Systems

The experiences of the health system in the Katrina incident can be placed in the context of a general consideration of resilience. Aguirre (2006) has argued that the concept of resilience encompasses physical, biological, psychological, social, and cultural systems. Resilience has been defined in many ways (for example, see Wisner et al. 2005) to include an ability to "bounce back" and continue to function; predict and prevent potential problems; improvise and recombine resources in new ways; develop a collective and shared vision of dangers and what to do about them; and constantly monitor threatening contextual conditions (Kendra and Wachtendorf 2003). For our purpose, we define resilience as a system's capability to effectively absorb, respond, and recover from an internally or externally induced set of extraordinary demands.

"Cultures of safety" can be developed that provide patterns of anticipated effects, actions, and strategies as well as templates for response, recovery, and mitigation.

Resilience is both the capacity of a system to react appropriately to moments of crises that have not been entirely anticipated, and the ability to anticipate these crises and to enact, through emergency and disaster planning, changes in the system that will mitigate their effects. The process is never ending, for the sources of often unanticipated demands that create changes in the known dynamics of the system are multiple. Past experiences cannot be used as the only source of information to anticipate possible crises, and imagination, creativity, and even luck are needed to succeed. A resilient system is one that incorporates both an awareness of potential hazards and their physical, biological, psychological, social, and cultural demands, and the taking of action in anticipation of these demands to forestall or minimize their effects.

Developing Resilience

To develop resilience, an organization must shift its mind-set from creating discrete strategies aimed at reducing vulnerability and risk to a more holistic, integrated, collective approach that enhances safety and security. The ability of systems to effectively respond to sudden demands is thus partly a function of conscious awareness, planning, and training.

Resilience is a type of cognitive, social, and cultural adaptation to threats. While not all significant system threats and their consequences can be known, "cultures of safety" can be developed that provide patterns of anticipated effects, actions, and strategies as well as templates for response, recovery, and mitigation (Aguirre 2006).

Vulnerability and Resilience

Disasters are the result of the combined effects of a hazard on a social organization that has a specific set of vulnerabilities and resilience. Both vulnerability and resilience fluctuate over time, allowing for the differential effects of hazards on the built and social systems. Vulnerability points to the need for systems to change. When these changes include preparedness, recovery, and mitigation geared to respond to specific hazards, resilience increases, which in turn results in the reduction of vulnerability. As a consequence, the reconstitution of the social system occurs, making it safer for the individuals, communities, and organizations that are part of it.

In the real world, as J. Nigg reminds us (2006), the changes that enhance resilience take place neither in a linear fashion nor without conflicting objectives. Policy changes are often contentious; changes in technology have unintended consequences; demographic transitions can bring their own pressures through changes in resource needs; and the built environment is constantly in need of maintenance and changed usage. The challenge for the incorporation of resiliency is thus to identify what enhances the ability of organizations to effectively rebound, taking into account the actual physical and social systems that are present and the limited amount of economic resources that may be available to lessen vulnerability.

Hospitals Are Resilient

As we have indicated in the case of Katrina, hospitals are highly resilient organizations. They are autonomous and self-referential organizations, yet they are also very much part of interorganizational systems; they change and orient their actions to accommodate the demands of these systems of cooperating agencies. The importance of the systemic links of hospitals to other community and regional organizations, particularly health service organizations, is that these links are often the way in which emergencies and crises are created in hospitals and solutions to emergencies and crises found for hospitals. At times, the potential demands generated by the system never materialize. Nevertheless, system-originated emergencies and crises in hospitals that create disaster conditions may take place purely on anticipatory grounds as a result of the hospital's connectedness with other hospitals and community organizations (Aguirre et al. 2005).

The importance of the Katrina experience is better understood if it is placed on a broader framework in which the disaster-hospital relationship is examined. Hospitals are in the business of handling emergencies, crises, and disasters. As we have shown elsewhere (Aguirre et al. 2005), demands generated by these types of events disrupt the operations of hospitals, and through a set of adaptive mechanisms gradually become routine programs and practices. Hospital staff experience and anticipate these disruptions, the disruptions become part of their imagined reality, and staff take anticipatory planning and corrective actions. Thus, over time, the strengthening of hospitals comes about as these extraordinary demands become routine events (Stallings 1998 and 1970).

Consequently, very often community disasters do not bring about disastrous effects for the hospitals in those communities. The claim that a disaster is taking place comes from outside the hospital, but the response to that claim is very much dictated by processes internal to the hospital. The activation of disaster plans in hospitals is a function of the staff's perception of the actual and/or potential effects of hazards and/or other incidents on their operations: whether the hospital will be able to continue to take care of patients optimally; the availability of staff, equipment, supplies, and other resources; and the hospitals' degree of preparedness and planning for the occasion. These decisions are suffused with uncertainty, so that what to call an occasion—emergency, crisis, or disaster—is a negotiated outcome. It is not always possible to predict how an incident with a given set of characteristics will be understood. The logic of the institution rather than the claims of

the community is usually what determines how an incident is understood and responded to by hospital staff (Aguirre et al. 2005).

Resilience Lessons from Katrina

As discussed previously in this article, Katrina was different in that it was a disaster if not a catastrophic event for both the communities and their hospitals (Quarantelli 2006). Katrina was the rare incident that (1) disrupted the external systems supplying many of the hospitals in the region with key services and resources needed for the organizations to function as organizations; (2) increased the number of patients, both present and expected, that required medical care; and (3) affected directly the physical plants of the hospitals, challenging their functionality. The near simultaneous occurrence of all three effects is rather unusual, resulting in the tremendous impact of the storm on the regional public health system. In this rare set of conditions, the hospitals in the region were not resilient to Katrina's extraordinary set of demands. How to make them resilient to these types of events should be a topic of sustained discussion, particularly since we should expect more frequent severe hurricanes in the years ahead.

Sorting through and gleaning useful lessons to increase the resilience of hospitals for this type of catastrophic incident will take time and will require system-wide public health planning and intervention. Needed is extensive research on the experience of the affected hospitals during this incident, to find out with greater certainty than we know today what challenged their functionality and what can be done to ameliorate these effects. Importantly, the changes that would likely be needed will involve organizations and systems outside any given hospital, so that extensive government intervention and support will become essential in the reconstitution of the systems in which the hospitals participate.

We will also need to know on a case-by-case basis what structural retrofitting and changes in building codes would be required to increase hospital buildings' resilience to high winds and flooding. Those in charge of such requirements will have to keep in mind the economic realities faced by hospital administrators who do not have the resources needed to pay for every technical and structural innovation mandated or suggested to improve the safety and efficiency of hospitals. Even if they have the funds, administrators realize that the outcome of investing in many of these recommended retrofitting measures is often shrouded in uncertainty, as the controversy surrounding seismic retrofitting of hospital buildings in California showed (Aguirre and Connell 2003; Alesch and Petak 2001).

The aftermath of Hurricane Katrina provides a window of opportunity to address a frail and failing healthcare system and many of the issues raised above. Structural and systemic changes supported by necessary funding from the local, state, and federal governments can allow for the development of a resilient and sustainable healthcare system. For example, the Mayor of the City of New Orleans has established the New Orleans Commission, which is composed of a number of committees focusing on the rebuilding of the city. A diverse set of committees are focusing on critical issues such as urban planning, education, infrastructure, culture, the criminal justice

system, public transit, economic development, and health. Many of these committees have already met and generated a number of important reports (see http://www.bringneworleansback.org).

The Health and Social Services Committee (2006) of the New Orleans Commission generated a report providing an extensive number of recommendations aimed at preparing hospitals for future disasters and with the goal of developing a sustainable and resilient healthcare system. Some of the recommended initiatives include:

1. the creation of community healthcare centers that would serve all segments of the population and that are linked to hospitals in the region;
2. evacuation planning;
3. developing effective and resilient communication systems;
4. the creation of a system that would allow for transportable key health information for patients and disaster victims who may need medical treatment in other hospitals and regions throughout the country;
5. developing systems of care that are community driven and community based;
6. generating databases with reliable and up-to-date demographic information that can contribute to enhancing hospital planning and decision making during crisis situations;
7. developing effective communication and outreach strategies; and
8. ensuring that temporary shelters have the necessary facilities, staff, supplies, and equipment to provide adequate healthcare to all patients but particularly to those with special needs.

In the context of a well-thought-out conceptual map of resilience, these recommendations are illustrative of the type of change that is needed to develop an effective and resilient healthcare system and infrastructure that will be able to provide adequate healthcare not only on a regular basis but also in times of crises and disasters.

As Quarantelli (1989, 6) indicates:

> *What is [also] needed is improvement both in medical technologies and in the* ***social organizational arrangements*** *that can be used in disaster situations. There is a need to be innovative in making use of medical technological advances and to work out better institutional and organizational arrangements to deliver disaster EMS [emergency medical services] (our emphasis).*

Quarantelli's recommendations are particularly relevant in the context of the many scientific, technological, and medical advancements in recent decades that have not only resulted in improved healthcare but have also increased vulnerability, particularly during emergency or crisis situations. Technological advancements have resulted in new types of vulnerabilities, for example, new technologies in the medical or health field are "too costly, unwieldy, require specialized knowledge and personnel, etc., to be quickly and efficiently used at times of massive casualties" (Quarantelli 1989, 7) or major disasters. Newly emerging, sophisticated, and complex medical technologies will continue to pose serious problems in the delivery of healthcare services during major disasters or when the lifeline infrastructure (that is, electricity, water, gas services) needed for their functionality are disrupted or destroyed, as the case of Hurricane Katrina has demonstrated (see Quarantelli 1985 and 1989).

Concluding Remarks

As we plan for the next crisis or emergency situation, disaster planning and management strategies must consider how medical and healthcare facilities will maintain their operations and functionality in the absence of essential services and during the disruption of interorganizational systems. Resources must be in situ or immediately mobilized to ensure that these medical facilities are able to provide essential healthcare services for at least seven days following a disaster. Moreover, strategies must be developed and set in place for the effective and immediate evacuation of patients, particularly those with severe or chronic diseases and injuries. Planning, access to adequate resources, networking, effective communication and coordination, and training and education of doctors, nurses, technicians, and medical staff are essential in the development of a resilient healthcare infrastructure that will be able to provide the much needed services to populations affected by disasters.

Notes

1. Prior to Hurricane Katrina, the deadliest "natural" disaster in U.S. history was the Galveston hurricane (or better known as "the storm") that devastated Galveston on September 8, 1900 and left a death toll of about 6,000 (see Dynes and Rodríguez 2005).
2. We should note that there are no systematic or centralized data collection processes or methodologies regarding disaster losses (e.g., deaths, injuries, economic impact). Consequently, disaster losses can vary quite significantly from one source to another and should be viewed with caution (Thomas 2001).
3. As a direct consequence of disasters, hospitals tend to experience a massive convergence of people, including medical care personnel, the media, public safety officials, volunteers, the victims of the disaster, and the friends and family of hospital personnel, staff, and patients, among others (Quarantelli 1985). Therefore, hospitals must be prepared to deal with, accommodate, and even provide services, food, and shelter to the rapidly increasing number of individuals.
4. Bourque et al. (2006) argue that many injuries and diseases, as a direct consequence of a disaster, may lead to disability or even death as a result of the damage or destruction of the healthcare infrastructure and the disruption of public health services.
5. It is noteworthy that a number of makeshift hospitals, healthcare facilities, and emergency triage centers were established to deal with the victims of Hurricane Katrina. For example, medical personnel, equipment, medical supplies, and other resources were deployed to the Louis Armstrong Airport, where a makeshift hospital was established in the immediate aftermath of Katrina.
6. The NDMS, established in 1984, is a section within the U.S. Department of Homeland Security (DHS). It is essentially a partnership between DHS, the Department of Defense, the Department of Health and Human Services, and the Department of Veteran Affairs. NDMS is responsible for the "management and coordination of the federal medical response to major emergencies and federally declared disasters" (see http://www.oep-ndms.dhhs.gov).

7. The number of uninsured individuals in the state of Louisiana increased from about 900,000 prior to Hurricane Katrina to over 1.2 million after the impact of this catastrophic event (see the 2006 report of the Health and Social Services Committee of the New Orleans Commission).

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