University of Texas Medical Branch Telemedicine Disaster Response and Recovery: Lessons Learned from Hurricane Ike

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Abstract
Despite previous efforts and expenditure of tremendous resources on creating and simulating disaster response scenarios, true disaster response, specifically for healthcare, has been inadequate. In addition, none of the >200 local and statewide telemedicine programs in the United States has ever responded to a large-scale disaster, let alone, experienced one directly. Based on its experience with hurricanes Rita and, most recently, Ike, the University of Texas Medical Branch (UTMB) experienced its most challenging trials. Although there were significant disruptions to a majority of UTMB’s physical and operational infrastructures, its telemedicine services were able to resume near normal activities within the first week of the post-Ike recovery period, an unimaginable feat in the face of such remarkable devastation. This was primarily due in part to the flexibility of its data network, the rapid response, and plasticity of its telemedicine program. UTMB’s experiences in providing rapid and effective medical services in the face of such a disaster offer valuable lessons for local, state, and national disaster preparations, policy, and remote medical delivery models and programs.

Key words: disaster medicine, telecommunications, telemedicine, extreme environments

Introduction
In its 2008 report to Congress, the Joint Advisory Committee on Communications Capabilities of Emergency Medical and Public Health Care Facilities found an imperative need to modernize and invest in telehealth systems and networks. This investment in an interoperable, survivable, and standards-based infrastructure that is critical for healthcare communications and services in disaster scenarios, which require coordination at the local, regional, and national levels. Despite previous efforts and the expenditure of enormous resources to create and stimulate disaster response scenarios, actual disaster responses, specifically for healthcare, have been inadequate.

As a result of the destructive effects of hurricanes Rita and, most recently, Ike, the University of Texas Medical Branch (UTMB) was faced with significant healthcare delivery challenges. Although there were significant disruptions to a majority of UTMB’s physical and operational infrastructures, its telemedicine services were able to resume near normal activities within the first week of the post-Ike recovery period, an unimaginable feat in the face of such a remarkable devastation. The quick recovery was primarily due to the flexibility of the university’s data network as well as the rapid response and plasticity of its telemedicine program. UTMB’s ability and experience in providing rapid and effective medical services in the face of such a disaster offer valuable lessons for local, state, and national disaster preparations, policy, and remote medical delivery models and programs.

The goal of this report was to describe the impact of the hurricane Ike on UTMB’s electronically mediated medical services and how UTMB telemedicine services recovered and responded in the storm’s
wake. In addition, we identify ways and approaches whereby telemedicine systems and infrastructures can be better prepared not only to respond to, but also to recover from, future impending disasters.

The Impact of Disasters on Health
Within the past 10 years, there have been a myriad of disasters (e.g., hurricane Katrina, Indonesian tsunami, London subway bombings, 9/11) that exacted a significant toll on local, state, and national resources. Simmons and colleagues have remarked that the common thread among these man-made and natural disasters is the detrimental effects on both human health and the healthcare delivery systems. Such effects on human health can come from a host of disaster-related sources such as traumatic injuries and burns from structural failures and fires or exposures to infectious diseases from contaminated flood waters, air, and sewage. Further complicating responses to the healthcare needs of those affected by the disaster is the potential compromise of the infrastructures of healthcare delivery organizations and resources that have been damaged or destroyed. This is particularly true in the case of large-scale natural disasters such as hurricanes Katrina and Ike, where millions of people were displaced and entire healthcare infrastructures immobilized or, in some instances, obliterated.

The demands for the basic needs of safety and survival may overwhelm local and state governments, further diverting resources from safeguarding healthcare assets. Given the recent events of the past decade, there is a renewed emphasis on developing a coordinated and comprehensive strategy to improve medical responses to catastrophic events.

The use of telehealth has been recommended as a way to improve medical responses to disasters. The advantages of incorporating telehealth into disaster response plans are clear and include real-time health monitoring, coordination among providers, assistance with triage, and access to telemedicine networks, to name a few. Although there have been efforts to utilize telehealth and telemedicine for emergency preparedness and response, they have mostly occurred on either a conceptual or simulated level. Prior to the hurricane Ike, none of the >200 local and statewide telemedicine programs in the United States had responded to a large-scale disaster, let alone, experienced one directly.

Overview of UTMB Telemedicine
UTMB has considerable experience in both the delivery of telehealth and the provision of health services to diverse populations statewide as well as conducting research on the impact of telehealth. The university has implemented an integrated healthcare delivery network linking correctional facilities across Texas as well as several underserved populations and rural communities. In addition to the utilization of a system-wide electronic medical record, UTMB has leveraged telehealth technologies to achieve impressive results in disease management, population care, and utilization management.

Central to UTMB’s telemedicine systems is the use of large-scale, geographically distributed broadband computer networks for secure medical applications. The broadband communication systems swiftly and easily transmit the large amount of digital data back and forth between physicians and patients. These networks, appropriately configured and operated, are the backbone on which UTMB systems operate to support medical quality video, electronic medical records, and other necessary systems.

From humble beginnings of providing limited services to prison populations, UTMB has grown and developed into a world leader in using technology to provide remote medical services. Since an initial contract with the State of Texas in 1994, UTMB has conducted >250,000 telemedicine consultations with the state’s prison inmates and ~100,000 telemedicine consultations in noncorrectional settings, including mental health clinics, community health clinics, regional maternal and child health clinics, and employee health programs. Figure 1 depicts UTMB’s telemedicine growth for the last 8 years.

Hurricane Ike
On September 12, 2009, the hurricane Ike made landfall in the Galveston, Texas area, becoming the third most destructive hurricane ever to hit the continental United States. It claimed 82 lives, almost destroyed the city of Galveston, and severely crippled the surrounding communities. UTMB, which houses the state’s oldest medical school, is comprised of 110 clinical, academic, and research buildings spread over 85 acres, each of which were inundated with anywhere from 2.5 to 4 feet of water. Damage estimates to UTMB were estimated at close to $1 billion.

Based upon the lessons learned during hurricanes Katrina and Rita, UTMB activated its Incident Command System and Emergency Plan to release nonessential personnel and prepare for patient evacuations several days before Ike’s arrival. Concurrently, local officials ordered the evacuation of ~2 million people from the expected landfall areas. There is no doubt that this preplanned evacuation routing and preplacement of essential services and resources saved lives. In addition to planning for evacuation routes, local governments also planned for the rapid reestablishment of essential services such as electricity, water, fire, and police and emergency medical services after the hurricane. Despite the brilliantly executed recovery plan, much of the affected area remained without electricity, landline phone service,
Fig. 1. UTMB telemedicine fiscal growth since 2001. UTMB, University of Texas Medical Branch.

As a result of the evacuation of Galveston Island and a significant portion of Houston, many residents of these communities found themselves displaced and without access to local medical care. Many of the displaced citizens found that few primary care “brick and mortar” clinics were available for nonemergency medical care. This was partly due to the fact that the evacuees included most of the primary care medical community. This community of local caregivers returned not only to homes that were damaged by the hurricane, but also to clinics that were flooded and without power and clean water. Although we do not have precise numbers, anecdotal evidence suggests that very few local providers were available to their patient populations for several weeks after Ike’s landfall. UTMB’s local corporate and county telemedicine patients were part of this displaced group without access to nonemergency care. Unfortunately, but not unexpectedly, many of the 2 million evacuees departed without a 30-day supply of their prescription medications. Upon their return to the sweltering heat and flooded areas strewn with debris, minor injuries and ailments were commonplace occurrences.

Telemicine Recovery

Given UTMB’s location in Ike’s strike zone, it is not surprising that our employee-based and community-based centers were not available to conduct clinical sessions as usual during the first weeks after the storm. Most of the medical staff servicing these clinics prudently and appropriately evacuated the area along with most of our patients. Given our comfort level with the remote operations inherent in the UTMB telemedicine healthcare delivery system, we recovered more quickly than most businesses and other organizations in the strike zone. By taking advantage of the power of the cell phone, UTMB was able to implement a temporary telemedicine disaster response network and reestablish normal clinical services to a majority of our clinical customers within 14 days of the storm.

As a first step, the UTMB telemedicine team forwarded our patient scheduling system to cell phones carried by our team members. This simple act proved to be a key component of recovery in the weeks following Ike’s landfall. Within the first post-Ike recovery week, UTMB turned to the telephone to establish a physician-mediated primary care consultation service for our locally displaced telemedicine patients residing in and around the Houston area. In cooperation with one of UTMB’s corporate employee health clients, UTMB also established a statewide primary care telephonic physician consult service for displaced patients. This system enabled the patients to call and speak with a primary care physician for non-emergency care issues within the first 2 weeks of the post-Ike recovery period. Notes generated from these calls were incorporated into the patient’s normal medical records in support of both disaster recovery medical care and continuity of postrecovery medical care.

In the process of utilizing cell phone technology, it became evident that the electronic medical record is indispensable in managing these medical problems. We found that notes in simple text format were the most transferable between the various medical systems involved in this short response period. Based on that experience, we recommend that any organization planning to develop a rapidly configuratable emergency response network consider using a secure, Web-accessible file server system housed in a secured location. UTMB is currently employing such a secure file-sharing system in its statewide pediatric psychiatry service and regional maternal and child health clinics. It is not unreasonable to expect to use this network during an unforeseen emergency.
A Fault-Tolerant Network

The hurricane Ike’s impact was also mitigated because of a deliberate decision made by UTMB years ago to build a fault-tolerant system capable of continuing operations despite marked interruptions or disruptions in parts of its system. The concept is akin to many industries with wide grid networks, such as electrical, natural gas, telecommunications, and banking. Although there may be disruptions to certain components of the grid, the disruptions are localized and do not significantly hamper the operations of the rest of the system. As result, UTMB’s distributed network of physicians was able to conduct many normal telemedicine clinical sessions with minimal interruptions. This was particularly true of the telemedicine programs offered in the state’s correctional facilities and in the cases where UTMB’s telemedicine providers operated from remote sites.

As part of its fault-tolerant network, UTMB has a campus data and a communications network as well as a statewide private internal network. Although the hurricane Ike eliminated the key central hub in Galveston for all UTMB medical and operational activities (see attached network diagram on Fig. 2), fortunately, most of the statewide network had an alternate disaster recovery hub located ~100 miles away in Huntsville, Texas. This allowed for the majority of the statewide network to continue to operate, as communication paths were redundant from the majority of statewide sites to both Galveston and Huntsville. Because of this redundancy, telehealth activities were minimally to moderately impacted for the month following Ike’s landfall, but returned to near normal activities shortly thereafter (Fig. 2).

The system was not perfect, however. For example, any connectivity that relied on a path through Galveston was eliminated, including the UTMB Internet connection. We also learned that too many of our remote sites were linked to too few hubs so that a failure at a major hub affected 8–10 individual sites. Additionally, the hubs’ physical locations were not sufficiently robust to withstand the strains imposed by the hurricane Ike.

UTMB is implementing a number of measures to reduce the impact of any future disasters. Specific actions include the following:

- Adding six to eight times the current bandwidth across major network highways.
- Locating major hubs or connection points on the hub in industrial strength data centers with stable power, air conditioning, Internet connectivity, and continuous manned operations.
- Reconfiguring infrastructure so that each statewide network will have only one hop to the major highway. In the current design, 8–10 sites are connected to a cluster hub location, which then links to the major highway.
- Establishing redundant connectivity between third-party vendors that transmit patient enrollment feeds, laboratory results, and other ancillary data essential to the electronic medical record; patient data are being established at a new disaster recovery site.

Lessons Learned

Lesson 1: The medical community is part of the local community and therefore affected by the same events affecting the community at large.
TELEMEDICINE DISASTER RECOVERY

Fig. 3. UTMB's telehealth video-conferencing activities pre- and post-hurricane Ike.

Given the fact that much of the medical care given in the United States is via primary care providers, their removal from the community because of evacuations for disasters or a pandemic greatly reduces the community's available medical services and may cause temporary emergency centers to be overrun by noncritical medical problems. In addition, the normal healthcare facilities may be inoperable or inappropriate during many large-scale emergencies. In the event of biological emergencies, congregations of the sick and the well may hasten the spread of the contagions.

Lesson 2: Geographic dispersion of caregivers in a telemedicine environment can help mitigate the impact of natural disasters or other disruptive events.

Although telemedicine is frequently touted as a way for remotely located patients to benefit from medical care, it also provides an opportunity for remotely located physicians to provide that care and consult with one another. Because in-person care may provide certain benefits that telemedicine cannot deliver, locally based networks and caregivers may still be the preferred method for constructing a healthcare network. However, complementing the locally based network with a geographically dispersed group of physicians linked by modern telecommunications can help reduce disruptions in care because of local circumstances and accelerate recovery of the care system. Many of the cell phones in wide use today have phone, e-mail, high-resolution still photographic capabilities, video, and Internet access. The intelligent and judicious use of cell phone technology can provide the medical and emergency response community with a rapidly configurable mobile primary care access point during medical emergencies.

We do not propose abandoning either real-time video telemedicine clinics or mobile clinics in favor of the cell phone. We are merely pointing out that many day-to-day medical issues that emerge during extreme circumstances can be effectively and efficiently managed via a simple phone conversation between the patient and his/her doctor.

Lesson 3: Cell phones can facilitate medical care by reconfiguring the system to enable remote consultations and reduce patient load on local and/or temporary facilities.

The use of cell phones by locally based caregivers can enable quick reconfiguration of the healthcare system by enabling patients and caregivers to connect for consultations, especially for routine care, when they are unable to visit in-person because of a natural disaster. In effect, the cell phone enables emergency reconfiguration of the healthcare system from face-to-face care to a de facto, albeit limited, telemedicine model.

Use of cell phone technology can also help ease the strain on mobile clinics established in response to the disaster by attending to routine care and thereby easing on-site patient loads.

Given the 260 million cell phone subscriptions in the United States and the nearly 1 billion subscribers worldwide, the cell phone is the current ubiquitous personal communication and information system. Many of the cell phones in wide use today have phone, e-mail, high-resolution still photographic capabilities, video, and Internet access. The intelligent and judicious use of cell phone technology can provide the medical and emergency response community with a rapidly configurable mobile primary care access point during medical emergencies.

We do not propose abandoning either real-time video telemedicine clinics or mobile clinics in favor of the cell phone. We are merely pointing out that many day-to-day medical issues that emerge during extreme circumstances can be effectively and efficiently managed via a simple phone conversation between the patient and his/her doctor.

Lesson 4: Developing protocols for using mobile communications devices in advance of disasters or other service disruptions can help to ensure rapid deployment of telemedicine.

Although preplacement of emergency medical systems and facilities is part of a proven and successful disaster response strategy, it does not provide for the overwhelming need of routine nonemergent medical care for the affected communities. Given the advances in the functional capabilities and network survivability of commercial telecommunications systems combined with the near ubiquitous availability of mobile handheld devices, their utility during large-scale emergency events is clear.

The coordination and development of plans and agreements for the use of commercial communication channels during disaster scenarios is an important task for the first responder communities and commercial telecommunication providers. Of more importance,
perhaps, is the development of protocols and provider networks to use mobile communications devices to provide routine, triage, and shelter in place medical care and services to the affected communities. These mobile healthcare systems account for and can accommodate for the fact that both the patients and the providers are displaced victims of the emergency.

Lesson 5: Advance planning that builds disaster operational and recovery capabilities into the healthcare system data and telecommunications network well ahead of the event is essential.

UTMB’s experiences with the hurricane Ike clearly illustrate the importance of fault-tolerant design methodologies that anticipate natural disasters or other mass disruptions of the healthcare system. Redundancy strategies that secure critical data for access throughout the disaster period and features that enable reconfiguration of the network information and control architecture in response to lost resources are vital. Disaster plans also must include tactics for ensuring the safety of caregivers, support personnel, and network operational staff and for bringing them back online as quickly as possible.

Lesson 6: Redundancy, including geographically diverse data centers, can sustain operations.

Remotely located data backup is essential, and the further away from the potential disaster area, the better. UTMB’s data backup facilities were located in Huntsville, Texas, about 108 miles from the parent site in Galveston. Although storm damage in Huntsville was relatively modest compared with Galveston, it turned out that the geographic separation was inadequate for the size and path of Ike’s destructive footprint beyond this location. Also, equipment for mission-critical systems should be housed at main data centers to allow for easy access and deployment.

Lesson 7: Network design that reduces reliance on individual failure points such as network hubs can limit service disruptions.

As noted previously, the UTMB computer network had been engineered around cluster hubs for the exchange of data between as many as 10 individual sites. An outage at a cluster hub could take all sites offline at one time. The network is now being reconfigured so that an outage at a hub would only affect one satellite site.

Lesson 8: Advance planning should identify critical systems, detail how to protect them, and establish a prioritization plan for all assets.

Although one can never anticipate all of the deleterious effects from a disaster, the system has to be flexible and fault tolerant. Written plans that identify critical systems and ways to protect, conserve, continue, recover, and restore them are all crucial elements that should be incorporated in disaster preparedness plans. They assist in identifying essential business processes as well as their related dependences. Once developed, these processes may need to be characterized along a tiered system that outlines and prioritizes the level of importance. A suggested tiered system may include the following:

- Persistent Tier—Systems that will not be shut off and are vital for communication (phones, e-mail, and Web).
- Tier 1—Critical and/or institutionally significant applications and infrastructure systems; these systems would be the last to be turned off during an event to save the integrity of the system.
- Tier 2—The next level of institutional or departmental significant applications. These systems are identified as impacting a specific set of customers, department, or business processes. Recovery processes for these systems should be implemented immediately, with precedence for staff resources given to persistent and tier 1 systems.
- Tier 3—Other applications and systems. These systems do not require immediate recovery and should be recovered as soon as possible.

Conclusions

Natural disasters are an unavoidable circumstance that can significantly disrupt the normal routines of community life, including the local healthcare system. Depending on the power and scope of the event, the impacts may be relatively modest or, as in the case of the hurricane Ike for Galveston or the hurricane Katrina for New Orleans, can be extremely devastating. Full recovery, including the rebuilding of damaged or destroyed physical plants, can take years.

However, careful advance planning may mitigate the impact by ensuring the survivability of critical electronic records and data and reducing the extent of disruption on the information network. The use of wireless communication devices, especially the cell phone, can enable a quicker restart of communications and consultations among caregivers, care centers, and patients. Moreover, existing telemedicine programs also have the ability to resume operations relatively quickly through the use of wireless devices in instances where wired networks have been knocked out of service and/or locally based caregivers have been forced to evacuate.

In short, the best approach to disaster recovery begins years in advance by designing and implementing fault-tolerant networks that fail gracefully. Disaster recovery planning, testing, and implementation is a continuous process to improve and address gaps in the system as well as to adjust to changing technology and business environments. The healthcare disaster response plan must account
for both emergency and routine health needs of the displaced and affected communities. Leveraging commercial resources upon a well-designed mobile and flexible medical system can be both an effective and necessary approach.

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REFERENCES


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