

# WORKING P A P E R

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## Planning the Safety of Healthcare Structures

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## **Key Findings**

- Mitigating the destructive impact of hurricane force winds will require developing and implementing new building codes.
- Mitigating the impact of floods will require site-specific investments in infrastructure and planning.
- California provides the best example of “lessons learned” from an aggressive policy to protect hospitals from the effects of natural disasters.

## **Overview**

As Louisiana prepares to rebuild and repair the hospitals damaged by Hurricane Katrina, there will be a statewide debate on possible engineering and construction standards to reduce the impacts from future disasters. To inform this decision making, we review:

- Decision making and strategies to make hospitals more resilient to natural disasters,
- Hospital building codes in different states, designed to reduce the impacts of seismic and wind hazards,
- Engineering and planning solutions to mitigate the impact of catastrophic floods on hospital operations.

## **Considerations for Policy Design**

The most important consideration for Louisiana decision-makers is whether to enact a policy framework designed to protect hospitals from natural disasters. Typically stronger than standard building codes or operational requirements, such a framework would be designed to ensure hospital operations in the period immediately following a natural disaster. The public health rationale for such an approach is summarized in the California state law governing seismic requirements for hospitals in that state.

It is the intent of the Legislature that hospitals, that house patients who have less than the capacity of normally healthy persons to protect themselves, and that must be reasonably capable of providing services to the public after a disaster, shall be designed and constructed to resist, insofar as practical, the forces generated by earthquakes, gravity, and winds.

The principal argument against this approach, which is common in all discussions of disaster policy, is that mitigation investments are costly yet the need is uncertain because future hurricanes, earthquakes, floods, etc. cannot be predicted with certainty. Why should precious hospital financial resources be focused on an ambiguous need when there are many other pressing and under-funded demands? In California, this issue has been the focus of a high pitched policy debate as the costs of state seismic requirements have been estimated at \$40 billion in new construction for a hospital industry of variable financial

health.<sup>1</sup> The ultimate outcome could be influenced by pending legislative action; however, there is little sign that California will deviate from its public policy goal of ensuring hospital operations following a natural disaster. Although state political leaders have recognized that this approach is very costly, they have concluded that they are justified in light of the risks and the public health requirements.

For Louisiana, an important factor in this discussion will be “who pays” for increased disaster resilience, especially if the costs turn out to be large. In general, property owners are almost always responsible for the costs of strengthened building codes. In California, hospital owners are responsible for the costs of seismic strengthening. In that state, there have been a number of legislative proposals for state funding relief, but all have been rejected for reasons of equity or budgetary constraints. In Louisiana, the situation may be different because of the substantial federal relief payments that will be applied to reconstruction in the State. Part of the top-level policy debate might focus on using some of these funds to increase hospital disaster resilience across the State.

The following issues must be considered in the State’s decisions regarding the structure safety of hospitals.

### **Building codes**

Strengthened building codes, enforced on a statewide level, are the most effective strategy to ensure structural resilience against hurricane winds. At present, Louisiana follows a State Uniform Construction Code (SUCC), based on the 2000 International Building Code, for commercial buildings. It does not have a statewide code for one or two family residential structures. Local governments may adopt building codes for the structures not subject to the SUCC but are not required to do so.

Where they exist, local building codes cover electrical, plumbing, and fire hazards. Outside of major metropolitan areas, building codes to protect against wind damage are essentially nonexistent. Even in the State’s largest city, New Orleans, building codes to protect buildings from wind damage are only designed to resist a 120 mph wind for three minutes. Wind gusts from a Category 3 hurricane can have sustained winds of 130 mph and reach much higher gusts. Furthermore, most of the buildings in New Orleans were built before the codes were in effect. In the aftermath of Katrina, there has been a spirited public debate on the wisdom of this approach to building codes.

There are two principal options for using building codes to ensure the structural safety of hospitals.

### ***Option 1: Let hospital code requirements be similar to general building code requirements***

This is essentially the “laissez faire” option. It assumes that the State of Louisiana will enact strengthened building codes for wind hazards for all structures, and that hospitals

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<sup>1</sup> *Estimating the Costs of California SB1953*, Charles Meade, Jonathan Kulick, and Richard Hillestad, RAND MR-1515.0, 2002.

will be subject to these requirements. Texas and Florida use similar approaches for wind hazards (i.e., there are no special requirements for hospitals).

From a public health perspective, there are two important features of this approach.

- General building codes are designed to prevent structural collapse, which is a far less stringent requirement than ensuring operational capabilities following a disaster. As a result, hospitals could be compliant with new requirements that might prevent significant structural damage during future hurricanes. However, the hospitals could become inoperable for extended periods because of damage to nonstructural components that are essential for medical services.
- Without exception, general changes to building codes only apply to new construction because retroactive requirements impose large costs on property owners. Thus new building codes in Louisiana would only apply to newly constructed hospitals. Structures that were damaged, and need repair, might escape the new requirements. And existing, undamaged structures would be totally exempt.

***Option 2: Develop hospital-specific building code requirements for wind hazards***

Louisiana decision-makers would pursue this option if they wanted to ensure hospital operational capabilities following a hurricane, similar to the California policy goals for seismic hazards. Given the importance of the public health requirements, the presumption is that the requirements under this approach would be more stringent and far reaching than general building code revisions. If a decision were made to pursue this approach, there would be important debates on the following issues.

- Magnitude and extent of code requirements. The key elements of building codes for wind hazards are the severity of the design requirements (e.g., ability to withstand winds of X mph) and the location for the requirement. The latter point reflects that fact that hurricane winds decrease with distance from shore, indicating that requirements in northern Louisiana might be substantially less than in coastal regions. The upper bound for the design requirement is an issue of engineering and scientific analysis (i.e., what winds are possible, what engineering solutions are possible, what would be the costs for solutions at different wind velocities). A key question for this analysis would be the design requirements to ensure operational capability rather than structural integrity. It is reasonable that decisions about these issues might be delegated to outside experts once the policy goal had been established for hospital building codes.
- Enacting retroactive requirements. If the goal is to ensure the integrity of all Louisiana hospitals, there will be a need to consider retroactive requirements for any codes designed to mitigate wind hazards. Otherwise, a large population of hospitals will remain vulnerable until they are reconstructed for other purposes. Like the issue of code requirements above, this issue would be strongly informed by outside analysis of engineering solutions and potential costs for retrofitting older hospitals.

In California, where the original seismic safety law only addressed new construction, there are important lessons learned on the point of retroactive requirements. For 20 years after the state law was passed, the seismic vulnerability of hospitals was relatively unchanged because hospital construction rates declined dramatically through the 1970's, 80's and 90's. Then, in the 1994 Northridge earthquake there was severe damage to local hospitals, all of which were compliant with the original law because they were built before 1973. To address this problem, a new legislative initiative followed the earthquake, extending the seismic safety requirements to all existing hospitals.

### **Flood hazards**

Floods cause significant losses across the United States, estimated at approximately \$5 billion/year based on historical averages prior to 2005. Despite these impacts, there are few engineering or construction standards to mitigate flood hazards because flood losses are relatively insensitive to the details of construction and engineering. Rather, the most important factor influencing loss is the location of a particular structure (elevation relative to the flood plain).

Even in California, where there are strong requirements for seismic hazards, there are few regulations pertaining to flood hazards for hospitals. Approximately 34 California hospitals are located in flood prone regions.

Strategies for reducing flood losses fall into the following general categories. We note the parties responsible for implementation.

- Regulating new construction to minimize development in regions susceptible to flooding (State and local governments),
- Strengthening flood control systems and infrastructure to protect preexisting structures and communities. (Federal, State, and local governments),
- Developing preparedness and mitigation plans on a case-by-case basis (individuals and businesses).

There are two principal options for using flood control strategies to ensure the structural safety of hospitals.

#### ***Option 1: Address hospital structural safety through regional flood control measures.***

Like the first option under building codes, this is also a “laissez faire” solution that assumes that hospital flood vulnerability will be addressed by larger flood control strategies. This may be a reasonable approach because engineering and flood control structures, implemented on regional scale, can provide the strongest defense against flood hazards. That is, improved flood control in Louisiana might be one of the most effective strategies for improving hospital structural safety because state-wide control offers the potential to prevent flooding in the first place.

However, these types of measures are typically designed for large communities, rather than single structures. Thus the debate on flood control addresses a broader range of

policy interests. As New Orleans and Louisiana weigh the costs and benefits of strengthening the flood control infrastructure, it will be useful to identify and quantify the potential beneficiaries. Reflecting on the Katrina experience, it is clear that hospital safety and operational capability should be an important component of this analysis.

***Option 2: Address hospital structural safety through site-specific infrastructure and planning initiatives.***

To mitigate the impacts of catastrophic floods on hospital and healthcare operations, it may be more appropriate to consider state-mandated performance requirements for hospitals under flood conditions. To this end, hospitals might be required to make infrastructure investments and to carry out operational planning to insure that they could continue to provide healthcare services during floods of a specified severity and duration (e.g., X feet above the first floor for Y hours).

The strategy for this approach would be strongly influenced by hospital experiences during past floods. Prior to Katrina, the most important flood affecting hospitals occurred in Houston during Tropical Storm Allison (1991), which produced 8.5 inches of rain in 2 hours. The storm flooded the basements of a number of hospitals in the Texas Medical Center, prompting closures ranging from a few hours to months (see Table 1). Following Allison, much of the effort in Texas focused on improved flood control measures as a way to protect hospitals against future storms. That is, there was no discussion of new engineering or construction standards for hospital buildings to mitigate flood losses.

At the same time, it was recognized that hospitals can fortify their buildings to protect the critical components in their operations during natural disasters. To this end, a number of hospitals in Houston have installed “submarine” doors that can be closed during a flood to create waterproof underground vaults protecting medical supplies, storage facilities, HVAC systems, and power facilities (backup generators and switches).

Reflecting on the healthcare problems created by flooding of basement power generators following Katrina, it is clear that deploying similar vault facilities could make an important contribution to the flood resilience of Louisiana hospitals. Such an approach is clearly the most straightforward and safest approach to protecting critical hospital facilities. It also eliminates the fire and safety hazards of housing generators and diesel on upper hospital floors. However, it is clear that the installation of vault facilities is sensitive to site-specific conditions and requirements. Therefore, it might be most appropriate to regulate this type of investment through performance requirements (e.g., continued operation through a flood) rather than specific engineering details in a building code.

To ensure that hospitals are capable of meeting this performance goal, the state could implement regulations requiring hospitals to carry out a number of steps such as:

- *Safeguarding critical operational components from flood damage.* Through building designs, layout of utility systems, and installation of waterproof vaults, hospitals could validate their capability to operate under flood emergencies.
- *Identifying best practices to govern operations during an emergency.* Through the use of drills and planning, hospitals would identify the specific mix of personnel, protocols, and supplies that would be needed for sustained healthcare operations following a severe flood or natural disaster.

There are two principal considerations for implementing the above. First, there will be an active debate on the physical characteristics of the flood to be used for planning and design purposes (magnitude and duration), because larger floods will require larger upfront investments to mitigate damages. Resolving this issue will require an analysis of flood probabilities together with an engineering analysis of local flood control measures. Second, there will be a need for a State government agency to validate that hospital investments and planning are likely to meet the performance requirements. That is, there would be requirements for hospitals to submit plans and proof of their actions for state review. Presumably this would require reviews on a site-by-site basis involving engineering and healthcare experts.

California’s experience with regulating hospital seismic safety offers a number of lessons.

**Table 1: Tropical Storm Allison Flood Damages to the Texas Medical Center<sup>2</sup>**

<i>Building Name</i>	<i>Damage Description</i>	<i>Comments</i>
Baylor College of Medicine	Basements flooded. Primary and back-up power failed. Critical storage freezers stopped. Lost 90,000 research animals & 60,000 tumor samples.	25 years of research data was destroyed. Facility was operational after a few weeks
Memorial Hermann Hospital	Basements flooded to depths of 38 feet (11.6 meters) through underground connections with other buildings & parking garages. About 50% of water came from 1 tunnel connection. Lost electrical infrastructure, HVAC, diagnostic equipment, morgue, and laboratories.	Took 4 days to pump water. Evacuated 540 patients; all returned after 8 days. 18 months estimated for full recovery

<sup>2</sup> *Tropical Storm Allison, June 2001 RMS Event Report, December 17, 2001.*

<i>Building Name</i>	<i>Damage Description</i>	<i>Comments</i>
The Methodist Hospital	Water entered the Neurosensory building. Flood depths of 40 feet (12 meters) in the basement damaged 300,000 sq. ft (27,871 sq. m) of space. Lost water, power, and air.	Insured for \$100 million. Discharged 400 patients, and did not fully reopen for 5 weeks. 6 months estimated for full recovery.
UT Houston Medical School	The force of floodwaters collapsed unreinforced walls. Lost 5,000 research animals.	Normal operations restored after 1 month. \$68 million needed to retrofit and prevent future flood damage.
St. Luke's Hospital	Basement flooding in older structures. Lost primary and back-up power	Moved 60 critical patients to an unaffected building; another 230 patients evacuated. Full operations resumed in 2 weeks.
Texas Children's Hospital	Second basement level had 8 feet (2.4 m) of water in one area. Major flooding occurred in older buildings. Lost primary power. Flood doors installed at tunnel connection to reduce damage.	Back-up power for essential services. Critical patients relocated from older, less protected buildings. Additional flood doors are being installed in basements near underground connections.
Texas Heart Institute	Research laboratories flooded. Pigs for artificial heart transplant tests drowned	Institute's main location is on the fifth floor of St. Luke's hospital.
M.D. Anderson Cancer Center	Lost primary power. Minor flooding	Back-up power functioned well.
Ben Taub General Hospital	Lost primary power, but undamaged by flooding.	Operated on back-up power for several hours. The only Level 1 trauma center in Houston for several days.
TIRR	Lost primary power for a few hours. Basement had 2 inches of water as well as some flooding on the first floor	Negligible Adjacent to Ben Taub Hospital. Backup power functioned well. Accepted patients from other hospitals.
Veterans Medical Center	Minimal flooding in the warehouse facility	Never lost power during the flooding.
St. Joseph's	Lost primary power. Little flood damage	Closed emergency room

### **Florida and Texas Wind Requirements**

In the final portion of this brief we review the requirements for hospitals and wind hazards in Florida and Texas. In Florida and Texas, these standards apply to hurricanes,

with added requirements for tornados in Texas. Although the standards make a valuable contribution to wind hazard loss reduction, they generally do not place a special emphasis on hospitals or hospital operations following a disaster. However, in many cases, older buildings can be retrofitted to mitigate hurricane hazards at relatively low costs by covering existing windows with hurricane shutters. Efforts to install these shutters are most common in coastal communities in eastern Florida.

### Florida

In 1997, Florida implemented a building code that required new hospitals to withstand winds to 146 mph. By 2002, this requirement was equivalent to the standard for all structures in the Miami-Dade county region. Hospitals built before 1997 are exempt from these requirements. Reminiscent of the California experience during the Northridge earthquake, the 2004 hurricane season resulted in significant damage to the older structures. Specifically:

#### *Hurricane Charley*

- Significant damage to the roof and windows of a regional medical center allowed rainwater infiltration into patient rooms and other medical service areas, and a loss of power for four days. Patients had to be evacuated to nearby hospitals. It took more than a month for the hospital to resume operations.
- A four-story patient building sustained major damage to its roof covering and windows, along with an adjoining two-story building housing the operating room, intensive care unit, and the cardiac catheterization lab. The resulting rainwater intrusion forced evacuation of patients from these areas.
- A community hospital sustained widespread damage to its windows and roof coverings. The subsequent intrusion of rainwater and broken glass into the patient rooms resulted in the relocation of patients to interior areas on the first floor.

#### *Hurricane Frances*

- Major damage to two elevator penthouses on top of a six-story patient tower eliminated elevator service. With inoperable elevators, a majority of the licensed beds in the obstetrics, pediatrics, and intensive care units were inaccessible.

### Texas

In Texas, the engineering standards for wind hazards apply only to counties designated as potential “catastrophe areas” by the Texas Department of Insurance. Most importantly, the standards are not mandatory. They are only a requirement if the owner wants to insure the building against wind hazards. As such, they apply to all buildings. There are no specific requirements for hospitals, either to minimize damage or to insure continued operation following a hurricane or tornado.