

Hurricanes Katrina and Rita: Scientific Surprises and Policy Failures

Michael K. Lindell and Carla S. Prater
Hazard Reduction & Recovery Center
Texas A&M University

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Impacts of Hurricanes Katrina and Rita

- Hurricane Katrina
 - Very large death toll—nearly 1500 people (the deadliest U.S. hurricane in 80 years and the third deadliest in U.S. history)
 - Approximately \$75 billion in damage, the costliest disaster in U.S. history.
 - Approximately \$75 billion in other economic impacts, especially business interruption.
- Hurricane Rita
 - Few deaths—less than 100 people because of early evacuations
 - Moderate destruction (about \$10 billion) because it struck a much less densely developed area.

Impacts of Hurricanes Katrina and Rita

- To understand the differences in impacts, it is important to understand
 - The structure of the United States emergency management system,
 - Political support for emergency management, and
 - Hurricane emergency management functions and their allocation.

Structure of the US Emergency Management System

- The US has a federal system
 - Local government responds to disaster, but requests state assistance if overwhelmed.
 - State government responds to local requests, but requests federal assistance if overwhelmed.
- In principle, higher levels of government provide *resource support* to lower levels but do not assume authority or responsibility for hazard management.
- This principle has become confused with the increased emphasis on homeland security from terrorist attack.

Political Support for Emergency Management

- US state and local jurisdictions are extremely variable in the quality of their environmental hazard management programs
 - Some are among the best in the world.
 - Others operate at third world levels.
- Emergency management departments are often used for political patronage in jurisdictions where disasters are so infrequent that qualified staff are rarely needed.
- Attention to terrorist threats is diverting attention from natural and technological hazards management.

Hurricane Emergency Management Functions

- *Emergency assessment:* Diagnoses of past and present conditions and prognoses of future conditions to guide emergency personnel.
- *Hazard operations:* Activities performed to limit magnitude of impact just prior to an event.
- *Population protection:* Actions taken to prevent or minimize people's hazard exposure.
- *Incident management:* Activities to activate, coordinate and maintain the human and physical resources needed for the response effort.

Emergency Response Function Allocation Across Social Units

Social units	Emergency assessment	Hazard operations	Population protection	Incident management
National Hurricane Center/ Tropical Prediction Center/ Weather Forecast Offices	<ul style="list-style-type: none"> • Threat detection • Impact protection • Emergency classification 		<ul style="list-style-type: none"> • Warning 	<ul style="list-style-type: none"> • Activation • Notification • Internal and external coordination • Public information
State Emergency Management Agencies	<ul style="list-style-type: none"> • Emergency classification 		<ul style="list-style-type: none"> • Protective action selection (some states) • Warning • Protective action implementation 	<ul style="list-style-type: none"> • Activation • Notification • Internal and external coordination • Public information
Local Emergency Management Agencies	<ul style="list-style-type: none"> • Emergency classification 		<ul style="list-style-type: none"> • Protective action selection (some states) • Warning • Protective action implementation 	<ul style="list-style-type: none"> • Activation • Notification • Internal and external coordination • Public information
News media	<ul style="list-style-type: none"> • (Risk perception) 		<ul style="list-style-type: none"> • Warning 	<ul style="list-style-type: none"> • Activation • Notification • Public information
Households, Businesses, Special facilities and other organizations	<ul style="list-style-type: none"> • (Risk perception) 	<ul style="list-style-type: none"> • Area protection • Debris control • Structural protection • Contents protection 	<ul style="list-style-type: none"> • Warning • Protective action implementation 	<ul style="list-style-type: none"> • Activation • Internal and external coordination

Hurricane Evacuation Management

Local emergency manager questions	Meteorologist information
Will the storm strike my jurisdiction?	Storm track
How soon must I make a decision?	Forward movement speed
How far inland must we evacuate?	Intensity/size

Hurricane Evacuation Management

Local emergency manager questions	Traffic engineer information
How fast will vehicles enter the evacuation route system (ERS)?	Demand, by time and location
How fast can they move inland to safety?	ERS capacity
How long will it take to evacuate?	Evacuation time estimate

Why Were the Impacts So Different for Hurricanes Katrina and Rita?

- The hurricanes were similar in many ways:
 - Intensity—both reached Category 5 (wind speed over 250 kph) as they approached the coast.
 - Impact timing—they struck about four weeks apart.
 - Point of landfall—the distance between points of landfall was less than 400 km.

Why Were the Impacts So Different for Hurricanes Katrina and Rita?

- However, the impact areas differed significantly.
 - The communities on the Texas/Louisiana border (landfall for Rita) are smaller and farther inland than those on the Louisiana/Mississippi border (landfall for Katrina).
- The evacuations also differed significantly.
 - Evacuations for Katrina were later and less complete than normal.
 - Evacuations for Rita were earlier and more complete than normal.

Why Were the Impacts So Different for Hurricanes Katrina and Rita?

- There was no difference in emergency assessment by the National Hurricane Center.
 - In both cases, the states and local jurisdictions were given ample forewarning of the severity of the hurricanes.
- However, the population protection and incident management functions were significantly different in the two hurricanes.

In New Orleans Before Katrina

- The mayor decided to issue an evacuation order over 48 hours before landfall.
- The actual dissemination of the order was delayed for almost 30 hours because of staff confusion about issues that should have been resolved in the planning process.
- If most households had not left before the official evacuation order, the death toll would have been even higher.
- Too many households remained because they underestimated their danger (overestimated the protection from the levees).
- There was inadequate transportation support for those with unreliable automobiles or none at all (at least one-third of households in the city).

In Texas Before Rita

- The Galveston mayor decided to issue an evacuation order over 72 hours before landfall and it was disseminated immediately.
- The Houston mayor issued an evacuation advisory shortly afterward, but it was much too broad (residents of “low lying areas”).
- Approximately *six times* as many households evacuated as predicted by hurricane evacuation studies and they left much earlier than predicted.
- Trips to inland destinations took *five times* as long as usual but traffic jams were well inland from the predicted surge area.
- The evacuation routes were cleared 24 hours before landfall by reversing inbound freeway lanes (“contraflow”).
- There appears to have been adequate support for those without reliable transportation.

In New Orleans After Katrina

- After the city flooded, many of those who remained were forced out of their homes and into the Superdome and Convention Center.
 - Neither of these facilities was stocked with food and water or had emergency generators.
- U.S. Coast Guard helicopters were immediately active in search and rescue operations.
 - These were supported later by search and rescue teams from other states, which experienced significant coordination problems.
- Victims were transported to mass care facilities throughout the country; some separated households took weeks to reconnect with family members.

In New Orleans After Katrina

- Medical care was a serious problem during the storm and immediately afterward.
 - The staff of some nursing homes abandoned their patients before the hurricane struck and some of these patients drowned when the city flooded.
 - A few hospitals remained in operation during the emergency, but few people in the city could reach them.
- Finally, access into New Orleans and other impact areas was tightly controlled in the storm's aftermath.
 - Counties with minimal damage (St. Charles and Jefferson, west of New Orleans) prohibited entry until a week later.

In Texas After Rita

- The large number of evacuees (hundreds of thousands) substantially complicated the reception and care operations.
 - Many evacuees appear to have stayed with friends and relatives.
 - Others filled hotels and motels for hundreds of miles inland.
 - This led to a very heavy demand for space in public shelters, which were also overloaded.

In Texas After Rita

- Search and rescue efforts were small but successful because of the small population in the impact area.
- Medical care was generally better than in Katrina because hospitals and nursing homes were evacuated before storm
- However, 24 nursing home residents died when their bus caught fire.

Scientific Surprises

- The only significant scientific surprise was the high level of early spontaneous evacuation before Hurricane Rita.
- Survey data are still being collected, but it appears that
 - Residents interpreted the Houston Mayor's warning as applying to areas that, in fact, were not at risk from the hurricane wind or storm surge.
 - People were extremely concerned about the hurricane threat, especially because so many people died four weeks earlier in Hurricane Katrina.

Policy Failures

- There were planning and operational failures at each level of government—local, state, and federal.
 - There had been a “successful” hurricane exercise in 2004, but its scenario seems to have been less severe than the actual event.
 - There was no indication that those who took charge of the incident participated in the training and exercising.
 - Most of the problems in the actual event seem to have been with agencies, organizations, and population segments that did not participate in the exercise.

Policy Failures

- New Orleans city government was overwhelmed and ineffective.
- Louisiana state government was also overwhelmed and only marginally effective.
- The Federal Emergency Management Agency (FEMA) was authorized to call on all federal resources, but was unable to deliver them to those in need.
- FEMA's (5000 personnel) capabilities had been declining since being absorbed and reorganized within the massive Department of Homeland Security (150,000 personnel).

Successful Environmental Hazard Management Requires Thorough

- *Hazard/vulnerability analysis*, that also addresses socially vulnerable population segments,
- *Emergency preparedness and response* that integrate all levels of government,
- *Disaster recovery* that is planned before disaster strikes, and
- *Hazard mitigation* that incorporates
 - Hazard source control,
 - Community protection works,
 - Land use practices,
 - Building construction practices, and
 - Contents protection practices.

Planning Needs for Emergency Preparedness and Response

- Emergency assessment
 - Threat detection/emergency classification
 - Hazard/environmental monitoring
 - **Population monitoring and assessment**
 - Damage assessment

Planning Needs for Emergency Preparedness and Response

- Incident management
 - Agency notification/mobilization
 - Mobilization of emergency facilities/equipment
 - Communications
 - Internal direction & control
 - External coordination
 - Public information
 - Resource management
 - Finance/administration

Planning Needs for Emergency Preparedness and Response

- Population protection
 - Protective action selection
 - Population warning
 - Evacuation transportation support
 - Evacuation traffic management
 - Sheltering in-place
 - Impact zone access control/security
 - Reception/care of victims
 - Search & rescue
 - Emergency medical care
 - Hazard exposure control

Planning Needs for Emergency Preparedness and Response

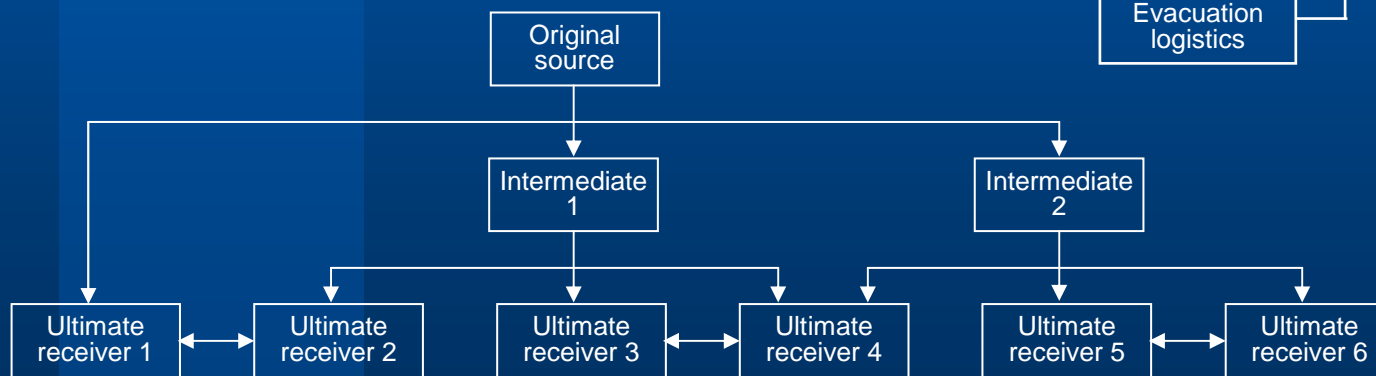
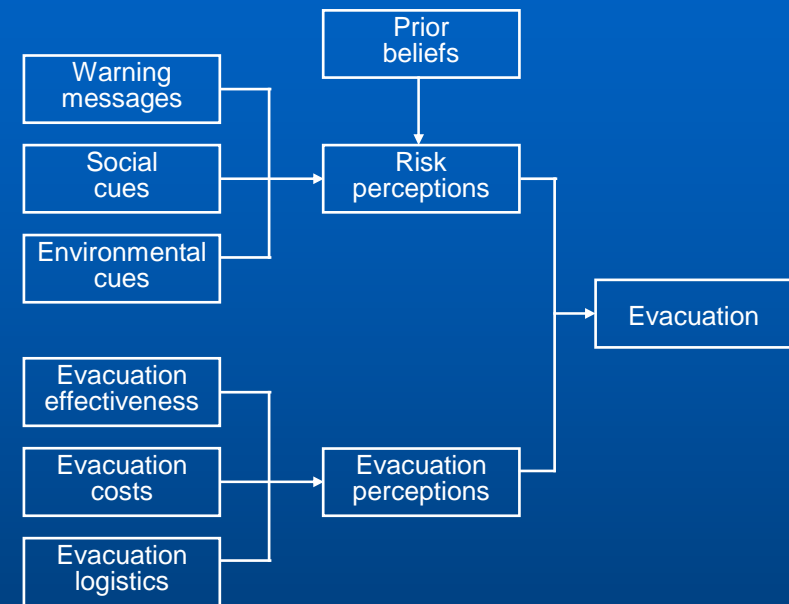
- Hazard operations
 - Hazard source control
 - Community protection works
 - Firefighting
- Coordination with other emergency management phases
 - Disaster recovery
 - Hazard mitigation

Planning Needs: Behavior of the News Media

- Emergency planners must understand and plan for the role the news media will seek in before, during, and after disasters.
- Planners must anticipate news media organizations' processing of emergency information.
 - Electronic (radio and television) vs. print (newspapers)
 - Local vs. national media
 - New technologies (e.g. cell phone and internet) that can either be used by the news media or by authorities to bypass the news media.

Planning Needs: Behavior of Households

- Planners need to use existing research on households' and businesses' warning and compliance behavior.

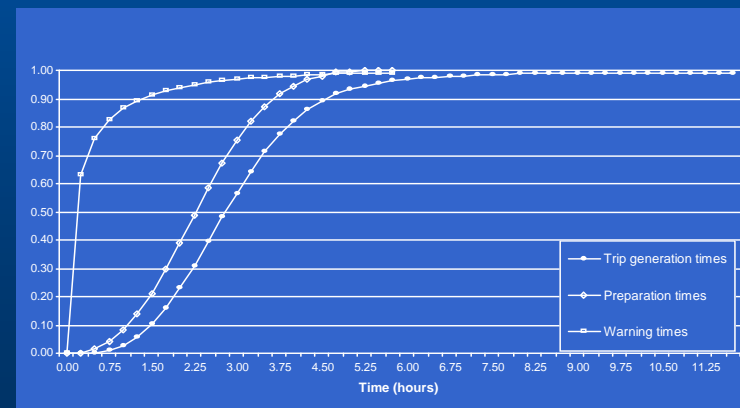


Planning Needs: Behavior of Households

- They also should address
 - Households' and businesses' compliance/spontaneous evacuation and response timing, and
 - Transient and transit dependent populations' warning and response.

Table 1: Smoothed percentages of households expecting to evacuate for hurricanes in Category One through Category Five, by Risk Area.

Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
1	45.9	63.7	87.8	98.2	100.0
2	35.9	53.7	77.8	88.2	91.4
3	31.1	48.9	73.0	83.4	86.6
4	28.2	46.0	70.1	80.5	83.7
5	26.5	44.3	68.4	78.8	82.0



Research Needs: Behavior of Households

- Further research is needed to extend existing lines of research on
 - Prior beliefs about hazards and evacuations,
 - Social and environmental cues,
 - Warning source perceptions,
 - Communications channels used,
 - Risk perception processes,
 - Evacuation perception processes, and
 - Warning compliance/spontaneous evacuation.

Research Needs: Behavior of Households

- New research is needed to
 - Expand linkages with traffic engineers' models of traffic flows,
 - Types of vehicles taken
 - Route and destination selection
 - Driving behavior in dense traffic flows
 - Assess the economic costs of evacuation incurred by households, businesses, and government agencies, and
 - Assess expected fatality rates in a late evacuation.

Hurricane Evacuation Management Decision Support System (EMDSS)

- Research is beginning to study hurricane tracking exercises
 - Situational awareness,
 - Mental workload, and
 - Evacuation decision making

EMDSS

Hurricane Tracking And Risk Area Evacuation Data For Hurricane Alpha

Start Simulation

Previous Forecast Advisory **Current Time** **Next Forecast Advisory** **Current Status**

Date : Wednesday 03 Aug 2005 Date : Wednesday 03 Aug 2005 Date : Wednesday 03 Aug 2005 Current Forecast Advisory Number : 2
 Local Time : 10:00CDT Local Time : 15:00CDT Local Time : 16:00CDT Current Hurricane Category : TS
 UTC Time : 15:00 Z UTC Time : 20:00 Z UTC Time : 21:00 Z Current Forward Movement Speed : 5-9 mph

FMS (mph)	24 Hrs	36 Hrs	48 Hrs	72 Hrs
0-4	29	31	33	40
5-9	42	38	34	20
10-14	25	24	20	18
15-19	3	5	8	12
20-24	1	2	4	8
25 or more	0	0	1	2

Category	24 Hrs	36 Hrs	48 Hrs	72 Hrs
Category 1	71	69	67	61
Category 2	25	24	21	19
Category 3	3	5	8	12
Category 4	1	2	3	6
Category 5	0	0	1	2

Location	24 Hrs	36 Hrs	48 Hrs	72 Hrs
Brownsville	0	0	0	0
Corpus Christi	0	0	0	0
Port O'Connor	0	0	0	0
Freeport	0	0	0	0
Galveston	0	0	0	0
Sabine Pass	0	0	0	0

FMS	24 Hrs	36 Hrs	48 Hrs	72 Hrs
	5-9	5-9	5-9	5-9

Category	24 Hrs	36 Hrs	48 Hrs	72 Hrs
	Catg 1	Catg 1	Catg 2	Catg 3

Select Expected Storm Forward Movement Speed
 10-14 mph FMS

Select Wind Speed Threshold for Evacuation
 Tropical storm wind (34kt/39mph)

03 Aug 2005	Aug 04 2005 (Thursday)				Aug 05 2005 (Friday)				Aug 06 2005 (Saturday)				Aug 07 2005 (Sunday)				Aug 08 2005 (Monday)			
16:00	17:00	23:00	05:00	11:00	17:00	23:00	05:00	11:00	17:00	23:00	05:00	11:00	17:00	23:00	05:00	11:00	17:00	23:00	05:00	11:00
Daylight	Nighttime	Daylight	Nighttime	Daylight	Nighttime	Daylight	Nighttime	Daylight	Nighttime	Daylight	Nighttime	Daylight	Nighttime	Daylight	Nighttime	Daylight	Nighttime	Daylight	Nighttime	Daylight
(21 hours) - Maximum probable				Evacuation Decision Delay Time (31 Hrs)				(52 Hrs) - Earliest probable ETA for Tropical storm wind (34kt/39mph)				(55 Hrs) - Most probable ETA for Tropical storm wind (34kt/39mph)				(58 Hrs) - Latest probable ETA for Tropical storm wind (34kt/39mph)				
(20 hours) - Most probable time																				
(19 hours) - Minimum probable																				

ETEs based on Immediate Evacuation of RA1 RA2 RA3 RA4 RA5


ETAs based on Tropical storm wind (34kt/39mph) / FMS = 10-14 mph

ETA for High-Profile Tipping >>	Latest	Most Probable	Earliest
ETE: Minimum Probable	100	100	100
ETE: Most Probable	100	100	100
ETE: Maximum Probable	100	100	100

Sector	Cost
Residential	4500000
Commercial	0
Governmental	0

Re-analyze Evacuation Time and Cost

Initiate Evacuation



Show Large Map

Turn OFF Predicted Storm Path

Turn OFF Hurricane Error Cone

EMDSS Research

- Studies are examining the effects of
 - *Community conditions*: Population size/distribution and evacuation route system capacity
 - *Situational characteristics*: Time of day/week/season
 - *Storm characteristics*: Track, forward movement speed, intensity, size
 - *Information displays*: Current/forecast/uncertainty data for storm and evacuee behavior
 - *Decision team composition*: Individuals, groups with varying levels of knowledge

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