Storm Surge and “Certain Death”: Interviews with Texas Coastal Residents following Hurricane Ike

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ABSTRACT

Hurricane Ike made landfall near Galveston, Texas, on 13 September 2008 as a large category 2 storm that generated significant storm surge and flooding. This article presents findings from an empirical case study of Texas coastal residents’ perceptions of hurricane risk, protective decision making, and opinions of hurricane forecasts related to Hurricane Ike. The results are based on data from interviews with 49 residents affected by Hurricane Ike, conducted approximately five weeks after landfall. While most interviewees were aware that Ike was potentially dangerous, many were surprised by how much coastal flooding the hurricane caused and the resulting damage. For many—even long-time residents—Ike was a learning experience. As the hurricane approached, interviewees and their households made complex, evolving preparation and evacuation decisions. Although evacuation orders were an important consideration for some interviewees, many obtained information about Ike frequently from multiple sources to evaluate their own risk and make protective decisions. Given the storm surge and damage Ike caused, a number of interviewees believed that Ike’s classification on the Saffir–Simpson scale did not adequately communicate the risk Ike posed. The “certain death” statement issued by the National Weather Service helped convince several interviewees to evacuate. However, others had strong negative opinions of the statement that may negatively influence their interpretation of and response to future warnings. As these findings indicate, empirical studies of how intended audiences obtain, interpret, and use hurricane forecasts and warnings provide valuable knowledge that can help design more effective ways to convey hurricane risk.

1. Introduction

Hurricane Ike was the ninth named storm of the 2008 Atlantic basin hurricane season. The storm reached category 4 intensity in the Atlantic and caused significant damage in the Caribbean (New York Times, 9 September 2008; NOAA 2009). After affecting the Florida Keys, Ike made its U.S. landfall as a large category 2 storm over the northern end of Galveston Island, Texas, on the early morning of Saturday, 13 September 2008 (NCDC 2009; NOAA 2009). In part because of its size, Ike generated substantial storm surge—3–6 m (10–20 ft)—across much of coastal southwestern Louisiana and eastern Texas, causing major damage. Twenty people died in Texas, Louisiana, and Arkansas as a direct result of Ike, and others are missing. Houston experienced wind damage, and an estimated 2.6 million customers in Texas and Louisiana lost power, some for days (NOAA 2009). As of April 2009, federal aid to help Texas recover from Hurricane Ike had exceeded $2 billion (FEMA 2009b). Ike continued to generate strong winds and record-breaking rainfall as it traveled across the midwestern United States (NCDC 2009; NOAA 2009). Overall, Ike caused an estimated $20 billion or more in damage in the United States, making it the fourth costliest hurricane to affect the United States (NOAA 2009).

While Ike affected many regions, its most dramatic effects in the United States were near Galveston Island and Galveston Bay, Texas, where the worst storm surge occurred (Fig. 1). Despite mandatory evacuation orders and dire warnings for these areas, many people—including an estimated 25%–40% of the population of Galveston Island—decided to stay (Houston Chronicle, 12 September 2008; USA Today, 13 September 2008). Galveston’s seawall protected a portion of Galveston Island from surge from the Gulf of Mexico, but a 3–4.5-m (10–15 ft) surge inundated the northern side of the island from the bay.
The western part of Galveston Island was relatively unprotected because it is beyond the seawall, and areas just east and north of the island (such as the Bolivar Peninsula and the Galveston County mainland) experienced similar or even higher surges and devastating damage. In some areas, most structures were completely removed from their foundations and destroyed. The majority of fatalities are from these areas (NOAA 2009).

A number of previous studies have examined people’s hurricane risk perceptions and decision making, both in specific cases of hurricanes and more generally (e.g., Dash and Gladwin 2007; Lindell et al. 2007; Phillips and Morrow 2007). The current study augments this previous work by examining Hurricane Ike, which presents an interesting case for investigating societal aspects of hurricanes for several reasons. Although the Houston–Galveston area has experienced damaging tropical storms, Ike was the first hurricane to cause major damage in the area in decades. In 2005, Hurricane Rita threatened the area and produced widespread evacuations and traffic jams but only minor damage in the Houston–Galveston

Fig. 1. Damage caused by Hurricane Ike in Galveston, TX, approximately five weeks after landfall. (top) Damage near Galveston seawall (foreground), along the Gulf coast. (bottom) Flood damage in inland Galveston. (Photos taken by the authors.)
area. Anecdotal reports suggest that some people’s experiences during Rita affected their decisions leading up to Ike (e.g., *Houston Chronicle*, 11 September 2008). Forecasts for Ike’s track as it approached the Texas coast were more skillful than average (Franklin 2009; NOAA 2009). Nevertheless, in part because of track uncertainty, officials did not issue mandatory evacuations for some Texas coastal areas until less than 48 h before Ike made landfall (*Houston Chronicle*, 12 September 2008). Further, because of Ike’s large wind field, water levels began rising earlier than usual. Many coastal areas were already flooded the day before landfall, making evacuation difficult—if not impossible—hours before strong winds arrived (*Houston Chronicle*, 12 September 2008; NOAA 2009). Concerned about the projected storm surge, National Weather Service (NWS) forecasters in the Houston–Galveston office issued statements warning that some coastal residents will or may “face certain death.” Yet some stayed through the storm; a few perished, and others experienced life-threatening circumstances. Many of those who left returned home to find much more damage than they expected based on past hurricanes and Ike’s wind speeds.

To examine these and related issues, this article presents results from 49 semistructured interviews with Texas Gulf coast residents conducted approximately one month after Hurricane Ike made landfall in Texas. The interviews gathered data on people’s perceptions of hurricane risk, their preparation and evacuation decisions, and their opinions of hurricane forecasts and warnings. While the study is based on a limited sample from two communities in a single hurricane case, comparison with other studies indicates aspects of the results that may be more broadly applicable.

We interviewed residents of two areas where Hurricane Ike caused significant damage: Galveston and Kemah, Texas (Fig. 2). Galveston (population approximately 57,000) lies on the eastern side of Galveston Island. The town of Galveston has a 5-m (17 ft)-high seawall, built after the devastating 1900 storm, that provided substantial protection during Ike. Nevertheless, Galveston still experienced significant flooding, an estimated $2 billion in damage, and an estimated loss of 85% of its business base. Kemah (population approximately 2,500) is a coastal town located on Galveston Bay about 35 km north of Galveston. Kemah suffered significant residential damage as well as severe damage to its seaside boardwalk area, a regional tourist attraction. Initial estimates suggest that the town may lose as much as 90% of its business income. The two communities also experienced significant effects on housing, transportation, medical care, and other infrastructure and services, as well as environmental damage (FEMA 2009a).

Section 2 describes the study methodology. Section 3 presents the major results, starting with interviewees’ perceptions of hurricane risk. It then discusses their preparation and evacuation decisions leading up to Hurricane Ike and their anticipated decisions about future hurricanes, as well as their sources, perceptions, and uses of hurricane forecasts. To take advantage of the data provided by the in-person interviews, we not only discuss findings across the interview population, but also use individuals’ quotes and anecdotes to illustrate key points and help elucidate the complex, contextual nature of many people’s hurricane-related risk perceptions and decisions. Section 4 summarizes and discusses the major findings, including ideas for further investigation.

2. Methodology

Data for the study were collected through semistructured, intercept interviews with 49 Texas coastal residents affected by Hurricane Ike: 41 in Galveston and 8 in Kemah (Figs. 2 and 3). The interviews were conducted in person over 3 days in mid-October 2008, approximately five weeks after Ike’s landfall in Texas.1 These two communities were chosen because they experienced significant effects from Hurricane Ike, but the

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1 Most of the interviews were conducted by the coauthors of this article; eight of the Galveston interviews were conducted by two Houston-area residents who assisted with data collection.
effects were not so severe that the areas were still largely unpopulated or inaccessible at the time of the interviews. In Galveston, interviews were conducted in neighborhoods of varying socioeconomic status and proximity to the coast (Fig. 3). In Kemah, interviews were conducted in one area, but several of the interviewees lived in surrounding towns (Fig. 3). Five of the Galveston interviewees also had homes in other Texas coastal areas and thus were only part-time Galveston residents.

The interview questionnaire included questions adapted from previous related work [especially the questionnaire used in the study of Hurricane Rita discussed in...]

FIG. 3. Approximate locations of interviewees' pre-Ike residences in (top) Galveston and (bottom) the Kemah area.
Zhang et al. (2007) and Morris and Zhang (2008) as well as new questions developed by the authors. Some questions were closed-ended, to generate quantitative data; others were open-ended, to contextualize closed-ended responses and allow respondents to describe their experiences and views in greater depth in their own words. The questionnaire was pretested with several residents of the Houston–Galveston area and revised prior to implementation based on the pretests.

Most interviews lasted approximately 15–20 min. The data were recorded by written notes taken by the interviewers; interviews were not audio-recorded to minimize researcher intrusiveness. Interviewers recruited subjects by approaching people at their homes and places of business and asking if they were willing to participate in the study. Twelve people declined to be interviewed. While the response rate was high, the relatively small size and convenience nature of the sample means that the results cannot be generalized to the broader population. Nevertheless, the results are indicative of how people in the areas studied view hurricane risk and their experiences related to Hurricane Ike. Because of the sample size, only basic quantitative analysis of the data was performed. To analyze responses to open-ended questions, the authors coded the qualitative data and examined them according to themes.

About half of the interviewees (26) were male. Interviewees’ ages ranged from 23 to 79, with a mean of 54. They had lived in the Texas Gulf coast region between 1 and 71 years, with a mean of 35. About 70% of interviewees were Caucasian or white, 12% were Hispanic or Latino, and the remainder were African American or black, Asian, American Indian, or of another background. One interviewee reported that Spanish was spoken most frequently in his/her home; the remaining interviewees spoke primarily English in their homes. Nearly all interviewees (47) lived in a single-family home, and more than 80% said that they or their family owned their residence. Thus, while our sample includes people with a variety of ages, time of residence in the area, and racial/ethnic backgrounds, it overrepresents homeowners and people residing in single-family homes. This is likely because of how we recruited interviewees, primarily by approaching people who were cleaning or repairing damage. Our sample also underrepresents some racial or ethnic minorities as well as non-English-speaking households, an important vulnerable population in the region. Some of these sample limitations are similar to those in other posthurricane studies, including larger surveys (e.g., Lindell et al. 2001, 2005). Nevertheless, the sample is not intended to be representative of the general population, and the results should be interpreted with these limitations in mind.

3. Results

a. Perceptions of hurricane risk

First, we examine interviewees’ perceptions of risk associated with Hurricane Ike and hurricanes in general, as well as their experiences with damage or harm due to Ike. Earlier research has shown that individuals’ perceptions of hurricane risk are affected by multiple factors, including their general orientations toward risk, perceptions of vulnerability and self-efficacy, previous experience with hazards, sociodemographic characteristics, and trust in authorities (e.g., Bateman and Edwards 2002; Peacock et al. 2005; Dash and Gladwin 2007). These risk perceptions are important because they influence people’s interpretations of situation-specific risk information such as forecasts, warnings, and evacuation orders, as well as their decisions in the face of a potential hurricane threat (Baker 1991; Mileti and O’Brien 1992; Gladwin et al. 2001; Lindell and Perry 2004; Arlikatti et al. 2006; Dash and Gladwin 2007). The results presented here add to the existing literature by examining Texas coastal residents’ perceptions and misperceptions of hurricane risk prior to Ike and how their experience with Ike affected their perceptions of future hurricane risk.

1) Perceptions of risk prior to Ike

On the basis of the information they received about Hurricane Ike before the storm, about three-quarters of interviewees (36) reported believing that their property might be at risk. About two-thirds (31) believed that they or their family might be at risk. Thus, most interviewees understood that Ike posed a risk. About 20% (9), however, reported perceiving neither personal nor property risk.

The 40 interviewees who perceived either personal or property risk were asked about what risks they were worried. Most responses focused on threats to personal safety or property due to flooding and/or wind. Approximately 20% (8) said that they were worried about both flooding and damaging winds, and a similar number (9) said they were worried primarily about flooding. More than one-quarter (11) said they were worried primarily about damaging wind. A number of respondents mentioned that they never expected the flooding to be so bad. For example, one interviewee said that she never dreamed of 7 ft of water (in her neighborhood); another said the storm surge caught her by surprise. Thus, while some of our respondents knew Ike could cause flooding in their area, a substantial portion did not.

2) Harm experienced because of Ike

The extent of the flooding and resulting damage was worse than many interviewees’ pre-Ike perceptions of
risk. Nearly all (47 of the 49) interviewees, including all of those in Galveston, experienced property damage to their homes because of Hurricane Ike. Although a few reported only cosmetic damage, the vast majority of interviewees reported extensive damage to their residences and other property, especially from flooding. One Kemah interviewee’s house had been moved 6 m (20 ft) off its foundation; another said that a pier ended up in his living room. A number of Galveston interviewees discussed how flooding destroyed everything (including furniture, appliances, sheetrock, and wiring) below a certain height inside their homes; a few lost everything. Two Galveston interviewees who incurred only minor damage mentioned that their homes had been raised about 2.1 m (7 ft) after the 1900 hurricane, which protected their main floor from flooding.

Ike caused deaths and injuries, and hurricanes pose significant threats to personal safety for at-risk coastal residents who do not evacuate. Nevertheless, for our interviewees, the most common threats to personal well-being (after property damage and financial harm) were not death or injury, but trauma or other issues related to long-term recovery. About one-quarter of interviewees (12) reported that they or their families experienced harm because of Hurricane Ike. Two of these experienced minor injuries, but the most common harm mentioned was emotional or psychological, reported by six interviewees. Other types of harm included lost jobs and pets. A few interviewees also mentioned concerns about personal and community economic recovery. One interviewee’s story illustrates the complex aftermath of an event such as Ike. Her family had evacuated, and they returned to find that their apartment had been inundated by floodwaters and their belongings were covered in mud and mold. Although the interviewee had washed the clothes they left behind multiple times, one of her children still developed rashes from wearing them. At the time of our interview, the family was living in a temporary tent city set up by the American Red Cross, but the shelter was scheduled to close soon, and she did not know where they would then live.

3) Concern about future hurricane threats

About 40% (21) of interviewees said that their concern about threats from future hurricanes had changed since Hurricane Ike. When asked how their concern had changed, many said that they were more scared,

particularly about flooding or storm surge. For example, one woman said that she had lived in Texas her whole life but found the amount of damage caused by Ike’s surge terrifying. Another said that after seeing Ike’s damage, she no longer felt safe in her own home during a hurricane. One of the nonevacuees (who ended up wading through chest-high water to seek shelter at a neighbor’s elevated house) mentioned that he would pay attention to the size of the next storm; if one as big as Ike comes, he would leave. Of those who said that their concerns about future hurricane threats had not changed, several explained that they had lived in the area a long time and so they knew what hurricanes could do. However, another long-time Galveston resident noted that she had a misconception about hurricanes; she did not think a category 2 storm would cause this much damage. These findings illustrate some of the ways that experience with a damaging hurricane can affect people’s perceptions of future hurricane risk.

b. Preparation and evacuation decision making

Next, we examine interviewees’ decisions leading up to Hurricane Ike, including the roles of evacuation orders and other considerations. We also explore interviewees’ anticipated decisions about future hurricanes. These results add to existing understanding of how and why people make hurricane-related decisions. This, in turn, provides insight into how people perceive hurricane risk, how they interpret and use hurricane information, and how improved information about hurricane risk might improve decisions and outcomes.

1) Preparation decisions

Ninety percent of interviewees said they or someone else prepared their residences for Hurricane Ike in advance of the storm. One of the five who reported not preparing specifically for Ike said that he was always ready; another said that his home’s windows were designed to withstand significant impact. Nevertheless, all five who did not prepare experienced significant damage, mostly from flooding. This further supports the discussion in section 3a that some people did not perceive the extent of the risk posed by Ike, particularly from flooding.

To add detail to previous discussions of people’s hurricane preparation decisions (e.g., Lindell et al. 2001, 2005), we asked people what was done to prepare their residences (see also Zhang et al. 2007). Of those who prepared, nearly all reported preparing for strong winds, for example, by boarding or shuttering windows and picking up loose items. About one-quarter prepared for potential flooding by moving household items or vehicles to higher ground, although several noted that they

2 The remaining two lived away from the coast in the Kemah area and experienced damage to their business or workplace in Kemah.
did or could not move property high enough. Other preparations included turning off appliances, electricity, and gas; purchasing supplies; preparing for power outages; and moving or securing important records or valuables. The overall level of preparedness suggests that our interviewees were generally aware of the risks to property posed by hurricane-force winds. However, the ways that interviewees prepared, again, suggests that some were not aware of the coastal flood risk associated with hurricanes in general and Hurricane Ike in particular.

2) EVACUATION DECISIONS

Other than preparing their residences, a major way that people can lower their risk from an approaching hurricane is to go somewhere safer. One interviewee was not in the Texas Gulf coast region when Hurricane Ike approached, and four owned homes in both Houston and Galveston and chose to ride out the storm in their Houston homes. Of the remaining 44 interviewees, about three-quarters (34) evacuated. When asked the main reason why they decided to leave, 7 of the 34 evacuees (about 20%) said it was because of an evacuation order. Eight discussed their concern about the storm’s danger or fear for their safety, and five said they left because of children or elderly parents. Seven discussed forecasts, warnings, or the storm’s characteristics. Three said they evacuated primarily because someone else convinced them to do so. Several interviewees also mentioned intrahousehold discussions on whether and when to evacuate, corroborating earlier findings on the importance of household interactions in decision making (e.g., Gladwin and Peacock 1997; Gladwin et al. 2001). Other reasons for evacuating included not being a risk taker, not wanting to be alone during the storm, and seeing environmental cues such as water rising as the storm approached.

These results agree with previous findings that evacuation orders are an important influence on some people’s evacuation decisions, but that many people consider other information—including forecasts, expected effects, and other people’s opinions—when evaluating their risk and deciding on appropriate action (Baker 1979, 1991, 1995; Dow and Cutter 1998, 2000; Gladwin et al. 2001; Lindell et al. 2005; Dash and Gladwin 2007; Zhang et al. 2007). This suggests that for many people, effective communication of forecasts and potential effects is important. For example, several interviewees reported hearing forecasts of potentially devastating storm surge and using that information in their decision making.

The 10 nonevacuees gave a variety of reasons for staying. Three discussed the elevation of their residence, its storm protection features, or their experience and confidence in the Galveston seawall, suggesting that they felt Ike posed limited risk to them. One of these three resided in a high-rise condominium complex that experienced only minor damage; the other two experienced substantial flooding in their homes and traumatizing or life-threatening situations. Another nonevacuee said he stayed because he said he always does, except for category 5 storms; he noted that category 2 storms (such as Ike) do not produce much wind damage. Although this man described his experience with Ike’s flooding as potentially life threatening, he did not seem to regret staying. Three nonevacuees had a large number of pets and discussed the difficulty of transporting them and finding shelter. Another nonevacuee was concerned that his older car would break down en route, given his experience with traffic jams during the Hurricane Rita evacuation. Other reasons for not evacuating included protecting personal and business property, job responsibilities, insufficient funds, a child with health issues that made evacuation difficult, not wanting to drive 8 h to a relative’s house, and past experience with hurricanes. A few of these nonevacuees also experienced traumatic or dangerous situations during Ike. These results are consistent with earlier findings on why some people do not evacuate when a hurricane threatens (e.g., Baker 1991; Dow and Cutter 1998; Riad et al. 1999; Gladwin et al. 2001; Zhang et al. 2007). Further, they highlight how some nonevacuees did not fully understand the risk posed by Ike: they found themselves in hazardous, frightening situations when it was too late to evacuate.

While evacuation decisions are sometimes viewed or modeled as one-time yes–no decisions, in reality, they are often complex and evolving. As discussed in Gladwin and Peacock (1997) and Gladwin et al. (2001), our data indicate that risk perception, experience, evacuation orders, forecasts, environmental cues, household interactions, and resources and constraints can all interact over a period of time as people decide whether to evacuate, when, and how. This is illustrated by the story of one nonevacuee we interviewed, a lifelong Galveston resident who has stayed for a number of hurricanes. Because the interviewee’s area had not flooded in his lifetime and his home’s main floor is elevated, he did not anticipate flooding despite the forecasts. However, the warnings concerned his teenage daughter, and she and his girlfriend convinced him to evacuate. They packed to leave, but he had only $50 and was unable to obtain additional cash because banks were already closed and no one else would cash his two-party paycheck. He also anticipated

3 This suggests that despite recent efforts to assist hurricane evacuees with pets (Burns 2008), pets remain a factor in some people’s evacuation decisions. Large numbers of pets, such as the five pit bulls one interviewee had, may pose a special problem.
difficulty finding a hotel to stay in with his five pit bulls. His family said that if he stayed, they would stay, so he purchased supplies and they all stayed. Although their main floor did not flood, the man had to rescue his dogs from the first-floor garage, and he and his family suffered emotional trauma from experiencing the storm.

To examine in more detail how different types of considerations influence people’s decisions, we asked interviewees to what extent they relied on 1) recommendations of authorities; 2) their own judgment; and 3) family or friends’ judgment when making evacuation decisions related to Hurricane Ike (Fig. 4). Most interviewees reported relying heavily on their own judgment, although this may have arisen in part because independent judgment is a socially desirable response. A smaller number of interviewees reported relying heavily on authorities’ recommendations or family or friends’ judgment. On average, family and friends’ judgment was approximately as important as authorities’ recommendations, which is consistent with previous disaster research (e.g., Lindell and Perry 2004). Further, Fig. 4 indicates that individuals’ responses tended to be on the extremes of the scale. This suggests that, as discussed earlier, different people weight information differently when making evacuation decisions. It also means that many interviewees can be categorized by their reliance on certain considerations over others. Such findings may have implications for designing hurricane risk message content and dissemination strategies.

3) EVACUATION ORDERS

Because evacuation orders are important for some people’s decisions, we were interested in how effectively such orders are communicated. When asked if officials had issued an evacuation order for their location for Ike, 40 interviewees said a mandatory order had been issued, and 7 said a voluntary order. One said no evacuation order had been issued, and one did not know. Six of those who said there was a voluntary order and the one who did not know resided in Galveston. A mandatory evacuation order was issued for all of Galveston Island prior to Ike, but not until Thursday, 11 September—later than officials’ plans to order evacuations 72 h before landfall (Houston Chronicle, 11 September 2008).

On Wednesday evening, a mandatory order had been issued for the western portion of the island, but evacuation on the eastern end (including the town of Galveston) was voluntary. This delay in issuing the evacuation order and the change in location appears to have confused some interviewees. Several thought evacuation was mandatory only for the west end, and two reported not hearing the mandatory order for the east end until hours after it was issued. This corroborates the discussion in Lindell et al. (2007) that timely issuance of evacuation orders is important, not only to give people time to travel to safety, but also to give people enough time to hear the information, decide to leave, and make necessary preparations. Three of the Galveston nonevacuees thought that they were under only a voluntary evacuation order; the remaining five knew the order was mandatory and stayed anyway.

We asked those who said they were under an evacuation order how they heard about it. More than half of the respondents reported hearing about the evacuation order on television (cable or local). The next most common source was radio, followed by their community’s reverse-911 system and other people. One interviewee described being in the grocery store to purchase supplies and hearing people discussing the evacuation order on cell phones. Others received the information from the Internet, their workplace, or police driving by with loudspeakers. Thus, while the majority of interviewees heard about the evacuation order through the news media, overall, a diverse set of sources was used. Corroborating the discussion in Phillips and Morrow (2007) and Cutter

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4 This question was adapted from a survey question on flood warnings discussed in Parker et al. (2007, their Fig. 4).

5 For example, 10 interviewees said they relied heavily on their own judgment and little on authorities or family and friends. Nine said they relied heavily on their own judgment and that of authorities but little on that of family or friends, while six said they relied heavily on their own judgment and that of family or friends but little on that of authorities.
and Smith (2009), these findings suggest the importance of disseminating such information multiple ways, so it reaches a wide audience as quickly as possible.

The relatively late issuance of evacuation orders combined with the relatively early arrival of flooding due to Ike’s size meant that mandatory evacuation orders were not issued for Galveston Island until 24–36 h before flooding began. Because evacuation orders are one cue to members of the public that a dangerous hurricane is threatening, we asked interviewees if they had enough time after receiving the evacuation order to do what they needed to do to protect themselves and their property. About 70% said yes. Several of those said that they had enough time only because they started preparing before the evacuation order was issued, based on experience or information they received on the news. This is consistent with Dow and Cutter’s (2002) data indicating that in Hurricane Floyd, many South Carolina residents evacuated or prepared to do so before a mandatory evacuation order was issued. It also highlights the importance of effectively communicating information other than evacuation orders—including forecasts of the storm and discussions of its possible effects—to help people prepare for an approaching hurricane.

Several interviewees said they did not have enough time to prepare their property, and several reported not having enough time to move belongings to a safe location. Three attributed this to uncertainty in the storm track, suggesting the potential value of improving hurricane forecasts. One noted the trade-off between spending more time preparing and leaving so late that one gets caught in traffic or cannot evacuate because of flooded roads. As discussed earlier, this indicates that people at risk must decide not only whether to evacuate but also when and how.

4) LEARNING FROM EXPERIENCE

Given that many people experienced more significant flooding than they expected, we asked interviewees whether, looking back on their decisions as Hurricane Ike approached the coast, they would do anything differently next time, and if so, what. About two-thirds (32) said yes, and 3 said maybe or they did not know. Of the 26 evacuees who would or might do something differently, 17 said they would do more to protect property, including moving more items out of their homes or moving items higher. Three said they would leave sooner. Only one evacuee said she might stay next time (because of delays in accessing her property after the storm). Nine (of 10) nonevacuees said they would or might do something differently next time. Five said they would leave or would probably leave, and four would do more to protect property. Other things that interviewees would do differently include purchasing more supplies, purchasing a generator, finding a motel room earlier, handling pets differently, and purchasing flood insurance. These results indicate that the vast majority of evacuees we interviewed did not regret leaving prior to Hurricane Ike, and a number of the nonevacuees would likely leave if a similar hurricane threatened. More generally, as found by Zhang et al. (2007) for Hurricane Rita, many interviewees—evacuees and nonevacuees—learned things from Ike that may help them respond to future hurricane threats.

5) FUTURE EVACUATION

Following several previous studies, we asked interviewees about their anticipated evacuation decision for a future category 1, 2, 3, 4, or 5 hurricane (Fig. 5). All interviewees were able to answer the question immediately and indicated the same or increasing likelihood to evacuate as the storm intensity increased. As we discuss further in section 3c, this suggests widespread understanding of the Saffir–Simpson scale among our interviewees, at least at a general level. Most said they would not evacuate for a category 1 storm. For a category 2 storm, nearly half would evacuate. For a category 3 or higher storm, most would evacuate. Although we cannot draw general conclusions given the sample, these results are broadly similar to those from other studies of Texas Gulf coast residents (e.g., Lindell et al. 2001; Lindell and Prater 2007; Zhang et al. 2007). This suggests that many people in the areas studied would evacuate if an intense hurricane threatened in the near future. Some, however, would still want to evaluate the situation for themselves,
even given a category 4 or 5 storm and an evacuation recommendation from authorities.

c. Sources, perceptions, and use of hurricane forecasts

As discussed in section 3b, the information people receive about a hurricane threat and their perceptions of that information affect their decisions as a hurricane approaches. Consequently, reducing the negative effects of hurricanes requires not only adequate forecasts and timely evacuation orders, but also disseminating and conveying this information in ways that promote appropriate public response. To investigate these issues, this section examines people’s sources of, opinions about, and uses of forecast and warning information about Hurricane Ike prior to landfall. The results add to the existing literature by examining forecast and warning communication and use in the case of Hurricane Ike. They also provide new knowledge about the limitations of the Saffir–Simpson scale as a mechanism for communicating hurricane risk and about the effectiveness of warnings such as the “certain death” statement issued by the NWS shortly before Ike made landfall.

1) SOURCES OF AND EXPOSURE TO FORECASTS

Figure 6 shows where interviewees reported getting forecast information about Hurricane Ike before the storm. The vast majority (all but three) got at least some information from television. The next most common source was the Internet, followed by family and friends, radio, and newspapers. Interviewees reported using an average of 3.5 of the 7 source options provided, indicating that many obtained hurricane information from multiple venues. This supports the discussion in section 3b and earlier findings (Dow and Cutter 1998, 2000; Zhang et al. 2007) that, given the volume of information available from diverse media venues, many coastal residents now obtain hurricane information from multiple sources for use in assessing their own risk.

Interviewees were then asked which of these sources was overall most important to them in obtaining information about Ike and why. More than two-thirds said television, most commonly local television. This agrees with earlier work that news media, specifically television, is a key information source as a hurricane approaches (Gladwin and Peacock 1997; Dow and Cutter 1998, 2000; Zhang et al. 2007). Interviewees said television was important because of its updated, round-the-clock, and convenient coverage, as well as the knowledge and information provided by trusted local broadcasters. This is corroborated by earlier research results indicating that people tend to develop relationships with specific media sources—particularly individuals—and many find television a trustworthy and expert source of hazard information and recommendations (Driscoll and Salwen 1996; Sherman-Morris 2005; Phillips and Morrow 2007).

About 20% of interviewees said the Internet was their most important source because of its accessibility or the up-to-date or detailed information it provided. This suggests, as discussed in Dow and Cutter (2000), that new technologies such as the Internet are becoming key sources of hurricane risk information for some populations. The importance of such sources compared to “traditional” media is an issue for more in-depth investigation in future work.

We examined people’s exposure to Hurricane Ike forecasts from two additional perspectives. First, we asked interviewees how frequently they obtained forecast information for Ike prior to the storm (Fig. 7). More than 90% checked forecasts more than once a day, and about half reported checking forecasts once an hour or constantly. We also asked interviewees whether they heard a forecast for Hurricane Ike at two different times before the storm hit the Texas coast (Fig. 8). Ninety percent reported hearing a forecast 5 days in advance, and all reported hearing a forecast 3 days in advance. These results suggest that several days before Hurricane Ike reached the coast, many Texas coastal residents were aware of the threat and obtaining forecast information frequently to evaluate their risk. This is corroborated by similar findings by Gladwin and Peacock (1997) for Hurricane Andrew, Dow and Cutter (2000) for Hurricane Floyd, and Zhang et al. (2007) for Hurricane Rita. However, as discussed in sections 3a and 3b, a significant portion of our interviewees did not adequately prepare for flooding and were surprised by the extent of Ike’s...
flooding and the resulting damage. Thus, further study is needed of what people actually hear and understand from the hurricane threat and preparation information to which they are exposed. For example, one interviewee noted that although the television in her home was on nearly constantly leading up to the storm, she and her family were busy preparing and so rarely paid full attention.

2) PERCEPTIONS OF FORECAST CONFIDENCE AND QUALITY

We investigated interviewees’ perceptions of forecasts from a few interrelated perspectives. To examine trust in forecasts and perceptions of forecast uncertainty, we asked interviewees about their confidence in forecasts of Ike at 3- and 5-day lead times (Fig. 8). Overall, interviewees tended to have medium to high confidence and somewhat higher confidence in 3-day than 5-day forecasts. We also asked interviewees about their overall perception of quality in Ike forecasts and how much confidence they will have in future hurricane forecasts (Fig. 9). Most interviewees rated forecasts as having medium to high quality and expressed medium to high confidence in future hurricane forecasts. These results are similar to those reported by Zhang et al. (2007) in their study following Hurricane Rita. These data, along with the additional comments interviewees provided, suggest that most interviewees were generally satisfied with the forecasts of Hurricane Ike.

3) PERCEPTIONS OF THE SAFFIR–SIMPSON SCALE

One of the primary mechanisms currently used to communicate hurricane intensity and expected effects to members of the public and other decision makers is the Saffir–Simpson scale. Although Ike was a category 2 storm as it approached the Texas coast and at landfall, it generated higher storm surge and more damage than many people expected. People’s perceptions of Ike’s

![Fig. 7. Responses to “Approximately three days before Hurricane Ike hit the Texas coast, how often did you check the weather forecast for the storm?” Respondents were asked to select one of five options: “once a day or less,” “two times a day,” “four times a day,” “once an hour,” or “constantly.”](image-url)

![Fig. 8. Respondents were asked “Around (five/three) days before Hurricane Ike hit the Texas coast, did you hear a forecast for the storm?” Those who said yes were asked, “How much confidence did you have in the (5 day/3 day) forecast for Hurricane Ike?” They were asked to rank their confidence on a scale from 1 to 5, with 1 meaning low confidence and 5 meaning high confidence. Percent of respondents who selected different confidence rankings is shown, along with the percent of respondents who said they did not hear a forecast or could not remember if they had. Mean confidence for each lead time is shown in parentheses in the legend.](image-url)

![Fig. 9. Responses to “Overall, how good do you think the weather forecasts were for Hurricane Ike?” and “In the future, how much confidence will you have in hurricane forecasts?” Respondents were asked to rank each on a scale from 1 to 5, with 5 meaning high quality or confidence. Mean quality and confidence are shown in parentheses in the legend.](image-url)
intensity and its effects may affect their interpretations of future hurricane forecasts. People’s opinions of Ike at landfall also provide information about how well they think the Saffir–Simpson scale communicates hurricane risk. Thus, we asked interviewees what category hurricane they thought Ike was when it hit Galveston. Every interviewee—including those for whom English was not a first language and those who had recently moved to the area—immediately knew what was meant by a “category” of hurricane. While our sample is small, this corroborates the discussion in section 3b and Morss and Zhang (2008) that the Saffir–Simpson scale is a salient risk communication mechanism for many, if not most, residents of areas such as the Texas Gulf coast.

As shown in Fig. 10, more than half of respondents knew that Ike was a category 2 hurricane at landfall. Not surprisingly given Ike’s effects, most of the remaining interviewees thought Ike was stronger. Although we did not ask for additional comments about Hurricane Ike’s intensity or the Saffir–Simpson scale, more than one-third of the interviewees provided them. The most common comment was that even though Ike might have officially been a category 2 (or 3) hurricane, the surge or flooding was that of a category 4 or 5 hurricane (or even worse). Others said that even though Ike was officially a category 2 storm, they thought it was stronger based on the damage they saw. Two specifically commented that Ike’s wind speeds or its rating on the Saffir–Simpson scale did not accurately reflect the damage it caused. Two others said they thought that Ike’s winds were different “categories” at different levels, that is, ground level compared to 100 ft or to where National Oceanic and Atmospheric Administration (NOAA) aircraft measure winds offshore.

These responses indicate that, for some, the Saffir–Simpson scale did not adequately represent the risk posed by Ike (see also Houston Chronicle, 29 November 2008). Thus, while the Saffir–Simpson scale has served its original purpose as a simple, well-understood mechanism for communicating hurricane intensity (Simpson and Saffir 1974), different scales may be useful for communicating different types of risks associated with a landfalling hurricane, such as wind damage, storm surge, and inland flooding (Morss and Zhang 2008). In recognition of these issues, the National Hurricane Center (NHC) is testing an experimental Saffir–Simpson hurricane wind scale (NHC 2009), the NWS is considering a storm surge warning product separate from hurricane wind warnings, and NWS offices are developing products to communicate local hurricane effects. To help develop new mechanisms for communicating hurricane risk that are as effective as possible, formal testing with broad audiences would be valuable. The importance of such message testing is indicated by people’s response to the “certain death” statement issued by the NWS prior to Hurricane Ike, discussed next.

4) PERCEPTIONS AND USE OF “CERTAIN DEATH” STATEMENT

Beginning on the evening of Thursday, 11 September, the Houston–Galveston NWS office began trying to communicate Ike’s potential effects by issuing statements that described the anticipated storm surge and included the phrase “Persons not heeding evacuation orders in single family one or two story homes will [may] face certain death.” The “certain death” portion of the statement was widely reported in the local and national media. To investigate the effectiveness of this NWS statement, we asked interviewees whether they heard the statement; those who had were asked where they heard it, what their opinion of it was before Hurricane Ike hit the coast, and whether and how it affected their decision to prepare or evacuate.

About 70% of interviewees (35) said they heard this statement before Hurricane Ike hit the coast. More than two-thirds of those who remembered where they heard the statement said they heard it from television, corroborating the earlier discussion about the importance of television as a source of information about an approaching hurricane. Other sources included radio, the Internet, and other people.

Of those who heard the statement, 14 expressed opinions that were generally positive; for example, they said they believed the statement or it increased their awareness of the risk. Thirteen expressed negative opinions; for
example, they did not believe the statement or thought it was exaggerated or too extreme. Four expressed opinions that were mixed, and the remainder could not be categorized. Most of those who had heard the statement recognized it immediately, and many had a strong opinion about it. Positive phrases used to describe the statement include “blunt . . . effective,” “correct,” “to the point,” “scared you to death,” and “people who didn’t heed were foolish.” Negative phrases include “harsh and over-reactive,” “overblown,” “ridiculous,” “humorous,” “stupid,” “rude,” and “not appropriate.” Some noted the trade-off between scaring people too much and convincing people to leave. For example, one interviewee thought the statement was too extreme but understands some people do not listen; another said that although the statement was very true and people should leave, it added too much stress and was very disturbing. Overall, some said they took it seriously, and others said they did not.

The “certain death” statement made a strong impression on a number of people. But how did it affect their decisions leading up to Ike? More than two-thirds (25) of the interviewees who heard the statement said that it did not affect their decision to prepare or evacuate. This is in part because many people had already left their residences by the time the statement was issued. Of the 10 whose decision was affected, 8 said it helped them decide to evacuate, and 2 said it reinforced the decision they had already made to evacuate. For example, one interviewee said the statement helped her talk her husband into leaving; another said that it made her realize the storm would be bigger than expected. One said that the statement was the “biggest factor in being convinced to evacuate”; another simply said “that’s why I left.”

These results suggest that the NWS statement motivated at least a few people to leave and thus may have saved lives. However, some people who had strong negative opinions about the statement indicated that it might decrease their sensitivity to communication of future hurricane threats. For example, one nonevacuee said that such statements make him lose confidence; another said the statement made him want to stay “to show them he’s not going to die.” This illustrates the importance of learning how to effectively communicate the risk associated with a threatening hurricane, in ways that motivate people at high risk to take action without substantially reducing future response.

5) ADDITIONAL INFORMATION NEEDED BY MEMBERS OF THE PUBLIC

To help improve information provision and decision making about future hurricanes, we asked interviewees if there was information they needed before Hurricane Ike hit the coast but did not get. Twenty percent (10) said yes and were asked what additional information they needed. Six mentioned better predictions of the storm’s track, surge, flooding, and/or effects. For example, one person said that nobody knew about the (flood) water, and that “everyone would have done something different if they knew.” Two mentioned information about flood preparations, and one wanted notification to leave sooner. Of those who did not report needing additional information, one commented that she had been to a hurricane preparedness meeting and was aware of necessary steps to secure property and safeguard her family. Another stated that there was a lot of information, and it was a matter of whether one paid attention and heeded the warnings. As discussed earlier, these results indicate that while some people understood the risks posed by Ike, others did not.

4. Summary and discussion

Despite significant enhancements in hurricane mitigation, forecasting, and warning over the last century, landfalling hurricanes in the United States continue to cause substantial damage as well as loss of life and other negative effects (Willoughby et al. 2007; Pielke et al. 2008). Reducing these effects requires both long-term mitigation and improved communication and use of forecasts and warnings when a hurricane threatens. To help address the latter need, this article investigates how coastal Texas residents perceived hurricane risk, viewed hurricane forecasts and warnings, and made hurricane preparation and evacuation decisions about Hurricane Ike, which made landfall near Galveston, Texas, in September 2008. The findings are based on data from interviews of 49 residents of the Galveston and Kemah, Texas, areas in October 2008. Both areas experienced major damage because of Ike, especially from storm surge and flooding. The study adds to the existing literature by presenting a new empirical case study of hurricane risk communication and decision making. Some of the issues investigated have been studied in other contexts, and some have not been previously explored.

Many of our interviewees experienced different effects from Ike than they anticipated prior to the storm. Most importantly, a substantial portion was surprised by the extent of Ike’s flooding in their community and the resulting damage. While nearly all interviewees prepared their residences for strong winds, many did not adequately prepare for flooding. Several nonevacuees experienced unanticipated hazardous, traumatizing situations. Ike’s forecasts were relatively skillful compared to other hurricanes, and our data suggest that many people at risk were paying close attention to the storm as
it approached. Despite this and the area’s general risk of flooding, many people did not fully understand the risks Ike posed, and these perceptions affected their preparation and evacuation decisions. The data suggest that interviewees did not conceive of severe flooding for a variety of reasons, including prior experience with hurricanes, lack of flooding in their neighborhoods since the 1900 storm, the elevation of their residences, mitigation since earlier storms, trust in the Galveston seawall, and lack of awareness that Galveston could flood from the bay side. Other likely contributors include uncertainty in Ike’s forecasts and the fact that specific forecasts of significant storm surge for Ike in Galveston were not issued until the morning of Thursday, 11 September, after many people had completed major preparations and made evacuation decisions. These new findings highlight the importance of effectively communicating hurricane risk and possible effects, both in general and when a storm threatens. Learning to do so requires building on previous work to investigate in greater detail how and why people develop perceptions of the specific risks of hurricanes.

The nonevacuees we interviewed had a variety of reasons for not leaving, including perception they were not at risk, negative aspects of evacuating, and financial or family constraints; these are similar to results from previous studies (Baker 1991; Dow and Cutter 1998; Riad et al. 1999; Gladwin et al. 2001; Zhang et al. 2007). Most of the nonevacuees interviewed described dramatic and in some cases potentially life-threatening experiences during Ike. Most said they would likely do something differently next time a hurricane threatens, including five who said they would likely leave. This is corroborated by media reports that some nonevacuees did not fully understand the risk posed by Ike until the storm arrived (USA Today, 13 September 2008; Houston Chronicle, 12 September 2008; New York Times, 13 September 2008). Some nonevacuees had experienced several previous hurricanes, yet Ike was still a learning experience. It is unrealistic to expect that everyone can be convinced to evacuate at-risk areas prior to a storm. Nevertheless, as previously discussed in the hazards literature (e.g., Phillips and Morrow 2007), it remains important to address the constraints that lead members of some at-risk populations to not evacuate. Our findings from Hurricane Ike further indicate the importance of improving communication of hurricane risk to the public, to aid people’s protective decisions.

About 20% of the evacuees interviewed said that the main reason they decided to leave was an evacuation order. The remainder said they left primarily because of concerns for safety, forecasts and warnings, or other reasons. Many interviewees reported relying heavily on their own judgment when making evacuation decisions, some almost exclusively. Some interviewees also noted the importance of preparing before evacuation orders, because they tend to be issued too late to initiate preparation and evacuation decisions. Evacuation orders (anticipated or issued) are a key influence on some people’s evacuation decisions, and authorities’ discussion of evacuation recommendations can help convince people that they are at significant risk. Weather forecasters and broadcasters therefore serve as key partners in the warning process by providing information that aids emergency management decisions and by disseminating emergency management advice to the public. Nevertheless, our results and those from previous studies indicate that many people consider other factors—including forecasts of storm conditions and effects—and make their own judgments of risk as a hurricane approaches (e.g., Baker 1991; Dow and Cutter 1998, 2000; Gladwin et al. 2001). Previous work suggests that people generally evacuate when they feel at risk, and they generally stay when they feel safe, subject to their constraints. Consequently, weather forecasters and broadcasters also play important roles by providing information that helps members of the public assess their own risk and decide on appropriate actions given their circumstances.

As previously discussed in the hazards literature (e.g., Gladwin and Peacock 1997; Gladwin et al. 2001; Parker et al. 2007), hazard preparation and evacuation decisions are complex and interactive. Corroborating earlier work, our findings illustrate that most hurricane evacuation decisions are not just about whether or not to evacuate; people must also decide when to evacuate and how, in conjunction with other household members. Hurricane preparation and evacuation decisions evolve over time, as the threat, the situation, and people’s understanding of them evolve. Environmental cues, if they are available sufficiently far in advance of a storm, can also be important. Further, experience can influence people’s perceptions of hurricane risk and their decisions when a hurricane threatens, sometimes in complex ways (see also Baker 1991; Dow and Cutter 2000; Peacock et al. 2005). Nearly half of our interviewees reported that Ike had changed their concern about future hurricanes, and about two-thirds said they would do something differently next time. Looking forward, Hurricane Ike will likely be the dominant storm in the memory of Houston–Galveston area residents, supplementing Hurricanes Rita, Alicia, Carla, and the 1900 storm—at least until the next major hurricane hits.

Most of our interviewees were aware of Ike’s forecasts and the evacuation orders, and they obtained forecast information frequently leading up to the storm. For most, local television—particularly specific trusted local
broadcasters—was especially important, although people obtained hurricane forecasts from multiple sources. These findings are similar to those from previous studies (Gladwin and Peacock 1997; Dow and Cutter 1998, 2000; Zhang et al. 2007). However, our data from Ike suggest that despite this wide penetration of forecasts, some interviewees did not receive key information as the threat and recommended actions evolved. Thus, further research is needed to understand what people interpret from the forecast and other information they receive from multiple sources as a storm approaches, as they make sense of information through the lens of their risk perceptions and experience and those of their family and friends. For example, people may anchor to initial impressions of a storm; if the forecast changes or the storm is evolving differently from people’s experience, then this information may need to be clearly communicated multiple times from multiple sources to be heard and acted upon (Sorensen 2000; Parker et al. 2007; Phillips and Morrow 2007).

Our findings indicate that the Saffir–Simpson scale used to communicate hurricane intensity is widely understood at a general level. However, the scale does not always effectively communicate the risks associated with a specific hurricane. Some interviewees volunteered concerns about the scale in the case of Ike; in particular, they wanted more information about the storm surge and flooding threat Ike posed. While the National Weather Service is beginning to address this issue (e.g., Houston Chronicle, 29 November 2008), further research is needed to understand how to most effectively, yet succinctly, convey various risks associated with an approaching hurricane. As experiences with the hurricane “cone of uncertainty” illustrate (Broad et al. 2007), attempts to communicate hurricane risk to broad audiences without adequate research or testing can lead to misunderstanding of important information.

One interesting aspect of Hurricane Ike was the widely disseminated statements issued by the Houston–Galveston NWS office warning that some people not heeding evacuation orders will or may “face certain death,” based on the significant storm surge forecasted. The majority of interviewees reported hearing the “certain death” statement, and many had strong opinions about it. Ten interviewees said the statement contributed to or reinforced their decision to evacuate. This suggests that the statement was effective in the sense that it helped convince some people to take protective action. However, a significant portion of our interviewees had strong negative opinions about the statement—for example, that it was overly dramatic or not credible—that may decrease their response to future hurricane warnings. These findings indicate how important it can be for communicators of public forecasts and warnings (such as NWS/NOAA) to engage in research to understand how people interpret and use their forecast messages. More generally, further work is needed to learn how to convey hurricane risk in ways that encourage appropriate protective action, without significantly reducing people’s sensitivity to future warnings. This research is especially important in the context of current efforts to improve estimation and communication of weather forecast uncertainty (NRC 2006; Morss et al. 2008). Such work must address communication and dissemination to diverse public audiences, particularly members of more vulnerable populations such as the poor, the elderly, and cultural minorities (Lindell and Perry 2004; Phillips and Morrow 2007).

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