Weathering the Storm: The Impact of Hurricanes on Physical and Mental Health

By
LINDA B. BOURQUE,
JUDITH M. SIEGEL,
MEGUMI KANO,
and
MICHELE M. WOOD

The authors briefly review the deaths, injuries, and diseases attributed to hurricanes that made landfall in the United States prior to Hurricane Katrina; recent hurricane evacuation studies and their potential for reducing death, injury, and disease; information available to date about mortality, injury, and disease attributed to Hurricane Katrina; and psychological distress attributable to hurricanes. Drowning in salt water caused by storm surges has been reduced over the past thirty years, while deaths caused by fresh water (inland) flooding and wind have remained steady. Well-planned evacuations of coastal areas can reduce death and injury associated with hurricanes. Hurricane Katrina provides an example of what happens when evacuation is not handled appropriately. Preliminary data indicate that vulnerable elderly people were substantially overrepresented among the dead and that evacuees represent a population potentially predisposed to a high level of psychological distress, exacerbated by severe disaster exposure, lack of economic and social resources, and an inadequate government response.

Keywords hurricanes; physical health; mental health; evacuation; morbidity; mortality; Hurricane Katrina

According to the United Nations Development Programme (UNDP; 2004), four developed nations (the United States, Japan, Australia, and New Zealand) and twenty-nine developing nations have substantial exposure to hurricanes, cyclones, and typhoons. Hurricanes directly affect the public's health by causing deaths, injuries, infectious diseases, and psychological distress. Injuries and diseases that result in serious disability or death are increased to the extent that the health care infrastructure is damaged and public health services are disrupted.

The UNDP (2004, 13) maintains that "human deaths are the most reliable measure of human loss" after a disaster. We suggest that the dependence on mortality rates as the "best" indicator of impact reflects the fact that few studies have attempted to assess the number of injury and disease events that can be directly or

DOI: 10.1177/0002716205284920

indirectly attributed to a given hurricane. This narrow focus on mortality has occurred because of the difficulties both in tracking persons who are injured or diseased and in determining whether the injury or disease of interest can, in fact, be attributed to the index hurricane. Shultz, Russell, and Espinel (2005) noted that "tropical cyclones [hurricanes] have caused an estimated 1.9 million deaths worldwide during the past two centuries and between 300,000 and 500,000 deaths in North America and the Caribbean since the 'discovery' of the Americas in 1492, of which 75,000 occurred during the 20th century" (citing Nicholls, Mimura, and Topping 1995; Rappaport and Fernandez-Partagas 1997, 23). Most deaths have occurred in developing nations, with 42 percent occurring in Bangladesh and 27 percent in India.

The United States and the Caribbean region have experienced many hurricanes during the past twenty years, starting with Hurricanes Elena and Gloria in 1985. The Centers for Disease Control and Prevention (CDC) differentiate between direct mortality caused by the physical forces of a hurricane, primarily flood surges and wind, and indirectly related deaths, caused by unsafe or unhealthy conditions. Shultz, Russell, and Espinel (2005) noted that prior to the development of effective warning, evacuation, and shelter systems, most deaths occurred by drowning in storm surges. Most of the 256 deaths that occurred in Hurricane Camille (1969) were associated with tidal surges, some as high as twenty-five feet. Between 1959 and Hurricane Katrina in 2005, no storms in Japan or the United States (developed countries at high risk of hurricanes, cyclones, and typhoons) resulted in more than 1,000 deaths. During the same time period, fifty high-fatality storms (more than 1,000 deaths) occurred in developing nations of the Asia-Pacific region and sixteen in the Caribbean and Central American area.

Linda B. Bourque is a professor in the Department of Community Health Sciences, associate director of the Southern California Injury Prevention Research Center, and associate director of the Center for Public Health and Disasters at the School of Public Health, University of California, Los Angeles. Her research focuses on community perceptions and responses to disasters, intentional and unintentional injury, and ophthalmic clinical trials.

Judith M. Siegel is a professor in the Department of Community Health Sciences at the School of Public Health at University of California, Los Angeles. She researches the relationship between stress and health, both physical and mental.

Megumi Kano, MPH, is a doctoral student in the Department of Community Health Sciences, UCLA School of Public Health, and a graduate student researcher, at the Southern California Injury Prevention Research Center, UCLA School of Public Health. Awards include the 2005 Chancellor's Dissertation Fellowship at UCLA and a 2005 Pre-Doctoral Fellowship at the National Center for the Study of Terrorism and Responses to Terrorism, University of Maryland.

Michele M. Wood is a teaching fellow at Frontiers in Human Aging (Undergraduate Cluster Program of the College of Letters and Sciences) and a doctoral student at the Department of Community Health Sciences, School of Public Health, at University of California, Los Angeles. Honors include a 2005 Pre-Doctoral Fellowship, National Center for the Study of Terrorism and Responses to Terrorism, University of Maryland, and a 2003-2004 Celia and Joseph Blann Fellowship, School of Public Health, UCLA.

In this article, we will briefly review the deaths, injuries, and diseases attributed to hurricanes that made landfall in the United States prior to Hurricane Katrina; recent hurricane evacuation studies and their potential for reducing death, injury, and disease; information available to date about mortality, injury, and disease attributed to Hurricane Katrina; and psychological distress attributable to hurricanes, including Hurricane Katrina.

United States Hurricanes Pre-Katrina

Consistent with the observations of Shultz, Russell, and Espinel (2005), the number and percentage of deaths attributed to drowning in hurricanes that made landfall in the United States has gradually decreased over the past thirty years, and outbreaks of infectious diseases have been rare. Woshon, Hamilton, et al. (2005) further noted that drowning in salt water caused by storm surges has been reduced, not drowning in fresh water. According to statistics reported by the National Oceanic and Atmospheric Administration (NOAA) Tropical Prediction Center, between 1970 and 1999, only 1 percent of deaths were caused by storm surge, while 59 percent of deaths were caused by fresh water (inland) flooding and 12 percent by wind (as cited in Wolshon, Urbina, et al. 2005, 130).

Between 1959 and Hurricane Katrina in 2005, no storms in Japan or the United States . . . resulted in more than 1,000 deaths.

Hurricanes Elena and Gloria, 1985

Hurricanes Elena and Gloria struck the Gulf of Mexico and the Atlantic coast in September 1985. Elena resulted in three storm-related deaths in Mississippi, two in motor vehicle accidents, and one due to electrocution. Visits to emergency rooms increased for approximately one week, but the frequency of total injuries roughly paralleled that of total visits. Gastroenteritis never emerged as a problem during the three-week period of observation (CDC 1986). Gloria resulted in five storm-related deaths in Rhode Island: one from a falling tree, one from a boating accident, two because of lack of electricity, and one because of cardiac arrest while the person cleared debris from a roof. The largest increase in hospital admissions was on the day of the hurricane, with the greatest number of emergency room visits

occurring the following day. Of 1,029 patients seen, 484 (47 percent) had sustained injuries. The most common diagnoses were laceration (22 percent), abrasions or contusions (20 percent), sprains (14 percent), and fractures (12 percent). More than half of the records reviewed contained insufficient information to determine whether they were storm related. Eighty-nine (9 percent) of the patients seen had problems clearly related to the storm; 73 had injuries including 26 (36 percent) with lacerations, 11 (15 percent) with fractures, and nine (10 percent) with chain saw injuries. Storm-related injuries were more likely to occur among males (71 vs. 60 percent) and among persons forty to forty-nine years of age (23 vs. 6 percent). Similar emergency room surveillance was conducted in a single Connecticut community of 51,430 residents. When comparing prehurricane to posthurricane periods, emergency room visits and visits for trauma increased, but the distribution of types of visits and the proportion of patients admitted to the hospital did not change. Rates were elevated for corneal abrasion (odds ratio = 3.9) and bee stings (odds ratio = 17.3) and were reduced for psychiatric categories (odds ratio = 0.23).

Hurricane Hugo, 1989

Hurricane Hugo struck Puerto Rico and the Atlantic coast of the United States in 1989. Nine persons died in Puerto Rico, two of whom refused to evacuate, subsequently drowning during the impact phase. Seven deaths were electrocutions, five of which were work related (CDC 1989a, 1989b, 1989c). It was unclear whether influenza-like outbreaks were increased in shelters (CDC 1990). In South Carolina, which was heavily hit by Hurricane Hugo, thirteen persons died during the impact phase, including six who drowned—five while attempting to bring boats inland and one when a storm surge hit a mobile home. Four persons were crushed by mobile homes, one person was crushed by the collapse of a house, and two were crushed by trees. Twenty-two postimpact deaths were recorded including nine in fires, four from electrocutions during cleanup activities, two from falling trees, and one in a chainsaw accident.

In inland North Carolina, 1,090 hurricane-related deaths and injuries were identified and studied. Three of 4 deaths were clearly related to Hurricane Hugo: 1 was caused by a falling tree, and 2 were attributed to drowning in creeks after motor vehicle accidents (Brewer, Morris, and Cole 1993). The number of patients seen in emergency departments was elevated by about 300 above baseline levels of 821 for three days during and following the hurricane, and 30 percent of all emergency department visits were hurricane related. Eighty-eight percent of hurricane-related cases were injuries, with wounds, insect stings, sprains, contusions, and fractures being typical, with wounds and stings accounting for approximately half of the cases. Of 329 wounds caused by cutting and piercing instruments, 135 (41 percent) were caused by chain saws.

Hurricane Andrew, 1992

Following Hurricane Andrew (1992), 462 hurricane-related events[1] were reported in Louisiana by twenty-one of forty-two emergency rooms, five of nine coroner's offices, and two public utilities. Most events occurred after the hurricane (N = 321), 15 occurred before landfall, and 70 occurred during the hurricane. Of the 17 fatalities, 8 occurred before the hurricane, including 6 by drowning, 1 in a motor vehicle accident, and 1 by being crushed during a prehurricane tornado. Of the 445 nonfatal events, 41 percent (N = 184) were cuts, lacerations, or puncture wounds; and 11 percent (N = 49) were strains and sprains, primarily to the upper and lower extremities. Sixty-two illnesses were reported, but no details were provided (CDC 1993a, 1993c).

In contrast to prior hurricanes, most deaths in Florida (Dade County) directly attributable to Hurricane Andrew resulted from blunt trauma or asphyxia, rather than drowning in either a storm surge or flooding (CDC 1992). Nine of the fourteen deaths during the impact phase were caused by blunt or penetrating trauma, four from asphyxia in collapsed buildings, and one from drowning. To control for malaria, dengue, and encephalitis, the density of nuisance mosquito populations was monitored in both Dade County, Florida, and Louisiana (CDC 1993b). Although increased numbers of mosquitoes were found in Louisiana, no increase in diseases associated with mosquito vectors was reported.

Hurricanes Marilyn and Opal, 1995

Hurricane Marilyn resulted in ten deaths in Puerto Rico and the Virgin Islands. The only preimpact death was caused by electrocution, and the death of a 107-year-old woman was attributed to natural causes. The remaining eight deaths occurred in boats, with seven persons drowning and one death by head trauma (CDC 1996a). Hurricane Opal (October 1995) resulted in a total of twenty-seven deaths in Florida (two), Alabama (twelve), Georgia (eleven), and North Carolina (two). One death occurred before the storm, thirteen during impact, and thirteen after impact. Seventy-eight percent (twenty-one of twenty-seven) of the decedents were males.

Of the twenty-seven deaths, twenty-four were considered unintentional while three were attributed to natural causes exacerbated by the hurricane. Thirteen deaths were related to falling trees with nine occurring during impact. Four deaths were attributed indirectly to power outages, including carbon monoxide poisoning (one) and house fires (three). One person drowned in a swollen creek, one was electrocuted while repairing a downed power line, and one suffered massive chest trauma when a tractor being used in cleanup overturned. Most of the 1,084 storm-associated injuries in the U.S. Virgin Islands involved minor wounds (e.g., abrasions, lacerations, puncture wounds) or trauma to the musculoskeletal system (e.g., fractures, sprains, strains, dislocations). In Florida, the only condition that

increased in prevalence during and after Hurricane Marilyn was the proportion of health care visits for insect bites (CDC 1996b).

Hurricane Georges, 1998

The contrast between the developed and developing world is clearly seen in reports of mortality and morbidity from Hurricane Georges (1998). In the Dominican Republic, approximately three hundred deaths were reported. Two months after the hurricane, a substantial number of households reported inadequate food, persisting medical needs, and lack of medications. In contrast, only eight deaths, all occurring after impact, were reported in Puerto Rico, with two deaths by carbon monoxide poisoning, four by fire, one by head trauma, and one by electrocution (CDC 1998, 1999).

Hurricane Floyd, 1999

Thirty-five (67 percent) of the fifty-two deaths attributed directly to Hurricane Floyd (1999) in North Carolina occurred on the day of the hurricane. The leading cause of death was drowning (thirty-six), with twenty-four occurring in a motor vehicle, seven in boats, four as a pedestrian, and one in a house. Most drowning occurred in flooded rivers, rather than in storm surges (Dow and Cutter 2000, 152). When emergency department (ED) visits in the following week were compared with the analogous period in 1998, increases were reported in suicide attempts (relative risk = 5.0; confidence interval, 1.4-17.1), dog bites (relative risk = 4.1; confidence interval, 2.0-8.1), febrile illnesses (relative risk = 1.5; confidence interval, 1.3-1.9), basic medical needs (relative risk = 1.4; confidence interval, 1.2-1.8) and dermatitis (relative risk = 1.4; confidence interval, 1.2-1.6). When ED visits during a one-week period one month after Hurricane Floyd were compared with ED visits during the same period in 1998, increases were reported in arthropod bites (relative risk = 2.2; confidence interval, 1.4-3.4), diarrhea (relative risk = 2.0; confidence interval, 1.4-2.8), violence (relative risk = 1.5; confidence interval, 1.1-2.2), and asthma (relative risk = 1.4; confidence interval, 1.2-1.7). Routine surveillance identified outbreaks in shelters of self-limiting gastrointestinal disease and respiratory diseases (CDC 2000).

Hurricane Isabel, 2003

Hurricane Isabel struck the Atlantic seaboard from North Carolina to New Jersey. Forty deaths have been officially attributed to the storm, but no detailed information about either the deaths or injuries has been reported.

2004 hurricane season

The 2004 hurricane season was highly destructive to the state of Florida. Four hurricanes hit Florida, with Hurricane Charley resulting in thirty-five deaths; Hur-

ricane Frances, forty; Hurricane Ivan, twenty-nine; and Hurricane Jeanne, nineteen (Dahlburg 2005). As of September 1, the CDC reported thirty-one deaths from Hurricane Charley (August 13, 2004), with twelve occurring on the first day of the storm, and eight during the next two days (CDC 2004b). Seventy-seven percent (twenty-four of thirty-one) were to males.

Of the thirty-one deaths, twenty-four (77 percent) were classified as unintentional injury, six were attributed to natural causes exacerbated by the hurricane, and one was a suicide. Of the twenty-four deaths attributed to unintentional injury, seventeen deaths, ten on the day of impact, were due to trauma caused by falling trees, flying debris, and destroyed physical structures. As in Hurricane Andrew, only one death was caused by drowning. Other causes of death, all after impact, were carbon monoxide poisoning (three), electrocution (one), and two with multiple causes of death (i.e., trauma and electrocution; carbon monoxide [CO] poisoning and burns).

Successful evacuation of vulnerable areas has the potential to reduce casualties, both fatal and nonfatal, that occur when a hurricane makes landfall.

The Florida Department of Health added thirty questions to the Behavioral Risk Factor Surveillance System (BRFSS) to assess the impact of the hurricanes on state residents (CDC 2005b). All sixty-seven counties in the state were sampled using random digit dialing. Participants included 919 (53.9 percent) persons who lived in the forty-one counties in the direct path of at least one of the four hurricanes, and 787 (46.1 percent) who lived in the twenty-six counties not in the direct path. Physical injuries were reported by 4.6 percent of the first group and 3.8 percent of the second group. Of persons with preexisting health conditions such as diabetes, asthma, or cardiovascular disease, 5.4 percent reported their conditions were made worse by the hurricanes. Of that group, 13.6 percent reported having difficulty getting needed medications, and 9.0 percent reported problems using essential medical equipment. At the time of the interview, 10.7 percent of all respondents reported feelings of nervousness, worry, or anxiety because of the hurricane; while 6.0 percent reported feeling sad or having loss of appetite or difficulty sleeping; and 3.9 percent reported reduced mental ability to work or study.

The most prevalent risk factor for indirect morbidity and mortality following the hurricanes was improper use of portable gas-powered generators. "A total of 167

persons had nonfatal CO poisoning diagnosed during the study period, representing a total of 51 exposure incidents. The number of cases and incidents peaked within three days after landfall of each hurricane" (CDC 2005a). Six persons died in five additional exposure incidents.

Evacuation before Hurricanes

Successful evacuation of vulnerable areas has the potential to reduce casualties, both fatal and nonfatal, that occur when a hurricane makes landfall. During the past decade, research on evacuation behavior and patterns of evacuation has increased substantially. Cutter and colleagues have conducted a series of studies of evacuation in South Carolina prior to tropical storms and Hurricanes Bertha (1996), Fran (1996), Bonnie (1998), Dennis (1999), Floyd (1999), and Irene (1999), with particular attention to the impact of prior repeated calls for evacuation on residents' decisions to evacuate in the future (Dow and Cutter 1998, 2000, 2002). Van Willigen et al. (2005) have examined evacuations in North Carolina before Hurricane Floyd (1999), and Whitehead and colleagues (2000) have examined how evacuation behavior in North Carolina before Hurricane Bonnie (1998) might influence future evacuation behavior. Wilmot and Mei (2004) have developed models of hurricane evacuation based on data collected after Hurricane Andrew (1992), and Prater, Lindell, and colleagues (Lindell, Lu, and Prater 2005; Zhang, Prater, and Lindell 2004) have examined evacuations during Hurricanes Bret (1999) and Lili (2002).

While evacuations have the potential to save lives and reduce injuries, they are costly in time, money, and credibility.

While evacuations have the potential to save lives and reduce injuries, they are costly in time, money, and credibility. Wolshon, Urbina, et al. (2005, 130) estimated that hurricane evacuations "can exceed one million dollars per mile of coastline [evacuated] from direct costs and losses in commerce, tourism, and general productivity." The timing and location of an evacuation order is critical if casualties are to be reduced. If an evacuation is ordered too early, however, the hurricane may change direction such that the evacuation order was either unnecessary or directed populations into areas that were more dangerous than the area that they evacuated. On the other hand, when evacuation orders are too late, dangerous areas may not

be completely cleared before the hurricane makes landfall (Urbina and Wolshon 2003). As Dow and Cutter (2000, 146) noted, "A discrepancy between timely and more accurate warnings has received considerable attention. The result is an evacuation policy that is, by design, precautionary, but raises concerns about credibility of the information and its source."

Prior to hurricanes Katrina and Rita, the largest evacuations occurred before Hurricanes Georges (1998) and Floyd (1999) (Wolshon, Hamilton, et al. 2005). These two evacuations resulted in traffic jams throughout the Carolinas, Florida, and Virginia, as 2 million people evacuated, some spending as many as twenty hours in transit. Exacerbating traffic flow was the tendency of South Carolina households to take two cars, to evacuate within a limited time window, and to evacuate only on major interstates. Because 56 percent of coastal South Carolina residents fled the state, with substantial numbers going to North Carolina, this exodus contributed to problems in North Carolina, where landfall and much of the heavy rainfall and flooding occurred (Dow and Cutter 2002).

Between one hundred and two hundred thousand residents of New Orleans were unable or unwilling to evacuate the area, and large portions of the city flooded after *the hurricane had passed through; these facts complicate efforts to assess when and how persons died.*

Despite the substantial problems associated with the Hurricane Floyd evacuation, South Carolina residents, who have experienced numerous voluntary and mandatory orders to evacuate, continue to support evacuation and consider life safety the primary goal of evacuation. At the same time, they want authorities to keep traffic flowing out of the area, and they expect to return home within one or two days, although they recognize that services may not be restored for an additional two or three days (Dow and Cutter 2000). This desire to return before services are fully restored could increase the probability that injuries and deaths will occur during cleanup, particularly if evacuated areas remain flooded.

Although Dow and Cutter (1998) found no associations between demographic characteristics (gender, race, and age) and decisions to evacuate, other researchers report that household size and the presence of children or older persons decreased the probability of evacuation before Hurricane Andrew (Gladwin and Peacock

1997). Van Willigen et al. (2005) reported that younger, low-income African Americans who were not married were more likely to evacuate in Pitt County, North Carolina, before Hurricane Floyd, but possibly the most salient factor was residents' perception that their homes were at risk of flooding. Past experience, perceived safety of residents' homes, anticipated severity of the hurricane, and the location of landfall increased evacuation in the Carolinas (Dow and Cutter 1998); and distance from the nearest body of water influenced evacuation in Hurricane Andrew (Wilmot and Mei 2004).

It appears that mandatory evacuation orders by officials are more effective than voluntary ones in increasing evacuation, but mandatory orders rarely result in bodily removal of persons from their homes by officials. Only 51 percent of Florida respondents reported having an evacuation plan before the 2004 hurricanes (CDC 2004a). Dow and Cutter (2000, 151) suggested that residents of areas like the Carolinas and Florida, where multiple hurricane evacuation orders have been issued over the past few years, pay less attention to what officials say than they did in the past and instead base their decision on what they hear from the media. The Weather Channel and local media are judged the most credible sources of this information. Decisions not to evacuate are influenced by not knowing where to go or how to get there, lack of transportation, the cost associated with evacuation, care for pets, perceived delays in returning home, and perceptions that homes are safe and that the impending hurricane is not sufficiently severe or threatening.

Hurricane Katrina

In June 2002, The New Orleans *Times-Picayune* suggested that efficient evacuation was the key to survival should a major hurricane hit New Orleans and that "for an evacuation of the New Orleans area to work, more than a million people have to travel at least 80 miles over an aging, low-capacity road system to reach high ground and shelter" (McQuaid and Schleifstein 2002). The authors noted that such an evacuation "requires a 72- to 84-hour window," which is substantially longer than the window within which forecasters can accurately predict a storm's track and strength. Such evacuations are highly dependent on private automobiles but, according to the 2000 Census, 27 percent of households in Orleans Parish, Louisiana, did not have an automobile. Wolshon, Urbina, et al. (2005, 136) estimated that 250,000 residents of New Orleans (not including tourists or "special needs" populations) have no means of private transportation and that the total number of buses available (464) could only evacuate 10 percent of those without cars. In fact, no buses were assigned to evacuate residents of New Orleans before Hurricane Katrina, and mandatory evacuation was ordered at 10:00 a.m. on August 28, only twenty hours before the hurricane made landfall at 6:10 a.m. on August 29, and twenty-five hours before the levees began to fail at 11:00 a.m.

Between one hundred and two hundred thousand residents of New Orleans were unable or unwilling to evacuate the area, and large portions of the city flooded *after* the hurricane had passed through; these facts complicate efforts to assess

when and how persons died. First, the extensive floods delayed the retrieval of bodies for weeks, which made it difficult to determine both time and cause of death. Second, preliminary information indicates that, in contrast to other recent hurricanes, substantial numbers of persons drowned. It may never be possible to ascertain whether they drowned in storm surges directly associated with the hurricane or in the subsequent flooding associated with the breaks in the levees.

Mortality

As of mid-December 2005, only the state of Louisiana had established an official Web site on deaths attributed to Hurricane Katrina that was updated as deceased were released to families (Louisiana Department of Health and Hospitals 2005). Combining that information with other, less dependable sources, 1,319 deaths had been attributed to Hurricane Katrina, with 1,070 (82 percent) from Louisiana; 228 (17.5 percent) from Mississippi; and a scattering of deaths in Alabama ($N = 2$), Florida ($N = 14$), Georgia ($N = 2$), Kentucky ($N = 1$), and Ohio ($N = 2$) (Wikipedia 2005). In addition, 57 evacuees were listed as official deaths, and more than 2,500 persons were listed as missing. In Mississippi, 40 percent (91/228) of deaths occurred to residents of Harrison County, 22.4 percent (51/228) in Hancock County, and 7.5 percent (17/228) in Pearl River County. No additional information was available about deaths of Mississippi residents at the time of this writing. Unlike Louisiana, it is somewhat more likely that the 228 deaths that occurred in Mississippi can be directly attributed to storm surge and wind at the time that the hurricane made landfall.

The Louisiana Department of Health and Hospitals continually updates the status of bodies examined at the St. Gabriel morgue. As of December 16, 2005, 902 of 1,095 recovered bodies had been examined. Of those examined, 97 percent (879/902) of deaths were determined to be storm related; the remaining 23 were listed as coroner's cases, suggesting that death occurred by violence or suspicious means. Of the 879 storm-related deaths, 512 had been identified and released to families, 169 were awaiting release to families, 1 had been identified and was awaiting autopsy, and the identities of 197 were unknown.

Of those that were storm related and who had been released to families, 74 percent (380/512) were residents of Orleans Parish where New Orleans is located; the remaining 132 persons were from Jefferson Parish ($n = 26$), St. Bernard Parish ($n = 94$), St. John Parish ($n = 1$), East Baton Rouge ($n = 1$), Washington Parish ($n = 1$), St. Tammany Parish ($n = 2$), Plaquemines Parish ($n = 2$), out-of-state ($n = 2$), and of unknown location ($n = 3$).

Commentators have speculated that vulnerable, poor African Americans were most at risk of death during and after Hurricane Katrina. By implication, this would suggest that women, African Americans, the elderly, and the young will be overrepresented among the dead. Gender, race, age, and parish of residence were reported for the 512 persons examined and identified at St. Gabriel Morgue, and released to families. When the 380 persons from Orleans Parish were compared to those from other parishes, 53.3 percent of Orleans residents were male as com-

pared to 43.2 percent from other areas ($p = .10$), and 63 percent were African American as compared to 13.6 percent from other areas ($p < .001$). When compared with census estimates for 2004, where 46.5 percent of Orleans residents were male and 67.9 percent were African American, males are overrepresented among the identified dead, and African Americans are somewhat underrepresented.

When age is examined, vulnerable elderly are substantially overrepresented among the deceased. Forty-seven percent (239/512) of the deceased were older than seventy-five, and an additional 26 percent (77/285) were between sixty and seventy-five. Among those identified and released to date, only seven were younger than twenty. Age distribution does not differ by parish.

Gender, race, and age also were available for the larger group of 705 bodies that had been examined and identified at St. Gabriel Morgue; this group includes the 512 bodies that had been released and the 170 bodies that had been identified but not yet released. Like the smaller group, males were disproportionately represented among the dead: 51 percent (359/705) were male, 48 percent (339/705) female, and 1 percent (7/705) were of unknown gender. This compares with a state population that is 51.6 percent female. Forty-eight percent (339/705) were African American, which compares with a state population that is 32.5 percent (1,451,944/4,468,976) and a New Orleans city population that is 67.9 percent (302,041/444,515) African American. The single most striking fact, however, is the age of decedents. Sixty-seven percent (475/705) of the dead identified to date at St. Gabriel Morgue were older than sixty, and 44 percent (309/705) were older than seventy-five. Although not reported, these numbers may include 68 persons whose bodies were recovered from four nursing homes in New Orleans and St. Bernard Parish.

According to the New Orleans *Times-Picayune*, deaths in Orleans Parish were caused by drowning and exacerbated medical conditions, while the deaths in St. Bernard Parish are being attributed to drowning in a storm surge that was estimated at more than twenty feet (Warner and Scott 2005).

Morbidity

Reports of physical injuries and disease episodes that occur after disasters, including hurricanes, are always less complete and less accurate than reports of deaths. In the case of Hurricane Katrina, this problem is exacerbated by the wide dispersal of evacuees, particularly those who left New Orleans. As we saw above, physical injuries are the most prevalent casualty after a hurricane, with most injuries occurring as a result of high winds and the collapse and movement of structures, trees, and other debris. Following hurricanes and other natural disasters, the media and others are quick to suggest that survivors are at increased risk of infectious diseases following hurricanes and floods, but in fact, detectable increases have rarely been documented, whether in the United States or elsewhere. To date, the CDC has issued reports on infectious diseases, dermatologic conditions,

norovirus outbreaks, vibrio illnesses, and CO poisoning cases attributable to Hurricane Katrina (CDC 2005a, 2005f, 2005d, 2005c, 2005e). A survey of Hurricane Katrina evacuees in Houston shelters has been reported (*Washington Post*, Kaiser Family Foundation, and Harvard University 2005), and assessments of the toxicity of the flood waters in New Orleans has been reported (Pardue et al. 2005).

Vibrio *illnesses*

While cholera is included in the *Vibrio* species, at least seven noncholeragenic *Vibrio* species have been reported as causing illness each year in the United States. Although these organisms are grouped with those that cause cholera, they cause distinctly different illnesses that are usually either food borne or wound associated. Food-borne illness results from eating raw or undercooked shellfish, particularly oysters or other contaminated foods; wound-associated infections result from exposure to seawater or brackish waters where the organism naturally occurs. The most frequently reported posthurricane vibrio illnesses were *V. vulnificus* and *V. parahaemolyticus* wound infections. Eighteen cases were reported in residents of Mississippi ($N = 7$) and Louisiana ($N = 5$); persons displaced from Louisiana to Texas ($N = 2$), Arkansas ($N = 2$), and Arizona ($N = 1$); and a person displaced from Mississippi to Florida ($N = 1$). Ages ranged from thirty-one to eighty-nine, and 83 percent (fifteen of eighteen) were male. Most patients were hospitalized and five died. In 72 percent (thirteen of eighteen), underlying health conditions including heart disease, diabetes, renal disease, alcoholism, liver disease, peptic ulcers, immunodeficiency, and malignancy may have contributed to the severity of the infection.

Four persons, including a two-month-old boy, were reported with non-wound-associated vibrio infection in Mississippi ($N = 2$), Louisiana ($N = 1$), and one person displaced from Louisiana to Arizona. None of these persons died.

On average, 412 cases of noncholeragenic vibrio illnesses were reported each year between 2000 and 2004 in the United States, with an average of 14 reported in Gulf Coast states and 7 being wound related. Clearly, the number of wound-associated cases reported in August and September of 2005 exceeds the average annual rate, and all can be traced to exposure to flood waters after Hurricane Katrina (CDC 2005e).

Infectious diseases and dermatologic conditions among evacuees

A partnership comprised of the *Washington Post*, Kaiser Family Foundation, and Harvard University School of Public Health (2005) conducted a survey of 680 adult evacuees residing in the Houston Reliant Park Complex (Reliant Astrodome and Reliant Center) ($N = 439$), the George R. Brown Convention Center ($N = 152$), five of fourteen Red Cross shelters ($N = 77$), and unrecorded locations ($N = 12$) between September 10 and 12, 2005. Ninety-eight percent of evacuees were from the greater New Orleans area. Sixty-one percent did not evacuate before the

storm, giving as their primary reason not having a car or way to leave (36 percent) or underestimating the severity of the storm and its aftermath (29 percent).

Thirty-three percent reported that they had experienced health problems or injuries as a result of the hurricane or flooding. No questions were asked about the health problems or injuries being experienced by evacuees, but the CDC later reported thirty cases of methicillin-resistant *Staphylococcus aureus* dermatologic infections among both child and adult evacuees in Dallas, Texas, and approximately one thousand cases of acute gastroenteritis among evacuees in Louisiana, Mississippi, Tennessee, and Texas during the first three weeks after the hurricane.

Between September 2 and 12, 2005, some 6,500 of the 24,000 evacuees at Reliant Park visited the medical clinic, with 1,169 (18 percent) having symptoms of acute gastroenteritis. Stool samples identified norovirus as the source of infection in 50 percent of cases. Noroviruses are the most common cause of outbreaks of acute gastroenteritis in the United States. Outbreaks are spread through person-to-person contact or from fomites[2] that form in crowded settings, such as cruise ships and shelters. Once an outbreak begins, norovirus is highly contagious, easily transmitted, and remarkably resistant to cleaning agents. No confirmed cases of *Shigella* dysentery, typhoid fever, or toxigenic cholera were identified (CDC 2005d, 2005c).

Surveillance of nonevacuees

CDC, the Louisiana Department of Health and Hospitals, and functioning treatment facilities established an active surveillance system "to detect outbreaks of disease and characterize post-hurricane injuries and illnesses" (CDC 1996a, 1018). Between September 9 and 25, the system had monitored 7,508 reports of health-related events of residents and workers in Jefferson, Orleans, Plaquemines, and St. Bernard Parishes. Retrospective data going back to August 27 were collected when possible. Fifty-five percent (4,169/7,508) of events were illnesses; 26.9 percent (2,018/7,508) were injuries; and 17.5 percent (1,321/7,508) involved medication refills, wound checks, and so forth. Thirty-four percent of events (2,567/7,508) occurred to residents, 13.8 percent (1,037/6,167) to relief workers, and status was unknown for 52 percent (3,904/7,508). The surveillance detected an apparent increase in acute respiratory illnesses over the period while, consistent with data reported after other hurricanes, 35.5 percent (716/2,018) of the injuries reported consisted of cuts, blunt trauma, burns, and environmental exposures; and 23 percent (464/2,018) of falls. Relief workers were significantly more likely than residents to be seen for rashes, such as prickly heat, arthropod bites, and the abrasive effects of wet clothing and moist skin (odds ratio = 1.7; confidence interval, 1.4-2.1).

Carbon monoxide poisoning

CO poisoning primarily occurs when people use portable generators in confined areas. Fifty-one cases of CO poisoning were reported between August 29 and

September 24 in Alabama, Louisiana, and Mississippi. Thirty-eight cases (74.5 percent) occurred within the first week after the hurricane. Five persons died; the forty-six survivors were treated either with hyperbaric oxygen ($N = 37$) or high-flow oxygen ($N = 9$) (CDC 2005a).

Toxicity of flood water

Considerable concern has been expressed about the potential toxicity of the flood waters in New Orleans. The only systematic study reported to date examined samples obtained on September 3 and 7 in the Lakeview district bounded by Lake Pontchartrain to the north and the 17th Street Canal to the west, where one of the levee breaks occurred, and from a comparison site some six to eight miles distant, the Tulane-Gravier neighborhood in the Mid-City district. Areas selected for sampling were determined by accessibility and safety issues (Pardue et al. 2005).

Surface waters were low on oxygen, and samples indicated that levels of lead, arsenic, and chromium exceeded drinking water standards. The floodwater was similar to normal stormwater runoff found both in this area and other areas. "What distinguishes Katrina floodwaters are their large volume and the human exposure to these pollutants that accompanied the flood rather than extremely elevated concentrations of toxic pollutants" (Pardue et al. 2005, 8595). The authors concluded by stating that "although some conclusions can be drawn about the quality of the floodwater based on this data set, more detailed human exposure, waste load allocation, and ecological risk assessment calculations for Lake Pontchartrain should be conducted prior to reaching ultimate conclusions regarding the environmental impacts of Hurricane Katrina" (Pardue et al. 2005, 8598).

Psychological Distress Attributable to Hurricanes

Explanatory models of disaster exposure and psychological distress primarily focus on four critical factors: characteristics of the stressor (disaster), cognitive processing of the traumatic event, individual characteristics, and qualities of the environment (such as social support systems) predisaster and postdisaster (Green et al. 1990). The extant models differ in their emphasis on the various factors, but all attempt to describe the interrelationships between the characteristics of the event and the resources of the individual. These include a conceptual model (La Greca et al. 1996), the conservation of resources theory (Freedy et al. 1992), the social support deterioration deterrence model (Norris and Kaniasty 1996), and an adaptation of stress theory (Folkman et al. 1986). Either in the context of these models or independently, many parameters have been studied as potential predictors of posthurricane distress. Two emerge as stable predictors of distress, severity of exposure and previous mental health problems, whereas most other factors show some inconsistency across studies (Caldera et al. 2001). In regard to outcome, post-traumatic stress disorder (PTSD) has been studied most commonly, using a variety of instruments that have been administered at varying

posthurricane intervals. Partly as a function of this variability, estimates of postdisaster PTSD range widely, but collectively, it is reasonable to conclude that hurricanes have a measurable impact on the mental health of children and adults, at least in the short run.

Although the relationship between exposure and distress is robust, intervening individual difference variables, such as coping self-efficacy and optimism, are important in determining degree of distress (Benight et al. 1999). Coping self-efficacy is conceptualized as the individual's perception of his or her ability to manage stressful or threatening environmental demands. Data collected from adults five months after Hurricane Hugo showed that resource loss directly affected level of distress (measured by the SCL-90 and the Impact of Events Scale) and also operated through coping self-efficacy. The extent to which optimism and available support were able to diminish the impact of resource loss depended on the individual's confidence in his or her coping abilities. This study and others emphasize the utility of considering both internal resources (such as optimism) and external resources (social support) in modeling the pathway between disaster exposure and psychological distress.

A number of studies have focused on children in affected communities. In general, increased exposure is associated with increased distress, although most children score in the normal range of distress, and their recovery tends to be relatively rapid. After Hurricane Andrew, the perception of life threat during the hurricane was a stronger determinant of the intrusion and avoidance subscales of the Impact of Events Scale (a measure of PTSD) than the actual number of traumas experienced (Jones et al. 2001), suggesting that children may be less sensitive to loss than adults. Regarding recovery, the proportion of elementary school children scoring in the severe to very severe range of PTSD on the Reaction Index was 30 percent at three months after Hurricane Andrew, 18 percent at seven months, and 13 percent at ten months postdisaster (La Greca et al. 1996). Among the factors that predicted a slow recovery (drop in PTSD score) were intervening, non-hurricane-related life events. Non-hurricane-related life events were as important as hurricane exposure variables in explaining psychological distress in other studies of children, as well (Hardin et al. 1994).

Studies that have collected data on children's postdisaster psychological distress from children's self-report and parents reporting on their children highlight where their perceptions diverge. After Hurricane Hugo, 90 percent of third- to fifth-grade students in high-impact areas scored in the range of severe psychic trauma on the Reaction Index (Belter, Dunn, and Jeney 1991). Parents' report showed a substantial but much smaller proportion of the children (69 percent) could be classified in the severe trauma category. Furthermore, children's trauma was not correlated with any of the objective indices of damage, whereas parents' report on their children's psychological state was correlated with each of the indices of damage, again underscoring that adults are more distressed than their children by tangible resource loss.

Investigations that have included outcomes in addition to PTSD demonstrate a high degree of comorbidity. For example, among Nicaraguan adolescents after

Hurricane Mitch, the comorbidity between PTSD (using the Structured Clinical Interview for *DSM* [SCID], based on *Diagnostic and Statistical Manual of Mental Disorders*, 3rd Revised Edition criteria) and major depression in the most severely affected city was 79 percent (Goenjian et al. 2001). Regressing depression on relevant predictor variables showed that PTSD accounted for 55 percent of the variance. A study of adults (David et al. 1996) yielded similar results (68 percent comorbidity between PTSD and major depression) and, in addition, showed that after adjusting for multiple statistical comparisons, severe damage was the only risk factor that was associated with all of the disorders.

The remainder of this section of the article will attempt to extrapolate to Hurricane Katrina what is known about disasters and mental health. Based on published reports from other disasters, we can offer several predictions about the psychological morbidity associated with Hurricane Katrina. These are discussed in light of the results of a survey conducted between September 10 and 12, 2005, among 680 randomly selected adult evacuees residing in Houston shelters. Interviews were conducted face-to-face, with an estimated 4 percentage point margin of error (*Washington Post*, Kaiser Family Foundation, and Harvard University 2005). The disaster literature shows that vulnerable persons are particularly prone to postdisaster stress, with vulnerability encompassing prior distress, social class, gender, and linguistic or social isolation. Disasters enhance socially structured inequalities already in place (Kaniasty and Norris 1995; Norris et al. 2002; Tierney 2000), particularly among community members who experience chronic adversity (Richmond 1993). Indeed, the most robust relationship in psychiatric epidemiological research is the negative association between socioeconomic status and psychological distress. The overwhelming majority of residents in the most severely affected counties/parishes (Orleans, St. Bernard, East Baton Rouge, and Jefferson Parishes in Louisiana; and Harrison and Hancock Counties in Mississippi) were poor. For example, the median household income in Orleans Parish before Katrina was $27,133, compared to $41,994 for the United States, and rates of poverty in 2000 were more than twice as high in Orleans Parish than in the United States as a whole (27.9 compared to 12.4 percent) (U.S. Census Bureau 2000). Of the evacuees surveyed in Houston (98 percent of whom had evacuated from the Greater New Orleans area), 59 percent reported that their total annual household income before taxes during the prior year was less than $20,000, and 32 percent said it was less than $10,000 (*Washington Post*, Kaiser Family Foundation, and Harvard University 2005). Thus, on this basis alone, one would expect high rates of psychological morbidity.

A second aspect relevant to Katrina is that disasters generate new, secondary stressors that serve as reminders of the trauma (Shaw, Applegate, and Schorr 1996) and further tax coping capacity. Such stressors include but are not limited to lack of food and shelter, relocation, crowding, financial strain, and coping with insurance companies and social services intended to be of assistance to survivors. In terms of financial strain alone, 72 percent of the evacuees surveyed in Houston reported having no insurance to cover their losses, and similar proportions of respondents had no bank accounts from which to withdraw money (68 percent) or any useable

credit or debit cards (72 percent) (*Washington Post*, Kaiser Family Foundation, and Harvard University 2005).

Paramount among the secondary stressors that emerge after a disaster is disruption of social networks. In disaster situations, demand for support can exceed a network's capacity to provide support (Kaniasty and Norris 1993; Norris et al. 2002). Instrumental, as opposed to emotional, support is especially important in the face of disaster stressors (Haines, Hurlbert, and Beggs 1999), yet potential support providers may not be in a position to provide instrumental support. After Hurricane Katrina, social networks were disrupted to the extent that individuals waited for days, and often weeks, without knowing the fate of their family members. Two weeks after the hurricane impact, 48 percent of the evacuees surveyed in shelters in Houston reported that they were still trying to find family or friends (*Washington Post*, Kaiser Family Foundation, and Harvard University 2005). Seventy-nine percent of the survey respondents also reported they had no relatives or friends that they could "move in with until you are back on your feet." Communication in all forms was severely impaired, and network members were unable to provide assistance, either because they could not reach the survivors or because they were overwhelmed with their own situation. This predicament is most likely exacerbated in New Orleans where an unusually high number of multigenerational family members reside.

Equally important to support from personal networks was the lack of timely assistance and response from governmental agencies. This has relevance from two perspectives: what is known about the impact of human-initiated disasters and the importance of a speedy return to normalcy. Human-initiated disasters tend to yield higher rates of mental impairment than natural disasters (Norris et al. 2002). Although Hurricane Katrina itself is classified as a natural disaster, human elements were potent, including inattention to preventive maintenance on the levees, poorly coordinated evacuation efforts, and an ineffective and seemingly uncaring postdisaster response. The majority of evacuees (79 percent) surveyed in Houston believed the government response to the hurricane and flooding was "too slow and there's no excuse," 68 percent believed that race and poverty affected the speed of rescue efforts, and 61 percent said their experience made them feel like the government does not care about people like themselves. Beyond the lack of prediction and control that is characteristic of all disasters, human elements in disasters shatter fundamental beliefs about vulnerability, mortality, and human nature, leaving survivors with a sense that their lives have spun out of control (Difede et al. 1979; Ursano, Fullerton, and Norwood 1995) and, in Katrina, that their lives are not valued.

In regard to achieving normalcy, the available literature on postdisaster mental health interventions converges to suggest that resources should be devoted to facilitating a quick return to predisaster conditions and routines in affected communities (Norris, Friedman, and Watson 2002; Sattler et al. 2002; Siegel, Shoaf, and Bourque 2000). This includes restoring utilities, reopening businesses, and reestablishing social services. In the immediate aftermath, survivors of disasters need concrete and timely information on how to find shelter and access other forms of

assistance (Joh 1997). In the longer term, to minimize the stress of relocation (Riad and Norris 1996), affected communities need to begin the process of rebuilding both the physical and social infrastructure. Survivors of Katrina are facing a seemingly open-ended time line in their community's return to normalcy. Accordingly, the negative psychological impact is likely to persist as well.

Overall, the data from the Katrina evacuee survey describe a population seemingly predisposed to a high level of psychological distress: a severe disaster exposure, a lack of economic and social resources, and an inadequate government response. Most likely, such distress will be described in future post-Katrina studies that sample from other settings and involve a postdisaster time interval more typical of published research. In the immediate aftermath, however, the evacuees that were housed in Houston were surprisingly resilient. When asked to describe their feelings about their future, a strong majority said they felt relieved (71 percent), grateful (82 percent), and hopeful (87 percent). Most felt that their religious faith had been strengthened by their experience (81 percent). Taken together, these responses most likely reflected their happiness at being alive and removed from any immediate peril. Still, a sizeable minority were depressed (50 percent), angry (39 percent), or frightened (35 percent) about their future. In future investigations of the mental health of Hurricane Katrina survivors, it will be important to document postdisaster experiences, including evacuation, to identify factors that exacerbate or diminish psychological distress following a major disaster.

Summary

The impact of hurricanes, cyclones, and typhoons on physical and mental health differs substantially between developed and developing countries. Within the United States and its territories, an area at high risk of hurricanes, mortality rates have declined over the past century, and the causes of mortality have shifted considerably. Few people drown in a storm surge; rather, they drown in flooded inland rivers and other bodies of water, or die from injuries caused by falling trees, collapsing structures, or other wind-tossed debris. In contrast, mortality in developing countries continues to be high, and a substantial proportion of deaths result from drowning in storm surges.

Deaths that occur during the impact phase could be prevented if officials issued timely evacuation orders and provided transportation for those unable to evacuate and if coastal residents heeded recommendations to evacuate. Preliminary information from Hurricane Katrina suggests that effective evacuation of New Orleans would have reduced postimpact deaths as well as those that occurred as the hurricane made landfall. If vulnerable elderly had been out of the area when the levees failed, death rates would have been substantially reduced.

Postimpact deaths and injuries primarily occur during cleanup activities and as a result of naïve attempts to replace nonfunctioning utilities. Both chain saws and portable generators consistently are reported to be a source of injury, illness, and death following hurricanes. Requirements that residents stay out of evacuated

areas until utilities are restored and preliminary cleanup has been completed probably would reduce some of these injuries and deaths, but evacuated residents are anxious to return home both to assess property damage and in an attempt to reestablish the normalcy of prehurricane routines.

Studies of psychological morbidity following hurricanes suggest that distress increases in both children and adults but diminishes with the passage of time. Severity of exposure and prehurricane mental health problems are the most consistent predictors of distress. The wide dispersion of Hurricane Katrina evacuees across the United States, which has disrupted social networks and prevented a return to normalcy, combined with the lack of timely assistance and response from governmental agencies, may exacerbate the mental health problems of victims. Hurricane Katrina was not just a natural disaster. It was also a human-initiated and technological disaster that, for some, may have no foreseeable end.

Notes

1. An event is defined as a reported clinical impression for illness or mechanism of injury for injuries, toxic exposures, or carbon monoxide poisonings.

2. A fomite is an inanimate object, like a used tissue or dish, that transmits an infectious agent from person to person.

References

Belter, R. W., S. E. Dunn, and P. Jeney. 1991. The psychological impact of Hurricane Hugo on children: A needs assessment. *Advances in Behaviour Research & Therapy* 13:155-61.

Benight, C. C., E. Swift, J. Sanger, A. Smith, and D. Zeppelin. 1999. Coping self-efficacy as a mediator of distress following a natural disaster. *Journal of Applied Social Psychology* 29 (12): 2443-64.

Brewer, R. D., P. D. Morris, and T. B. Cole. 1993. Hurricane-related emergency department visits in an inland area: An analysis of the public health impact of Hurricane Hugo in North Carolina. *Annals of Emergency Medicine* 23 (4): 731-36.

Caldera, T., L. Palma, U. Penayo, and G. Kullgren. 2001. Psychological impact of the hurricane Mitch in Nicaragua in a one-year perspective. *Social Psychiatry and Psychiatric Epidemiology* 36:108-14.

Centers for Disease Control and Prevention. 1986. Hurricanes and hospital emergency room visits—Mississippi, Rhode Island, Connecticut. *Morbidity and Mortality Weekly Report* 34:765-70.

———. 1989a. Deaths associated with Hurricane Hugo—Puerto Rico. *Morbidity and Mortality Weekly Report* 38 (39): 680-82.

———. 1989b. Medical examiner/coroner reports of deaths associated with Hurricane Hugo—South Carolina. *Morbidity and Mortality Weekly Report* 38 (44): 759-62.

———. 1989c. Update: Work-related electrocutions associated with Hurricane Hugo—Puerto Rico. *Morbidity and Mortality Weekly Report* 38 (42): 718-25.

———. 1990. Surveillance of shelters after Hurricane Hugo—Puerto Rico. *Morbidity and Mortality Weekly Report* 39:41-42, 47.

———. 1992. Preliminary report: Medical examiner reports of deaths associated with Hurricane Andrew—Florida, August 1992. *Morbidity and Mortality Weekly Report* 41 (35): 641-44.

———. 1993a. Comprehensive assessment of health needs 2 months after Hurricane Andrew—Dade County, Florida, 1992. *Morbidity and Mortality Weekly Report* 42:434-37.

———. 1993b. Emergency mosquito control associated with Hurricane Andrew—Florida and Louisiana, 1992. *Morbidity and Mortality Weekly Report* 42:240-42.

———. 1993c. Injuries and illnesses related to Hurricane Andrew—Louisiana, 1992. *Morbidity and Mortality Weekly Report* 42 (41): 242-43, 250-51.

———. 1996a. Deaths associated with Hurricanes Marilyn and Opal—United States, September-October 1995. *Morbidity and Mortality Weekly Report* 45 (2): 32-38.

———. 1996b. Surveillance for injuries and illnesses and rapid-health-needs assessment following Hurricanes Marilyn and Opal, September-October 1995. *Morbidity and Mortality Weekly Report* 45 (4): 81-85.

———. 1998. Deaths associated with Hurricane Georges—Puerto Rico, September, 1998. *Morbidity and Mortality Weekly Report* 47 (42): 897-98.

———. 1999. Needs assessment following Hurricane Georges—Dominican Republic, 1998. *Morbidity and Mortality Weekly Report* 48 (5): 93-95.

———. 2000. Morbidity and mortality associated with Hurricane Floyd—North Carolina, September-October 1999. *Morbidity and Mortality Weekly Report* 49 (17): 369-72.

———. 2004a. Carbon monoxide poisoning from hurricane-associated use of portable generators—Florida, 2004. *Morbidity and Mortality Weekly Report* 54 (36): 697-700.

———. 2004b. Preliminary medical examiner reports of mortality associated with Hurricane Charley—Florida, 2004. *Morbidity and Mortality Weekly Report* 53 (36): 835-42.

———. 2005a. Carbon monoxide poisoning after Hurricane Katrina—Alabama, Louisiana, and Mississippi, August-September 2005. *Morbidity and Mortality Weekly Report* 54:996-98.

———. 2005b. Epidemiologic assessment of the impact of four hurricanes—Florida, 2004. *Morbidity and Mortality Weekly Report* 54 (28): 693-97.

———. 2005c. Infectious disease and dermatologic conditions in evacuees and rescue workers after Hurricane Katrina—Multiple States, August-September, 2005. *Morbidity and Mortality Weekly Report* 54:1-4.

———. 2005d. Norovirus outbreak among evacuees from Hurricane Katrina—Houston, Texas, September 2005. *Morbidity and Mortality Weekly Report* 54:1016-18.

———. 2005e. Surveillance for illness and injury after Hurricane Katrina—New Orleans, Louisiana, September 8-25, 2005. *Morbidity and Mortality Weekly Report* 54:1018-21.

———. 2005f. *Vibrio* illnesses after Hurricane Katrina—Multiple stages, August-September 2005. *Morbidity and Mortality Weekly Report* 54:928-31.

Dahlburg, John-Thor. 2005. Towns in big storms' path still winded. *Los Angeles Times*, May 30, p. A16.

David, D., T. A. Mellman, L. M. Mendoza, R. Kulick-Bell, G. Ironson, and N. Schneiderman. 1996. Psychiatric morbidity following Hurricane Andrew. *Journal of Traumatic Stress* 9:607-12.

Difede, J., W. J. Apfeldorf, M. Cloitre, L. A. Spielman, and S. W. Perry. 1979. Acute psychiatric responses to the explosion at the World Trade Center: A case series. *Journal of Nervous and Mental Disease* 185:519-22.

Dow, K., and C. L. Cutter. 1998. Crying wolf: Repeat response to hurricane evacuation orders. *Coastal Management* 26:238-52.

———. 2000. Public orders and personal opinions: Household strategies for hurricane risk assessment. *Environmental Hazards* 2:143-55.

———. 2002. Emerging hurricane evacuation issues: Hurricane Floyd and South Carolina 2002. *Natural Hazards Review* 1:12-18.

Folkman, S., R. Lazarus, C. Dunkel-Schetter, A. DeLongis, and R. Green. 1986. The dynamic of a stressful disaster: Cognitive appraisal, coping, and encounter outcomes. *Journal of Personality and Social Psychology* 50:992-1003.

Freedy, J. R., D. L. Shaw, M. P. Jarrell, and C. R. Masters. 1992. Towards an understanding of the psychological impact of natural disasters: An application of the conservation of resources stress model. *Journal of Traumatic Stress* 5:441-54.

Gladwin, H., and W. G. Peacock. 1997. Warning and evacuation: A night for hard houses. In *Hurricane Andrew: Ethnicity, gender, and the sociology of disasters*, ed. W. G. Peacock, B. H. Morrow, and H. Gladwin. New York: Routledge.

Goenjian, A. K., L. Molina, A. M. Steinberg, L. A. Fairbanks, M. L. Alarez, H. A. Goenjian, and R. S. Pynoos. 2001. Posttraumatic stress and depressive reactions among Nicaraguan adolescents after Hurricane Mitch. *American Journal of Psychiatry* 158:788-94.

Green, B. L., J. D. Lindy, M. C. Grace, G. C. Oteser, A. C. Leonard, M. Korol, and M. A. Winget. 1990. Buffalo Creek survivors in the second decade: Stability of stress symptoms over 14 years. *American Journal of Orthopsychiatry* 60:43-54.

Haines, V. A., J. S. Hurlbert, and J. J. Beggs. 1999. The disaster framing of the stress process: A test of an expanded model. *International Journal of Mass Emergencies and Disasters* 17 (3): 367-97.

Hardin, Sally Brosz, Martin Weinrich, Sally Weinrich, Thomas L. Hardin, and Carol Garrison. 1994. Psychological distress of adolescents exposed to Hurricane Hugo. *Journal of Traumatic Stress* 7:427-40.

Joh, H. 1997. Disaster stress of the 1995 Kobe earthquake. *Psychologia* 40:192-200.

Jones, R. T., R. Frary, P. Cunningham, J. D. Weddle, and L. Kaiser. 2001. The psychological effects of Hurricane Andrew on ethnic minority and Caucasian children and adolescents: A case study. *Cultural Diversity and Ethnic Minority Psychology* 7:103-8.

Kaniasty, K., and F. H. Norris. 1993. A test of the social support deterioration model in the context of natural disaster. *Journal of Personality and Social Psychology* 64:395-408.

———. 1995. In search of altruistic community: Patterns of social support mobilization following Hurricane Hugo. *American Journal of Community Psychology* 23:447-77.

La Greca, A., W. Silverman, E. Vernberg, and M. Prinstein. 1996. Symptoms of post-traumatic stress in children after Hurricane Andrew: A prospective study. *Journal of Consulting and Clinical Psychology* 64:712-23.

Lindell, M. K., J. C. Lu, and C. S. Prater. 2005. Household decision making and evacuation in response to Hurricane Lili. *Natural Hazards Review* 6:180-90.

Louisiana Department of Health and Hospitals. 2005. *Vital statistics of all bodies at St. Gabriel morgue*. December 16. http://www.dhh.state.la.us/news.asp?Detail=769 (accessed November 23, 2005).

McQuaid, J., and M. Schleifstein. 2002. *Left behind: Washing away (Part 1)*. June 23-27. http://www.nola.com/printer/printer.ssf?/washingaway/harmsway_1.html (accessed November 1, 2005).

Nicholls, R. J. N., N. Mimura, and J. C. Topping. 1995. Climate change in south and south-east Asia: Some implications for coastal areas. *Journal of Global Environment Engineering* 1:137-54.

Norris, F. H., M. J. Friedman, and P. J. Watson. 2002. 60,000 disaster victims speak: Part II. Summary and implications of the disaster mental health literature. *Psychiatry* 65 (3): 240-60.

Norris, F. H., M. J. Friedman, P. J. Watson, C. M. Byrne, E. Diaz, and K. Kaniasty. 2002. 60,000 disaster victims speak: Part I. An empirical review of the empirical literature, 1981-2001. *Psychiatry* 65 (3): 207-39.

Norris, F., and K. Kaniasty. 1996. Received and perceived social support in times of stress: A test of the social support deterioration deterrence *Journal of Personality and Social Psychology* 71:498-511.

Pardue, J. H., W. M. Moe, D. McInnis, J. Thibodeaux, K. T. Valsaraj, E. Maciasz, I. Van Heerden, N. Korevec, and Q. Z. Yuan. 2005. Chemical and microbiological parameters in New Orleans floodwater following Hurricane Katrina. *Environmental Science and Technology* 39 (September): 8591-8599.

Rappaport, E. N., and J. J. Fernandez-Partagas. 1997. History of the deadliest Atlantic tropical cyclones since the discovery of the New World. In *Hurricanes, climate, and socioeconomic impacts*, ed. H. F. Diaz and R. S. Pulwarry. New York: Springer-Verlag.

Riad, J. K., and F. H. Norris. 1996. The influence of relocation on the environmental, social, and psychological stress experienced by disaster victims. *Environment and Behavior* 28:163-82.

Richmond, N. 1993. After the flood. *American Journal of Public Health* 83:1522-24.

Sattler, D. N., A. J. Preston, C. F. Kaiser, V. E. Olivera, J. Valdez, and S. Schlueter. 2002. A cross-national study examining the preparedness, resource loss, and psychological distress in the U.S. Virgin Islands, Puerto Rico, Dominican Republic, and the United States. *Journal of Traumatic Stress* 15:339-50.

Shaw, J. A., B. Applegate, and C. Schorr. 1996. Twenty-one-month follow-up study of school-age children exposed to Hurricane Andrew. *Child and Adolescent Psychiatry* 35:359-64.

Shultz, J. M., J. Russell, and Z. Espinel. 2005. Epidemiology of tropical cyclones: The dynamics of disaster, disease and development. *Epidemiologic Reviews* 27:21-35.

Siegel, J. M., K. I. Shoaf, and L. B. Bourque. 2000. The C-Mississippi scale for PTSD in postearthquake communities. *International Journal of Mass Emergencies and Disasters* 18:339-46.

Tierney, K. J. 2000. Controversy and consensus in disaster mental health research. *Prehospital and Disaster Medicine* 15:181-87.

United Nations Development Programme (UNDP). 2004. *Reducing disaster risk: A challenge for development*. New York: John S. Swift Company.

U.S. Census Bureau. 2000. *The United States Census 2000*. http://www.census.gov/po/www/foia/foiaweb.htm (accessed November 1, 2005).

Urbina, E., and B. Wolshon. 2003. National review of hurricane evacuation plans and policies: A comparison and contrast of state practices. *Transportation Practices Part A* 37:257-75.

Ursano, R. J., C. S. Fullerton, and A. E. Norwood. 1995. Psychiatric dimensions of disaster: Patient care, community consultation, and preventive medicine. *Harvard Review of Psychiatry* 3:196-209.

Van Willigen, M., B. Edwards, S. Lormand, and K. Wilson. 2005. Comparative assessment of impacts and recovery from Hurricane Floyd among student and community households. *Natural Hazards Review* 6:180-90.

Warner, C., and R. T. Scott. 2005. Where they died: When it came to choosing its victims, Hurricane Katrina spared few neighborhoods. In fact, gentility and the lakefront may have suffered as many deaths as the lower 9th. Document no. 10D6ECF050C624C8. *The Times-Picayune*, October 23. http://www.nola.com/printer/printer.ssf?/base/news-4/1130050973 (accessed November 1, 2005).

Washington Post, Kaiser Family Foundation, and Harvard University. 2005. *Survey of Hurricane Katrina evacuees*. September. No. 7401. http://www.kff.org/newsmedia/upload/7401.pdf (accessed November 1, 2005).

Whitehead, J. C., B. Edwards, M. Van Willigen, J. R. Maiolo, K. Wilson, and K. T. Smith. 2000. Heading for higher ground: Factors affecting real and hypothetical hurricane evacuation behavior. *Global Environmental Change Part B: Environmental Hazards* 2:133-42.

Wikipedia Foundation. 2005. *Hurricane Katrina*. http://en.wikipedia.org/wiki/Hurricane_Katrina (accessed November 12, 2005).

Wilmot, C. G., and B. Mei. 2004. Comparison of alternative trip generation models for hurricane evacuation. *Natural Hazards Review* 5:170-78.

Wolshon, B., E. U. Hamilton, M. Levitan, and C. Wilmot. 2005. Review of policies and practices for hurricane evacuation, II: Traffic operations, management, and control. *Natural Hazards Review* 6:143-61.

Wolshon, B., E. Urbina, C. Wilmot, and M. Levitan. 2005. Review of policies and practices for hurricane evacuation, I: Transportation planning, preparedness, and responses. *Natural Hazards Review* 6:129-42.

Zhang, Y., C. S. Prater, and M. K. Lindell. 2004. Risk area accuracy and evacuation from Hurricane Bret. *Natural Hazards Review* 5:115-20.