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# Prevalence and Consequences of Disaster-Related Illness and Injury From Hurricane Ike

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***Objective:*** To explore the extent to which disasters may be a source of injury and disability in community populations, we examined the prevalence and short-term consequences of disaster-related illness and injury for distress, disability, and perceived needs for care. ***Design:*** A random population survey was conducted 2–6 months after Hurricane Ike struck Galveston Bay on September 13, 2008. ***Participants:*** The sample was composed of 658 adults representative of Galveston and Chambers Counties, Texas. ***Results:*** The prevalences of personal injury (4%) and household illness (16%) indicated that approximately 7,700 adults in the two-county area were injured, and another 31,500 adults experienced household-level illness. Risk for injury/illness increased with area damage and decreased with evacuation. In bivariate tests, injury or illness or both were related to all outcome measures. In multivariate analyses that controlled for co-occurring stressors representing trauma, loss, adversities, and community effects, injury or illness or both were associated with global stress, posttraumatic stress, dysfunction, days of disability, and perceived needs for care, but not with depression or anxiety. ***Conclusions:*** The associations of injury with distress and disability suggest that community programs should reach out to injured persons for early mental health and functional assessments and, where indicated, intervene in ways that reduce further disability and need for complex rehabilitative services. The results also point to the potential effectiveness of evacuation incentives with regard to the prevention of disaster-related injury and disability.

*Keywords:* disaster, injury, posttraumatic stress disorder, Hurricane Ike

Disability research and disaster research intersect in two primary ways. First, research can identify the special needs and vulnerabilities of persons with disabilities with regard to preparing for, responding to, or recovering from the effects of disasters. Second, research can show the extent to which disasters are a source of injury and disability in community populations. It is the latter intersection that we address here, with a particular focus on the psychological consequences of illness and injury.

McFarlane and Norris (2006) defined disasters as potentially traumatic events that have acute onset and are collectively experienced. By classifying disasters as potentially traumatic, they highlighted the potential of these events to engender situations where people are confronted with threats to life or bodily integrity and are likely to experience intense fear, horror, or helplessness (American Psychiatric Association, 1994). Major earthquakes, hurricanes, bombings, and many other agents of disaster cause sudden and sometimes unimaginable levels of destruction, creating high potential for physical injury and other sources of traumatic stress.

Past research suggests that physical injury during a disaster increases risk for subsequent psychological distress. For example, Briere and Elliott (2000) studied a general population sample of 935 persons, of whom 22% reported exposure to disaster an average of 13 years previously. Disaster exposure was associated with higher scores on six of ten symptom measures. The type of disaster was far less important than the characteristics of exposure, especially whether the participant recalled fear of death or physical injury. In a study of 831 adults interviewed 12, 18, and 24 months after Hurricane Hugo, Thompson, Norris, and Hanacek (1993) documented persistent effects of injury on a variety of domains of mental health (depression, anxiety, somatic complaints, general stress, traumatic stress). Maes, Mylle, Delmeire, and Altamura (2000) studied 128 victims of a ballroom fire and 55 victims of a mass traffic accident 7 to 9 months after these disasters in Belgium. Injury was prevalent in this sample, of which 46% developed posttraumatic stress disorder (PTSD), 13% major depression, and 18% any anxiety disorder other than PTSD. In the subgroup exposed to the fire, the severity of burns (burn stage) was strongly related to depression and anxiety disorders. Six months after the bombing of the Murrah Federal Building in Oklahoma City, North

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and colleagues (1999) studied 182 adults from a health department registry of persons documented to have experienced bombing-related injuries. Most participants (77%) had required medical intervention, including hospitalization (20%) and surgery (15%). One-third (34%) of the sample met criteria for PTSD, and 45% had some postdisaster disorder. Participants with postdisaster PTSD reported an average of six injuries, compared with an average of three injuries among others. Number of injuries was also associated with development of disorders other than PTSD.

Although these findings strongly suggest a link between disaster-related injury and postdisaster distress, such conclusions are not as clear-cut as they may at first seem. Injury has to be understood as one type of stressor that occurs along with many others in the context of disaster. We know relatively little about the unique contributions of disaster-related injuries, independent of these co-occurring stressors. In their review of the disaster literature, Norris and Wind (2009) organized the array of potential disaster experiences into four categories of (1) traumatic stressors, (2) loss, (3) ongoing adversities, and (4) community effects. These are not truly discrete categories but reflect the multitude of factors affecting psychosocial outcomes of adults and youth in the aftermath of disaster.

Thus to determine the psychological and disabling impact of injuries, researchers need to control for a variety of other aspects of exposure. In addition to injury, traumatic stressors (the first category) include bereavement (the death of a loved one in the event), threat to life (feeling that one's life was in danger during the incident), and witnessing (exposure to the grotesque and aversive sights). Although mortality is uncommon in U.S. disasters, threat to life can be highly prevalent even in events that do not cause extensive loss of life. For example, in the study of Hurricane Hugo referenced earlier (Thompson et al., 1993), life threat was reported by 46% of respondents in the two stricken cities (Charleston, South Carolina, and Charlotte, North Carolina) although few people on the U.S. mainland lost their lives in this storm. Perceptions of life threat were even more prevalent (73%) in a subsequent study of several neighborhoods damaged by Hurricane Andrew (Norris, Perilla, Riad, Kaniasty, & Lavizzo, 1999). In both of these studies, perceptions of life threat were related to PTSD and depressive symptoms over time. In Galea et al.'s (2002) study of the September 11th terrorist attacks, participants who directly witnessed the events had a higher prevalence of PTSD and depression (10.4% and 10.8%, respectively) than nonwitnesses (5.5% and 9.2%). Witnessing, however, was not predictive of either condition in multivariate analyses that controlled for panic (a peri-event emotional response similar to fear) and loss.

The second category, loss, may be the prototypical stressor associated with natural disasters, such as floods, hurricanes, and earthquakes. Resource loss has correlated highly with symptom severity in several disaster studies that have spanned disaster type, location, and phase of recovery (e.g., Arata, Picou, Johnson, & McNally, 2000; Freedy, Shaw, Jarrell, & Masters, 1992; Hobfoll, Tracy, & Galea, 2006). The relative influences of property loss and trauma have varied in past research. McFarlane (1989) studied a sample of firefighters 4, 11, and 29 months after the 1983 bushfires in Australia. The sample was highly exposed to traumatic aspects of the event, with 20% reporting near-panic, 27% injured, and 7% knowing someone who died. In addition, 23% experienced property damage from the fire itself. In multivariate analyses, property damage was a significant predictor of distress at Month 4 but not at Month 11. Panic, however, showed both initial and more lasting effects on distress. Thompson and colleagues (1993) found that both financial losses and personal losses were significantly correlated with depression, anxiety, somatic complaints, general stress, and traumatic stress 1 year after Hurricane Hugo, but most of these effects dissipated over the next few months, whereas those of life threat and injury did not. On the other hand, losing a job was the only factor that predicted PTSD at 6 months among persons who met criteria for probable PTSD 1 month after the September 11th terrorist attacks on the World Trade Center (Galea et al., 2003). Property damage in combination with injury formed the strongest set of predictors of psychopathology at 3-month follow-up in a study of 357 persons seeking emergency assistance after the 2003 fire storm in California (Marshall, Schell, Elliott, Rayburn, & Jaycox, 2007).

In the aftermath of many natural disasters, the acutely stressful experiences of trauma and loss are soon followed by a host of other challenges associated with poor housing conditions, rebuilding, and other stressors in the postdisaster environment. Such ongoing adversities (the third category of stressors) typically show strong relationships to distress (e.g., Burnett et al., 1997; Galea, Tracy, Norris, & Coffey, 2008; Norris et al., 1999). Displacement may be especially problematic (e.g., Najarian, Goenjian, Pelcovitz, Mandel, & Najarian, 2001; Quarantelli, 1985). After Hurricane Katrina, Larrance, Anastario, and Lawry (2007) surveyed 366 residents of FEMA group and commercial trailer parks to assess needs approximately 8 to 9 months after the hurricane struck the Gulf Coast. Participants had been displaced an average of 246 days. During the 2 months before the survey, over half of all households had one or more members with a chronic or acute illness. Fifty percent met criteria for major depressive disorder, 20% had suicidal ideation, and 14% had increased substance use since displacement.

Disaster exposure entails more than personal injury, loss, and adversity because disasters impact whole communities, creating the potential for community-wide economic, environmental, governmental, social, and cultural disruptions (the fourth category) that can influence mental health. For example, in a study of floods across multiple counties in Kentucky, "community destruction" (an objective, county-level measure of homes damaged) explained significant variance in psychological well-being (Phifer & Norris, 1989), physical health (Phifer, Kaniasty, & Norris, 1988), and social functioning (Kaniasty & Norris, 1993) over and above that explained by personal loss.

The present study explores the prevalence and short-term consequences of disaster-related illness and injury for distress, disability, and perceived needs for care relative to other elements of exposure—specifically the severity of fear (representing the traumatic stress category), number of types of property damage and disaster-related unemployment (representing loss), length of displacement (representing ongoing adversity), and severity of area damage/disruption (representing community effects). The disaster was Hurricane Ike, a strong Category 2 storm (maximum winds were 1 mph below Category 3 status), which struck Galveston, Texas on September 13, 2008. The Galveston Bay area had more than 200,000 people heavily affected by the hurricane and over $12 billion in personal and infrastructure damage; 12 fatalities occurred and 34 people were still missing after 5 months (FEMA, 2008). In November 2008, we launched the Galveston Bay Re-

covery Study (GBRS). The GBRS began with a longitudinal epidemiologic survey of Bay Area households (defined according to predisaster residence), the long-term purpose of which is to study the components, trajectories, and determinants of postdisaster wellness. The target population was persons 18 years and older living in Galveston and Chambers counties (the most severely damaged counties) on the date when Hurricane Ike hit Galveston Bay and who had been living in the area for at least one month prior to the event.

## Method

### Participants and Procedures

A disproportionate stratified cluster sampling was employed in order to acquire samples in areas that experienced more damage from the hurricane and to sample groups that were more likely to be more heavily exposed to hurricane-related traumas. In order to determine appropriate sampling ratios, we initially identified five different strata in the Galveston Bay area using FEMA maps of flooding after Hurricane Ike. The poverty rates for the different areas were also determined using Census 2000 data. Stratum 1 included areas in Galveston Island and the Bolivar Peninsula which experienced storm surge damage, stratum 2 consisted of flooded areas in the mainland, stratum 3 was composed of nonflooded areas of the mainland but with relatively high poverty rates, stratum 4 included nonflooded and relatively low poverty areas east of Route 146, and stratum 5 was composed of nonflooded and relatively low poverty areas west of Route 146 and the rest of Chambers county. Route 146 was deemed a convenient division between mainland areas of Galveston Bay; the east side was more likely to have been affected by storm surge and high winds.

Clusters were created by aggregating different census blocks. Eighty clusters (area segments) were then randomly selected within the five strata; each stratum having a number of segments proportional to its number of occupied households. A random sub-sample of households was obtained from the selected segments of every stratum. The sampling ratio was set at 4:4:2:2:1 for strata 1 to 5, respectively—obtaining relatively more subsamples from strata assumed to have suffered more damage.

In total, 1285 household units were located and contacted, out of which 935 units were screened. A complete list of household members of each sampled household was obtained and the respondent was randomly chosen from all eligible members; 861 individuals were found to be eligible for the study. The cooperation rate was 74%, yielding an overall sample size of 658. The sample distribution per stratum is as follows: stratum 1 = 239, stratum 2 = 68, stratum 3 = 123, stratum 4 = 33, and stratum 5 = 195.

Interviews were performed using a computer-assisted interview system, of which 88% were conducted via telephone and 12% were conducted in person. All interviews took place between November 7, 2008 and March 24, 2009 and lasted an average of 70 minutes. The location of respondents within the sampling area is shown in Figure 1.

The data were weighted to correct for oversampling and response biases. In the weighted data, 50.6% of the participants were women; 13.5% were African American, 13.8% were Latino, and 6.6% were foreign-born. About one fifth (19.3%) of the sample had less than a high school education, 66.5% completed high school or some college; and 14.1% were college graduates. Most participants (54.5%) were married or living as though, and 33.4%

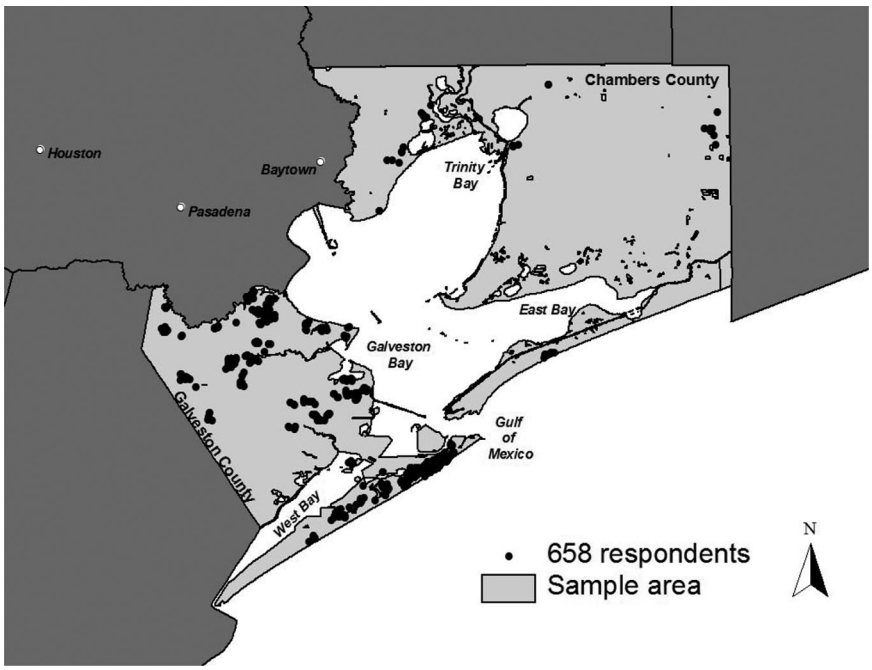


*Figure 1.* Sampling area and distribution of respondents in Galveston and Chambers Counties, Texas.

were parents of children under 18. The mean age of the sample was 47.5 (*SD* = 17.6). Approximately half of the sample (50.6%) had previously experienced a disaster, and many participants (40.4%) had experienced a serious injury at some point in their lives prior to Hurricane Ike.

## Measures

**Exposure.** Participants were asked a series of questions about their experiences during and after Hurricane Ike. Many of the questions described household-level experiences rather than personal experiences. The categorical variable, illness/injury, reflects the combination of two questions (a) "Have you or anyone else in your household had any health problems that you think developed as a result of the hurricane?" and (b) "Were you physically injured in any way as a result of Hurricane Ike? Note that we are asking about injuries that may have happened during the hurricane or after the hurricane, but that were caused by Hurricane Ike." Respondents with neither experience formed one category, those with household illness but no personal injury formed the second category, and those with personal injuries (with or without household illness) formed the third category.

To represent the traumatic stress category of disaster exposure, we measured the individual's immediate emotional response to the hurricane (fear severity) by using the four-item "STRS" scale (Bracha et al., 2004). This was introduced as follows, "Now I would like you to try to remember how you felt and what you experienced at the time of Hurricane Ike and in the first few hours afterward . . . tell me how much you experienced each of the following . . . . (1) shortness of breath; (2) trembling, shaking, or buckling knees; (3) heart pounding or racing, and (4) sweaty palms or other sweating." The measure was scored as a sum of the four questions, each of which was answered on a 5-point scale from *not at all* to *an extreme amount*. The alpha in the GBRS sample was .86.

Losses were measured in two ways, property loss and job loss. Property loss was assessed with a series of questions pertaining to losses or damages to the respondent's (1) house or apartment, including damage to the roof, windows, or other parts of the residence, (2) furniture, appliances, other household contents, (3) sentimental possessions, such as photographs, (4) cars or trucks, (5) pets, and (6) any other property. The measure used here was scored as a count of affirmative responses, collapsed into five categories (0, 1, 2, 3, 4+). Participants were also asked if they were laid off from their jobs as a direct result of Hurricane Ike and, if so, for how long. Parallel questions elicited similar information about job losses of persons on whose income they depend. Respondents who reported a lay-off of one month or longer for either themselves or these other persons received scores of 1 (others = 0).

Displacement, representing ongoing adversities, was measured with the question, "How many days did you remain out of your home, because you evacuated or because your home was damaged during Hurricane Ike?" Because of the non-normal distribution, responses were grouped into quintiles: 0 days, 1–4 days, 5–10 days, 11–27 days, and 28 days or longer. Finally, community damages were assessed with a six-item measure regarding the level of damages and disruption to (1) area schools, churches, or hospitals, (2) streets and highways, and (3) places for recreation. The measure was the sum of the six questions, each of which was answered on a 4-point scale from 1 = *none* to 4 = *a lot*.

**Outcome measures: Stress, distress, and disability.** Global stress was assessed on a 10-point scale with the question, "Overall, considering both big ways and little ways that you were touched by Hurricane Ike, how stressful would you say your life has been since the hurricane? Please answer this question on a scale of 1 to 10, where 1 means that you have experienced no stress and 10 means that you have been extremely stressed."

Three scales were used to capture symptoms of distress. Posttraumatic stress disorder (PTSD) symptoms were assessed using the PTSD Checklist (PCL-C; Blanchard, Jones-Alexander, Buckley, & Forneris, 1996; Weathers, Litz, Herman, Huska, & Keane, 1993), a 17-item ($\alpha$ = .92 in this sample) self-report measure of *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)* symptoms of PTSD (American Psychiatric Association, 1994), as well as additional questions about timing, duration, severity of illness, and disability resulting from PTSD symptoms. All questions were specifically anchored to Hurricane Ike. A diagnosis of "probable PTSD" required 1 intrusion symptom, 3 avoidance/numbing symptoms, and 2 arousal symptoms in combination with distress or dysfunction and duration of at least one month.

Depression was measured with the Patient Health Questionnaire (PHQ-9), which is also based on *DSM-IV* criteria. Each of the nine questions is scored as 0 (*not at all*) to 3 (*nearly every day*), with summed scores ranging from 0 to 27 (Kroenke et al., 2002). The alpha in this sample was .96. Generalized anxiety disorder (GAD) symptoms were assessed with the GAD-7 (Spitzer, Kroenke, Williams, & Lowe, 2006). Each item was scored from 0 (*not at all*) to 3 (*nearly every day*) to describe how often the respondent experienced each of the 7 problems in the past month; summed scores ranged from 0 to 21 ($\alpha$ = .93).

Two measures were included to provide more general measures of dysfunction and disability. The first was composed of six functioning questions ($\alpha$ = .92) drawn from the Sprint-E (Norris et al., 2006) that asked about the extent to which the respondent's reactions to the hurricane had caused role impairment, interference with social activities, interference with health behaviors (e.g., eating poorly, smoking more, not getting enough rest), or difficulties handling other stressors in their lives, and if they were bothered by their reactions and needed help to deal with them. The scale was scored as the sum of the six questions, each measured on a 5-point scale from *not at all* to *very much.* Disability, in days, was assessed with three items used routinely in the Behavioral Risk Factor Surveillance System and the National Health and Nutrition Examination Survey (Benson & Marano, 1998). These questions ask how many days in the past month the participant experienced problems with physical health, mental health, and activity limitations. The summary measure was a mean of the three responses. Although the alpha ($\alpha$ = .69) was not high, it was reasonable for a three-item measure. Item-to-total correlations were .78, .72, and .86 for physical health, mental health, and activity limitations, respectively.

**Needs.** The Perceived Need for Care Questionnaire (PNCQ; Meadows et al., 2000a) was originally designed for use in the Australian National Survey of Mental Health and Well-Being. Meadows et al. (2000b) presented extensive evidence of the reliability and validity of the measure. The PNCQ provides an assessment across different categories of need, including information, medication, psychological intervention, and social intervention. We modified the questions slightly to fit the disaster context, e.g.,

for information, we asked, "In the past two months, did you ever feel a need for information about common stress reactions or about services available to help with them?"

## Data Analysis

The study questions required a combination of descriptive analyses, multiple regression analyses for continuous outcome measures, ordinal regression analyses for count data, and logistic regression analyses for dichotomous outcome measures. All analyses were conducted with Version 11 of STATA (StataCorp, 2009), statistical software designed for use with complex samples that yields unbiased standard errors of the estimates.

Before conducting the primary regression analyses, we conducted preliminary regression analyses to select a set of demographic and background measures that should be controlled for. Gender (female = 1; male = 0), race (African American = 1, White = 0), ethnicity (Latino = 1; nonHispanic = 0), birthplace (foreign-born = 1; U.S.-born = 0), education (scored in 4 levels from < high school = 1 to college graduate = 4), marital status (currently married or co-habitating = 1; other = 0), parental status (parent = 1, not = 0), past injury (= 1, others = 0), and past disaster (= 1, others = 0) showed effects on one or more dependent variables at $p < .10$ and thus were included in the primary analyses.

The primary regression analyses also included the set of exposure measures: fear severity (continuous), number of types of property loss (0–4), job lay off (=1, others = 0), displacement (5 levels), and community damage (continuous). The effects of injury/illness were tested with two dummy variables, personal injury (= 1, others = 0) and household illness (= 1, others = 0), with neither experience serving as the reference category. The total effect of injury/illness is captured by the effects of the two dummy variables combined.

# Results

## Prevalence of Injury/Illness, Other Stressors, and Distress

We interviewed 37 individuals who reported personal injury and 109 who reported a household illness but not a personal injury (these are unweighted *n*s). In the weighted data (Table 1), approximately one fifth of the sample (19.4%) experienced either personal injury (3.8%) or household illness (15.6%) because of the hurricane. Medical care was required by 10.8% of all households, but only 1.8% required hospitalization.

Although the focus of this paper is on the consequences of illness and injury rather than their causes, the distribution of these stressors within the sample is informative for interpreting the data on injury prevalence. Logically, the prevalence of personal injury was greater in areas with higher damage (above median) than in areas with lower damage (5.7% vs. 2.1%), $\chi^2(1, N = 658) = 5.84$, $p < .05$, and the same was true for household illness (23.8% vs. 9.5%), $\chi^2(1, N = 658) = 24.88$, $p < .001$.

Most of the GBRS sample (weighted $n = 451$; 68.5%) had evacuated their homes before the storm. The frequency of evacu-

Table 1
*Disaster Experiences and Distress Levels*

| | Weighted *n* | % | *M* | *SD* |
|---|---|---|---|---|
| Ike-related illness and injury (categories) | | | | |
| Neither | 531 | 80.6 | | |
| Household illness (but no personal injury) | 103 | 15.6 | | |
| Personal injury | 25 | 3.8 | | |
| Fear response severity (range = 4–20) | | | 5.8 | 3.0 |
| # Types property loss (range = 0–4) | | | 1.7 | 1.3 |
| Damage to residence | 534 | 81.2 | | |
| Damage to furnishings | 270 | 41.1 | | |
| Damage to things with sentimental values | 145 | 22.0 | | |
| Damage to cars/vehicles | 159 | 24.2 | | |
| Harm to pets | 39 | 6.0 | | |
| Job lay-off self or other > 1 month | 75 | 11.4 | | |
| Self > 1 month | 47 | 7.1 | | |
| Other > 1 month | 46 | 7.0 | | |
| Days displaced (range = 0–190) | | | 16.0 | 30.4 |
| 1 (0 days) | 163 | 24.8 | | |
| 2 (1–4 days) | 128 | 19.5 | | |
| 3 (5–10 days) | 147 | 22.4 | | |
| 4 (11–27 days) | 129 | 19.6 | | |
| 5 (28 days +) | 91 | 13.8 | | |
| Community damage (range = 3–24) | | | 14.1 | 5.2 |
| Schools, churches, hospitals "a lot" | 292 | 44.9 | | |
| Streets "a lot" | 170 | 25.8 | | |
| Recreational settings "a lot" | 271 | 41.8 | | |
| Global stress (range = 1–10) | | | 5.3 | 2.8 |
| Posttraumatic stress (range = 17–85) | | | 26.1 | 12.0 |
| Depressive symptoms, past month (range = 0–27) | | | 1.9 | 4.0 |
| Anxiety symptoms, past month (range = 0–21) | | | 1.4 | 3.2 |
| Dysfunction (range = 6–30) | | | 9.0 | 4.7 |
| Days disability, past month (range 0–30) | | | 3.9 | 6.1 |

ation was somewhat higher from areas that were more heavily damaged (77.1% vs. 62.2%), $\chi^2(1, N = 658) = 17.08$, $p < .001$. Within the subset of the sample at greater risk for injury because of higher damage to their areas, evacuation was associated with decreased risk of personal injury (4.2% injury if evacuated, 10.9% if not), and to a lesser extent with decreased risk of household illness (22.2% illness if evacuated, 29.7% if not), $\chi^2(2, N = 280) = 5.98$, $p < .05$. Injuries were rare given the combination of evacuation and lower area damage (2.1%).

Table 1 also shows the prevalence of other disaster stressors. On the autonomic indicators of acute fear ("STRS"), frequencies were 11.8% (*somewhat*, *very much*, and *extremely*) for "shortness of breath," 13.1% for "trembling or shaking," 14.8% for "racing heart," and 11.6% for "sweaty palms or sweating." On average, participants experienced two types of property loss. Most (84%) experienced at least one type of property loss, and 11% had experienced disaster-related unemployment for one month or longer. Most of the sample was briefly displaced from their homes, but a minority (14%) was displaced four weeks or longer. Sizable percentages reported that the hurricane had damaged the schools, churches, hospitals, streets, and recreational settings in their areas "a lot."

Table 1 also provides descriptive statistics for the outcome measures. Participants perceived a considerable amount of stress in their lives (mean of 5 on a 10-point scale), with 11% claiming "extreme stress." Although levels of posttraumatic stress were moderate, levels of depression and anxiety were relatively low, with 26%, 69%, and 77% of participants, respectively, reporting no current posttraumatic stress, depression, or anxiety. At least moderate levels of dysfunction (item scores of 3–5) were reported by 8.1% for ability to carry out daily role activities, 12.4% for being able to handle other stressors in their lives, 16.9% for ability to take care of health, and 16.4% for ability to carry out social activities. A similar percentage of participants (13.3%) were highly bothered by their reactions to the hurricane. On average, participants reported 4 days of disability in the past month; 21% reported that their physical health was not good for 7 or more days, and 18% reported that their mental health was not good for 7 or more days.

## Consequences of Injury/Illness for Distress and Disability

To determine the total effect of injury/illness on the continuous outcome measures, personal injury and household illness were entered into the regressions as dummy variables with neither injury nor illness serving as the reference category. In these regressions, multiple correlations were .37, $p < .001$, for global stress; .37, $p < .001$, for posttraumatic stress; .32, $p < .001$, for depression; .27, $p < .001$, for anxiety; .37, $p < .001$, for dysfunction; and .26, $p < .001$, for disability. Thus, when considered alone, the categorical variables of injury/illness was strongly associated with postdisaster distress and disability.

Table 2 shows the bivariate correlations between the specific disaster stressors and the continuous outcomes in the first column for each dependent variable. Personal injury was significantly associated with higher scores on all outcome measures except depression and anxiety. With effect sizes ranging from $r = .15$ (disability) to $r = .21$ (dysfunction), however, most of these associations were relatively modest in magnitude. Household illness was significantly but modestly associated with higher scores on all outcome measures, with effects ranging from .20 (disability) to .32 (depression).

Personal injury and household illness were either unrelated or only modestly related to other aspects of disaster exposure. Injury correlated most highly with property loss, $r = .25$, $p < .001$, and household illness correlated most highly with fear, $r = .29$, $p < .001$. The highest bivariate correlation between any two exposure measures was .49, $p < .001$, between displacement length and property loss.

Table 2 also presents the results of the multiple regression analyses. When the effects of demographic and background variables and other stressors were controlled, personal injury showed significant associations with global stress, posttraumatic stress, dysfunction, and disability, but not with depression or anxiety. Household illness showed significant associations with global stress, but not with posttraumatic stress, depression, anxiety, dysfunction, or disability.

The stressor that most consistently showed strong associations with outcomes was the severity of the person's immediate emotional response, a subjective measure which captured acute fear in physiological terms. Loss (either property or job loss) had significant effects on global stress, posttraumatic stress, and dysfunction. Displacement and community-level damage were both related to global stress, posttraumatic stress, and dysfunction; community damage was, in addition, related to anxiety.

Analysis of dichotomous outcomes was conducted only for Ike-specific PTSD, which had a prevalence of 7.4%. Frequencies meeting all criteria for PTSD were 25.0% among persons with personal injuries, 14.6% among persons reporting household illnesses but no personal injuries, and 5.3% among persons with neither experience. Because of the limited number of PTSD cases available for analysis (unweighted $n = 68$; weighted $n = 49$), the logistic regression analysis was conducted with only subsets of control variables (either demographic/background variables or other exposure variables) in the equation. In the analysis limited to the categorical variable injury/illness, injury and illness were each associated with probable PTSD: odds ratios [ORs] (confidence intervals, CIs) were 6.3 (1.2–31.8) for personal injury, $p < .05$, and 3.1 (1.1–8.5), $p < .05$, for household illness, Wald $\chi^2(2, N = 658) = 8.09$, $p < .05$. The effects remained significant when demographic and background variables were controlled: for personal injury, OR = 8.5 (CI = 1.6–46.5), $p < .05$; for household illness, OR = 3.6 (CI = 1.3–9.9), $p < .05$. However, no effects of injury and illness were detected when other exposure measures were controlled. In contrast, acute fear showed a strong influence on PTSD, OR = 1.6 (CI = 1.3−1.8), $p < .001$, in the multivariate analysis. Job loss, OR = 12.0 (CI = 3.8−37.7), $p < .001$, and community damage, OR = 1.2 (CI = 1.1−1.4), $p < .05$, also increased the likelihood of PTSD.

## Consequences of Injury/Illness for Perceived Needs for Care

The final analyses examined the influence of illness and injury on perceived needs for care. In the total sample, the percentages

Table 2
*Associations Between Exposure Variables and Distress Measures: Correlations and Betas*

| | Global stress | | | | Posttraumatic stress | | | | Depression | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *r* | B | (*SE* B) | β | *r* | B | (*SE* B) | β | *r* | B | (*SE* B) | β |
| Female sex | .13*** | 0.64 | (0.18) | .11*** | .09* | 1.02 | (0.62) | .04 | .03 | −0.23 | (0.47) | −.03 |
| Age | −.07 | 0.02 | (0.00) | .11** | −.04 | 0.06 | (0.02) | .08** | .02 | 0.02 | (0.01) | .11* |
| African American | .16*** | 0.18 | (0.28) | .02 | .21*** | 4.88 | (0.97) | .14*** | .25*** | 1.86 | (0.81) | .16* |
| Latino | .07 | 0.50 | (0.30) | .06 | .13*** | 2.72 | (1.04) | .08** | −.06 | −0.27 | (0.62) | −.02 |
| Foreign born | .05 | 0.16 | (0.39) | .01 | .16*** | 8.03 | (1.39) | .17*** | −.03 | 0.55 | (0.72) | .03 |
| Education | −.13*** | −0.28 | (0.09) | −.10*** | −.07 | −0.09 | (0.31) | −.01 | −.08* | −0.18 | (0.25) | −.05 |
| Married | −.12** | −0.56 | (0.19) | −.10** | −.08* | −1.40 | (0.68) | −.06* | −.11** | −0.90 | (0.41) | −.11* |
| Parent | .13** | 0.87 | (0.22) | .15*** | .00 | −1.31 | (0.77) | −.05 | .07 | 0.96 | (0.46) | .12* |
| Past injury | −.04 | 0.08 | (0.19) | .01 | −.03 | 0.53 | (0.65) | .02 | .01 | 0.16 | (0.45) | .02 |
| Past disaster | −.05 | 0.09 | (0.18) | .02 | −.13*** | −1.00 | (0.65) | −.04 | .08* | 0.94 | (0.43) | .12* |
| Personal injury | .18*** | 1.50 | (0.47) | .10** | .18*** | 7.08 | (1.67) | .11*** | .02 | −0.63 | (0.79) | −.03 |
| Household illness | .31*** | 0.93 | (0.26) | .12*** | .30*** | 1.65 | (0.91) | .05 | .32*** | 1.21 | (0.87) | .11 |
| Fear severity | .33*** | 0.18 | (0.03) | .19*** | .60*** | 2.13 | (0.11) | .53*** | .44*** | 0.51 | (0.13) | .39*** |
| # types property loss | .48*** | 0.48 | (0.09) | .22*** | .41*** | 0.71 | (0.31) | .07* | .26*** | 0.07 | (0.21) | .02 |
| Job lay-off > 1 month | .28*** | 1.28 | (0.28) | .14*** | .31*** | 6.82 | (0.99) | .18*** | .14** | 1.24 | (0.76) | .10 |
| Displacement (5 levels) | .33*** | 0.21 | (0.07) | .10** | .28*** | 0.69 | (0.26) | .08** | .18*** | 0.22 | (0.20) | .08 |
| Community damage | .43*** | 0.11 | (0.02) | .20*** | .42*** | 0.44 | (0.07) | .19*** | .25*** | 0.06 | (0.04) | .08 |
| $R^2$ | | | | .43*** | | | | .61*** | | | | .34*** |
| *F* (17, 634–636) | | | | 29.51*** | | | | 60.38*** | | | | 4.82*** |

| | Anxiety | | | | Dysfunction | | | | Disability | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *r* | B | (*SE* B) | β | *r* | B | (*SE* B) | β | *r* | B | (*SE* B) | β |
| Female sex | .02 | −0.39 | (0.37) | −.06 | .02 | −0.35 | (0.27) | −.04 | .04 | 0.18 | (0.45) | .01 |
| Age | .04 | 0.03 | (0.01) | .18** | −.06 | 0.02 | (0.01) | .08* | .11** | 0.06 | (0.02) | .16*** |
| African American | .28*** | 1.81 | (0.68) | .20** | .22** | 1.46 | (0.43) | .11*** | .04 | −0.12 | (1.04) | −.01 |
| Latino | −.05 | 0.16 | (0.34) | .02 | .00 | −0.17 | (0.46) | −.01 | −.06 | −0.66 | (0.76) | −.04 |
| Foreign born | −.06 | −0.06 | (0.33) | −.00 | .03 | 1.24 | (0.61) | .07* | −.08* | −0.98 | (1.01) | −.04 |
| Education | −.09* | −0.03 | (0.15) | −.01 | −.03 | 0.04 | (0.14) | .01 | −.02 | −0.09 | (0.23) | −.01 |
| Married | −.17*** | −1.23 | (0.34) | −.19*** | −.13*** | −1.29 | (0.30) | −.14*** | −.08* | −1.77 | (0.49) | −.14*** |
| Parent | .06 | 0.88 | (0.37) | .13* | .05 | 0.51 | (0.34) | .05 | −.04 | 0.34 | (0.56) | .03 |
| Past injury | .00 | −0.08 | (0.37) | −.01 | .02 | 0.27 | (0.29) | .03 | .04 | −0.04 | (0.48) | −.00 |
| Past disaster | .04 | 0.46 | (0.36) | .07 | −.08 | −0.29 | (0.29) | −.03 | .03 | 0.21 | (0.47) | .02 |
| Personal injury | −.02 | −0.92 | (0.76) | −.06 | .21*** | 3.41 | (0.74) | .14*** | .15*** | 4.41 | (1.21) | .14*** |
| Household illness | .27*** | 0.75 | (0.64) | .09 | .28*** | 0.38 | (0.40) | .03 | .20*** | 1.09 | (0.66) | .06 |
| Fear severity | .38*** | 0.39 | (0.07) | .36*** | .53*** | 0.73 | (0.05) | .47*** | .37*** | 0.73 | (0.08) | .36*** |
| # types property loss | .17*** | −0.03 | (0.17) | −.01 | .44*** | 0.47 | (0.14) | .13*** | .22*** | 0.40 | (0.23) | .08 |
| Job lay-off > 1 month | .07 | 0.47 | (0.49) | .05 | .25*** | 1.97 | (0.44) | .14*** | .08* | 1.07 | (0.72) | .06 |
| Displacement (5 levels) | .13*** | 0.01 | (0.14) | .00 | .30*** | 0.39 | (0.12) | .12*** | .13*** | 0.30 | (0.19) | .07 |
| Community damage | .22*** | 0.09 | (0.03) | .15** | .40*** | 0.13 | (0.03) | .14*** | .12** | −0.04 | (0.05) | −.04 |
| $R^2$ | | | | .30*** | | | | .49*** | | | | .20*** |
| *F* (17, 632–637) | | | | 4.41*** | | | | 38.54*** | | | | 10.81*** |

* $p < .05$. ** $p < .01$. *** $p < .001$.

acknowledging needs ranged from 9.1% for help discussing causes of their distress that may stem from the past to 25.7% for help sorting out housing, employment or money problems. Table 3 shows the frequency of perceived needs for groups differing in the presence/absence of household illness or personal injury. Prevalences varied significantly between illness/injury groups with regard to need for information; medication for nerves; help changing thoughts, feelings, or behaviors; help talking through problems or reactions; and help with tangible problems. In an ordinal regression analysis, which controlled for demographics and other exposure measures, personal injury was significantly associated with the number of perceived needs for psychological help (count of needs 1–5), OR = 2.8 (CI = 1.1–7.4), $p < .05$, but household illness showed only a trend, OR = 2.3 (CI = 0.9–6.1), $p < .10$. However, in a logistic regression predicting perceived need for help with tangible problems, only household illness had a significant effect, OR = 3.1 (CI = 1.2–7.9), $p < .05$, whereas personal injury did not.

## Discussion

Statistics derive meaning from interpretation, and findings of 4% prevalence of personal injury and 16% prevalence of household illness related to Hurricane Ike are good examples of this. On the one hand, these prevalences translate into sizable numbers of affected persons in the populations of Galveston and Chambers Counties, Texas, where the hurricane caused the greatest damage. On the basis of an estimated predisaster population size of slightly less than 202,000 adults, approximately 7,700 adults (95% CI = 2,900–12,400) were personally injured and 31,500 adults (95% CI = 21,000–42,400) experienced a household-level illness. A substantial number of households required medical care (11% or

Table 3
*Percent With Service Needs in Past Two Months by Disaster-Related Illness (Household) or Injury (Personal)*

| Need | Neither illness nor injury ($n$ = 531) % | Household illness ($n$ = 103) % | Personal injury ($n$ = 25) % | Total sample ($N$ = 658) % | Wald $\chi^2$ (2, $N$ = 658) |
|---|---|---|---|---|---|
| Information about common stress reactions or services to help with them | 6.1 | 25.7 | 30.6 | 10.0 | 11.28** |
| Medicine from a doctor to help you feel better with problems with emotions or nerves | 5.8 | 29.1 | 10.4 | 9.4 | 11.07** |
| To discuss causes of your distress that may stem from your past | 6.8 | 22.4 | 6.1 | 9.1 | 4.11 |
| To change your thoughts, feelings, or behaviors | 12.7 | 36.0 | 23.9 | 16.6 | 7.45* |
| To talk through your problems or reactions | 18.0 | 51.1 | 26.0 | 23.2 | 11.96** |
| To get help to sort out housing, employment, or money problems | 19.2 | 58.6 | 36.3 | 25.7 | 18.23*** |

* $p < .05$. ** $p < .01$. *** $p < .001$.

approximately 22,000), but fewer (1.8% or 3,600) required hospitalization, suggesting that most of the illnesses and injuries were minor to moderate in severity.

On the other hand, the rates of illness and injury were less than they might have been without the concerted effort of public safety officials to evacuate Galveston Island and the Bolivar Peninsula. Emergency management in the United States typically emphasizes protection of persons over protection of property when disasters are imminent. Our data suggest that approximately 70% of adults in the Bay Area left their homes before the storm and that this high frequency of evacuation reduced risk of disaster-related injury, especially among respondents in the areas of greatest damage. The psychology of evacuation has been identified previously as a crucial area for policy-relevant research (Riad, Waugh, & Norris, 2001). Our findings further support the significance and potential effectiveness of evacuation incentives with regard to the prevention of disaster-related injury and disability.

Perhaps because injuries were relatively infrequent and less serious than they might have been in Galveston Bay, their consequences for distress, disability, and perceived needs were also relatively modest. In the bivariate analyses, injury/illness showed correlations with most outcome measures, but these effects were diminished in the multivariate analyses that controlled for losses, adversities, community effects and, especially, trauma in the form of acute fear. These findings support the basic tenet of this paper that it is necessary to evaluate the impact of one type of disaster stressor in the context of the others with which it co-occurs.

More than any of the other measures, including injury, the STRS measure of fear showed particularly strong associations with PTSD, depression and anxiety symptoms, disaster-related dysfunction and disability, and perceived needs for care. These findings suggest that in the absence of fear or panic, minor to moderate injuries may not be particularly traumatic or likely to lead to mental disorders, such as PTSD. However, even with other aspects of exposure controlled, personal injury was independently associated with increased stress, distress, dysfunction, and days of disability in the population; this finding further bolsters the importance of preventing injuries to the extent possible.

The findings in this study can be used to inform the mental health and health care community about the secondary prevention needs of individuals following a disaster. As was shown, those with personal injuries and household illnesses related to a disaster have an increased risk for problems with mental health and disability. Many of those with injuries or household illness perceived themselves as having immediate needs for psychological services (e.g., 24% and 36%, respectively, perceived needs for help changing their thoughts, feelings, or behaviors) and especially for social services (36% and 59%, respectively, perceived needs for help sorting out housing, employment, or money problems). Thus, this population can be targeted for early mental health and functional assessments and intervention strategies to reduce further disability and need for complex rehabilitative services (Lollar, 2008). Follow-up support services that address mental health and functional problems could be part of the treatment plan for those people treated for disaster-related injuries or illnesses.

In closing, some strengths and shortcomings of the study should be noted. The GBRS employed an unusually rigorous sampling strategy in which households were selected on the basis of predisaster location. Even by disaster research standards, the fieldwork was challenging because of the devastation in parts of Galveston Island and the Bolivar Peninsula. Nearly three quarters of the selected households had to be tracked to new addresses. Although our sample is larger than most, the unanticipated displacement and increased cost of the fieldwork had repercussions for overall sample size and accordingly for inclusion of rare populations, such as persons with serious injuries. However, we can be more confident in the representativeness of the sample—and thus the validity of prevalence estimates—than can most prior disaster studies. Another strength of our approach was a comprehensive hour-plus interview that included sound measures of PTSD, depression, and anxiety, as well as other conditions not included in this particular analysis. However, the epidemiologic nature of the study required measures suitable for use by lay interviewers. Therefore, it is safer to refer to the outcome variables as "probable PTSD" and so forth, than as clinically verified diagnoses. Another limitation is that we had no specific information on the nature of the disaster-related injuries and illnesses, beyond noting the frequencies with which medical care and hospitalization were required. In addition, we had only limited data on predisaster disability, with the exception of information on whether a serious injury had been experienced before Hurricane Ike. Because of our unusual National Institute for Mental Health-funded program project, which enabled us to have

administrative infrastructure and Institutional Review Board approvals in place before the disaster, we were able to enter the field quite quickly in the aftermath of Hurricane Ike. Thus the study should capture well the shorter-term (first few months) consequences of disaster-related illness and injury, with little threat of retrospective recall bias. The present analysis focused solely on results from the initial wave of data collection; the third wave of data collection was recently completed, which will afford the opportunity to study the components, trajectories, and determinants of resilience and wellness over time.

Finally, the events to which our study applies should be considered. Our results should be relevant to the types of disasters most commonly experienced in the United States, which are primarily caused by water and wind. Hurricanes and floods cause substantial destruction of property and ecosystems but relatively little loss of life, in part because they often can be anticipated a few days in advance. Our results cannot necessarily be applied to certain natural disasters, such as earthquakes, nor to human-caused disasters, such as bombings, which strike with no warning and have tremendous potential for physical injuries. More than perhaps most other fields, disaster research depends upon the entire body of knowledge that accumulates across events, settings, and populations studied. Nonetheless, our findings do suggest that even for other types of disasters, studies need to recognize the multi-faceted and complex nature of disaster exposure and effects.

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