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The course of posttraumatic stress symptoms and functional impairment following a disaster: what is the lasting influence of acute vs. ongoing traumatic events and stressors?

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Abstract

Purpose—Ongoing traumatic events and stressors, rather than acute sources of trauma, may shape long-term post-disaster mental health. The purpose of this study was to compare the influence of acute hurricane-related exposures and ongoing post-hurricane exposures on the short- and long-term course of posttraumatic stress symptoms (PTSS) and functional impairment (FI).

Methods—A random sample of adults (n=658) in Galveston and Chambers Counties, Texas, was selected 2–6 months after Hurricane Ike and interviewed 3 times over eighteen months. Hurricane-related exposures included traumatic events such as death of a family member due to the hurricane and stressors such as loss/damage to personal property due to the hurricane. Post-hurricane exposures included traumatic events such as sexual assault and stressors such as divorce or serious financial problems.

Results—Experiencing an acute hurricane-related traumatic event or stressor was associated with initial post-hurricane PTSS [RR=1.92(95% CI=1.13–3.26) and RR=1.62(1.36–1.94), respectively] and FI [RR=1.76; (1.05–2.97) and RR=1.74(1.46–2.08)], respectively, and acute hurricane-related stressors were associated with a higher rate of increase in FI over time [RR=1.09; (1.01–1.19)]. In contrast, ongoing post-hurricane daily stressors were not associated within initial PTSS and FI, but were associated with PTSS and FI at the second and third interviews.

Conclusions—While immediate postdisaster interventions may influence short-term mental health, investment in the prevention of ongoing stressors may be instrumental to manage long-term mental health status.

Keywords

Posttraumatic stress disorder; Disasters; Functional impairment; Traumatic events; Daily stressors

Conflict of interest: The authors declare that they have no conflict of interest.

Natural disasters are a major worldwide problem associated with increased population prevalence of mental disorders. More than 800,000 deaths resulted from disasters in the past decade [27]. In 2010, disasters cost $109 billion worldwide; that estimate more than doubled for 2011 due to the Japanese earthquake and tsunami [33, 54]. The relationship between exposure to natural disasters and posttraumatic stress disorder (PTSD) is particularly well established [23, 42]. PTSD is likely the most common mental disorder following a disaster [23]: its prevalence following disasters ranges between 30–40% among direct victims to 5–10% in the general population [42].

A persistent puzzle however, is that the prevalence of post-disaster mental health problems varies widely across populations, and such variation is not explained by the severity of the disaster itself [22, 24, 39, 46]. Some work has suggested that while acute disaster-related events shape mental health immediately following the disaster [42, 45], ongoing post-disaster traumatic events, such as robbery, mugging or unwanted sexual contact, and stressors, such as job loss or persistent displacement, are what accounts for long-term differences in mental health [22, 24, 38, 39, 55]. Few studies have used a longitudinal approach to examine the timing at which acute disaster-related and ongoing post-disaster traumatic events and stressors shape mental health.

In this study, we compared the relative contribution that acute and ongoing hurricane-related and post-hurricane traumatic events and stressors made to the longitudinal course of two key dimensions of post-disaster mental health: symptoms of posttraumatic stress disorder (PTSS) and functional impairment. The diagnosis of PTSD requires that the person experience significant distress or impairment. However, little attention has been paid to identifying factors that influence functional impairment after a natural disaster. Most studies focus on symptoms of psychopathology but persons experiencing these symptoms as well as those treating them are most interested in how the symptoms impact daily life [34, 35, 36, 52, 57]. Investigating whether natural disasters shape the trajectories of PTSS and functional impairment through comparable or distinct pathways can help us identify targets for intervention that effectively reduce the lasting disabling consequences of disasters.

METHODS

The disaster

We focused on a sample representative of the population of Galveston and Chambers counties in Texas and affected by Hurricane Ike in September 2008 to varying degrees. Hurricane Ike was the third costliest hurricane ever to hit the United States, after Hurricane Katrina in 2005 and Hurricane Andrew in 1992. Nearly 200 deaths have been attributed to Hurricane Ike, with more than half of these deaths in the U.S. Galveston Bay, where the hurricane made landfall, was the hardest hit area, although the hurricane caused damage across a large swath of the U.S. southern coastline, from Louisiana to Texas.

The sample

As part of the three-wave Galveston Bay Recovery Study (GBRS), a population-based epidemiologic study of mental health in the aftermath of Hurricane Ike, we recruited adults (aged 18 or older) who lived in Galveston and Chambers counties in southeastern Texas at least one month prior to the hurricane, which hit the area on September 13, 2008. We divided the counties into five strata based on level of hurricane damage and likelihood of greatest distress among residents: (1) Galveston Island and Bolivar Peninsula, which suffered significant damage from the storm surge; (2) flooded areas of the mainland; (3) non-flooded areas of the mainland with high poverty rates, defined as 15% or more households living at or below the poverty level, according to data from the 2000 U.S.

Census [17]; (4) non-flooded, non-poverty areas of the mainland east of Route 146, which were affected by the storm surge and severe winds; and (5) non-flooded, non-poverty areas of the mainland west of Route 146 and the rest of Chambers County. From the five strata, we selected 80 areas made up of multiple census blocks and then selected 2,263 households from all households in these areas. Respondents were randomly selected from all eligible members of participating households.

Respondents completed baseline interviews in November 7, 2008 - March 24, 2009, approximately 2–5 months after Hurricane Ike, reflecting a cooperation rate of 83% and a response rate of 41% [2]. Respondents were re-interviewed twice: 529 of the 658 (80%) baseline respondents participated in the second study wave approximately 3–7 months after the baseline interview (February 6-June 29, 2009); a third interview was conducted approximately 7–12 months later (November 19, 2009-April 13, 2010) among 487 of the 658 baseline participants (74% overall, 85% of those who participated in both the baseline and Wave 2 surveys). Participants who were interviewed in Wave 1 but not in Wave 2 could rejoin the study in Wave 3; Wave 3 thus included 39 respondents who participated in the baseline survey but not in the Wave 2 survey.

A computer-assisted interview system was used to conduct interviews; 88% of the baseline interviews were conducted over the telephone and 12% in person. Some of the affected households could not be reached by telephone, since recruitment began two months after the hurricane, so in-person locating efforts were undertaken in Galveston. In the course of those efforts, when sampled households were identified and agreed to participate, some interviews were conducted at that time, in person. For the other households, all contact was via telephone.

After the study was described, oral informed consent was obtained from participants. The study was approved by the Institutional Review Boards of the University of Michigan, Dartmouth College, and Yale University.

Measures

Outcomes of interest: PTSS and functional impairment—We evaluated participants for posttraumatic stress symptoms (PTSS) related to Hurricane Ike based on Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) criteria, using the Posttraumatic Stress Disorder (PTSD) Checklist – Civilian Version (PCL-C) for criteria B (re-experiencing), C (avoidance/numbing), and D (hyperarousal) symptoms [3, 4, 51, 56]. The PCL-C has demonstrated substantial agreement in diagnoses of PTSD compared to the Structured Clinical Interview for DSM-III-R (SCID) and in symptom ratings compared to the Clinician-Administered PTSD Scale (CAPS) [4, 51, 56].

At Wave 1, respondents were asked to report how much they were bothered by each of 17 symptoms with reference to Hurricane Ike; responses ranged from 1 (not at all) to 5 (extremely), referring to the time since the hurricane. Consistent with prior studies, symptoms rated as “moderately” or more bothersome (endorsing response categories 3 to 5) were counted as present. Wave 2 and 3 interviews evaluated symptoms of Hurricane Ike-related PTSD experienced since the previous interview. The number of posttraumatic stress symptoms at each wave was used as the PTSS outcome of interest. We considered the symptom count to be more interpretable than the total PCL score, since with the PCL score, it is difficult to differentiate between individuals who score very highly on a few symptoms and those who score moderately on multiple symptoms.

We assessed functional impairment using the Short Post-Traumatic Stress Disorder Rating Interview Expanded version (SPRINT-E), which is a 6-item measure assessing functioning

in the past month [44]. It was developed as a brief measure of current disaster-related distress, functional impairment and perceived need for professional help, notwithstanding the presence or absence of particular psychiatric symptoms. The scale version used in this study was modified from the original version by eliminating the 5 questions that overlapped with assessment of PTSD (intrusion, avoidance, arousal) and depression. Items on the SPRINT-E include “How much have your reactions interfered with your ability to work or carry out your daily activities, such as housework or schoolwork?” and “How much have your reactions affected your relationships with your family or friends or interfered with your social, recreational, or community activities?” (with “reactions” declared to mean feelings, emotions or thoughts about Hurricane Ike in instructions to participants). Possible item scores range from 1 (not at all) to 5 (very much). The total scale score, ranging in values 6–30 (recoded to 0–24) was used as the functional impairment outcome of interest.

Exposures of interest—The main exposures of interest in this analysis were hurricane-related potentially traumatic events, peri-event emotional reactions to the hurricane, and hurricane-related stressors, as well as post-hurricane traumatic events and stressors that were not directly related to the hurricane. The scales were adapted from instruments used following previous natural disasters, including Hurricane Andrew and Hurricane Katrina [25, 50].

Acute hurricane-related potentially traumatic events included physical injury; death of a family member or close friend as a result of the hurricane; witnessing dead bodies during or after the hurricane; and other traumatic events including assaultive violence reported to be related to the hurricane. This measure was treated as a dichotomous variable, denoting exposure to at least one traumatic event vs. none. The variable was dichotomized due to the low proportion of respondents (10.4%) exposed to any hurricane-related traumatic events.

We assessed the immediate emotional reaction to the disaster (i.e. fear severity), using the four-item “STRS” scale[8]. The scale asked the respondent to remember how he/she felt at the time of the hurricane and the first few hours afterward, and assessed responses such as shortness of breath and trembling, shaking, or buckling knees. The measure was dichotomized to contrast respondents with high levels of peri-event emotional reactions (i.e. in the top tertile of the scale) to those with mid or low levels of emotional reactions (i.e. in the middle and low tertiles). A tertile cutoff was used instead of a continuous measure due to the high skewness of the measure.

Hurricane-related stressors were divided into two categories: 1) acute stressors, measured only in the baseline interview, including being without any resource (e.g., food, water, shelter, electricity) for more than one week; any loss of or damage to personal property (e.g., house, furniture, appliances, vehicles); any loss of or damage to sentimental possessions (e.g., photographs, pets); a health problem of oneself or a household member developing as a result of the hurricane; and experiencing significantly increased demands after the hurricane; and 2) ongoing stressors, measured at each interview, including being displaced from home for more than one week and experiencing financial loss (e.g., lost job, fall in household income) as a result of the hurricane. Number of acute hurricane-related stressors was summed into a count variable due to the high proportion of respondents exposed to any acute hurricane-related stressors. Discrete ongoing hurricane-related stressors such as displacement and financial loss were each examined separately as dichotomous variables.

We also assessed the number of ongoing post-hurricane traumatic events and stressors at each interview, using a subset of DSM-IV Criterion A traumatic events from Breslau et al. [11] and a modified list of stressful life events [5, 6]. Post-hurricane ongoing traumatic events included combat exposure, robbery or mugging, and unwanted sexual contact,

whereas post-hurricane ongoing stressors included experiencing stressful legal problems, a divorce or break-up with a partner, and serious financial problems. At Wave 1, participants were asked whether each traumatic event and stressor reported occurred before or after Hurricane Ike, with the option of reporting that the same type of event or stressor occurred both before and after the hurricane. At Waves 2 and 3, traumatic events and stressors occurring since the last interview were assessed. Exposure to ongoing post-hurricane traumatic events was dichotomized as one or more traumatic event vs. none since Hurricane Ike (at Wave 1) and since the last interview (at Waves 2 and 3), due to the low prevalence of reported traumatic events. The number of ongoing post-hurricane stressors was counted for each of these time periods.

Confounders—Counts of lifetime traumatic events reported at Wave 1 to have occurred prior to Hurricane Ike, including assaultive violence events (e.g. being mugged), other injuries or shocking events (e.g. car accidents, house fires), and the sudden, unanticipated death of a loved one were included as potential confounders, as was the count of lifetime stressors experienced prior to Hurricane Ike. At Wave 1, we used the PCL-C to assess lifetime PTSD related to the lifetime traumatic event (other than Hurricane Ike) rated by the respondent as the "worst". Respondents were classified as meeting criteria for lifetime PTSD related to this event, if they reported feeling terrified or helpless at the time of the event; one or more re-experiencing symptoms; three or more avoidance symptoms; two or more arousal symptoms; duration of symptoms over one month; and substantial impairment related to these symptoms.

Probable lifetime major or other depression was assessed using the Patient Health Questionnaire-9 (PHQ-9) [31, 32, 53]. Study participants met criteria for lifetime depression if they met all criteria for major depressive disorder or other depressive disorder by reporting, in the baseline interview, that at least two symptoms ever occurred at least "more than half the days" over a two week period (suicidal thoughts were counted if present at least "several days"), with one of those symptoms being depressed mood or anhedonia [31].

Additional covariates included family history of drug or alcohol problems, gender, age, race/ethnicity, educational attainment, marital status, and income.

Analysis

The association between trajectories of PTSS and functional impairment was estimated using parallel process models [18]. These models allowed us to also compare the influence that acute hurricane-related traumatic events, peri-event emotional reactions, hurricane-related stressors, and post-hurricane ongoing traumatic events and stressors had on the baseline levels and trajectories of PTSS and functional impairment symptoms.

Parallel process models are a type of latent class growth curve models, which fit within the structural equation framework (LGM) [18]. LGM estimates an underlying growth trajectory from the repeated measures of a construct. The trajectory is described by two unobserved latent factors: the intercept (or baseline level) and the slope (or rate of change over time) [18]. A parallel process model is a type of structural equation model comprised of two or more separate LGMs: this structure allowed us to account for the correlation between baseline levels of PTSS and functional impairment and between the rate of change of the two outcomes.

PTSS and functional impairment were modeled assuming a Poisson distribution, to account for the highly skewed distribution of the PTSS symptom count and the functional impairment score. Trajectories were estimated using measures at three time points (November 2008-March 2009, February-June 2009, and November 2009-April 2010).

Following the example set by Needham et al. [41], the factor loadings for the slope of each outcome were set to 0, 1, and 2.7 to define the rate of change as linear: the Wave 1 factor loading was set to zero to establish the first wave as baseline; a factor loading of one at Wave 2 represented a three-month change in time; and a factor loading of 2.7 at Wave 3 represented a one-year change in time. We estimated alternative models with quadratic and cubic specifications for the slopes of each outcome, but they did not improve model fit, so we kept both slopes as linear.

All analyses were conducted in Mplus [40], using an option that corrected for stratification. Analyses were also weighted to account for differential sampling probabilities across the five study strata, probabilities of selection within households, nonresponse, and differences between the sample and the adult population in Galveston and Chambers counties on race/ethnicity, age, educational attainment, and household income, according to the 2005–2007 American Community Survey. Models were estimated with weighted least squares procedures [40].

Missing data on the latent class indicators were handled in the EM (expectation-maximization) type maximum likelihood procedure used to estimate model parameters, assuming that data on the indicators was missing at random. Missing data on the covariates was addressed using multiple imputation, which was carried out using IVEware software [49].

We used the following modeling procedure. First, we estimated the unconditional parallel trajectories, to estimate the magnitude of covariation between the slope and intercept factors of the two outcomes (results not shown). Since the baseline levels and rates of change of the two outcomes were highly correlated, we decided to pursue a parallel trajectory analysis. This allowed us to estimate the relative association of acute hurricane-related and ongoing hurricane-related and post-hurricane traumatic events and stressors with each outcome, while accounting for concurrent co-occurrence of the two outcomes. Second, we incorporated baseline covariates as predictors of the intercept and slope factors for each outcome, and time-varying covariates as predictors of the risk ratio for each outcome at that particular wave. We could thus estimate the baseline risk ratio for PTSS and impairment associated with a one-unit change in the covariate (intercept predictors), and the risk ratio of change in PTSS and impairment symptoms over time associated with a one-unit change in the covariate (slope predictors). Time-varying predictors of wave-specific outcome measures provided estimates of the risk ratio of PTSS and impairment symptoms at each wave, associated with having reported one additional stressor at the same wave.

We estimated the following models: Model 0 (not shown) included sex, age, race/ethnicity, education, marital status, income, lifetime PTSD, lifetime depression, family problems with alcohol/drugs and lifetime (i.e., pre-hurricane) exposure to traumatic events and stressors, to determine which confounders to include in the models of interest; Model 1 added hurricane-related acute and ongoing traumatic events and stressors and peri-event emotional reactions; Model 2 added post-hurricane ongoing traumatic events and stressors; and a final model (Model 3) included only the significant predictors of each intercept and slope factor. Demographic covariates were kept across models while other covariates were only carried forward if they were significantly associated with the parameter of interest. If a covariate was significantly associated with the slope but not the intercept, it was still kept as a predictor of both.

RESULTS

The majority of participants were White (63.5%), had more than high school education (55.0%), were married (55.0%), and had a household income of at least $40,000 (60.2%) (Table 1). On average, participants had experienced two acute hurricane-related stressors. At Wave 1, 36.8% had been displaced for over a week since Ike, and 21.9% had experienced job loss as a result of the hurricane.

The initial count of PTSS was positively correlated with the initial symptom count of functional impairment (covariance between intercepts = 3.90 (standard error (SE) = 0.50)), and the rate of change in PTSS was positively correlated with the rate of change in functional impairment symptomatology (covariance between slopes = 0.52 (SE=0.10)). However, there was no relationship between initial levels of one outcome and the rate of change of the other.

We first examined whether acute hurricane-related exposure to traumatic events and stressors, and peri-event emotional reactions, explained variation in the intercepts and slopes for PTSS and functional impairment (Table 2, Model 1). Acute hurricane-related traumatic events were associated with the intercepts but not the slopes of PTSS and functional impairment: the initial PTSS and impairment risk ratios were higher for participants who had experienced at least one acute hurricane-related traumatic event [Risk Ratio (RR): 1.92, 95% confidence interval (CI): 1.13–3.26 and RR: 1.76; 95% CI: 1.05–2.97 respectively] (Model 1, Table 2). Participants who experienced a high peri-event emotional reaction to the hurricane also started out with higher PTSS and functional impairment risk ratios (RR: 4.28; 95% CI: 2.93–6.23 and RR: 2.75; 95% CI: 1.86–4.08 respectively) but did not exhibit a different rate of change in either outcome from participants with mid- or low-level emotional reactions to the hurricane. In contrast, participants who experienced a higher number of acute hurricane-related stressors started out with higher PTSS and functional impairment risk ratios (RR: 1.62; 95% CI: 1.36–1.94 and RR: 1.74; 95% CI: 1.46–2.08), but also experienced a higher rate of change over time in functional impairment (RR: 1.09; 95% CI: 1.01–1.19).

We also examined the association between ongoing hurricane-related stressors and the risk of PTSS and functional impairment at each study wave (Table 2, Model 1). Of the two ongoing hurricane-related stressors considered, displacement from home for over a week since the last interview was associated with higher PTSS and functional impairment risk ratios at Wave 1 (RR: 1.67; 95% CI: 1.28–2.18 and RR: 1.50; 95% CI: 1.11–2.01), just with PTSS at Wave 2 (RR: 1.43; 95% CI: 1.07–1.90), and with PTSS and functional impairment (marginally) at Wave 3 (RR: 2.00; 95% CI: 1.02–3.94 and RR: 1.42; 95% CI: 0.99–2.04) (Model 1, Table 2). Financial loss was not associated with either outcome at any wave.

Finally, we examined the association between post-hurricane ongoing traumatic events and stressors and PTSS and functional impairment at each study wave (Table 2, Models 2–3). Post-hurricane ongoing traumatic events were not associated with PTSS or functional impairment at any wave. In contrast, post-hurricane ongoing stressors were significantly associated with PTSS and functional impairment at Wave 2 (RR: 1.08; 95% CI: 1.01–1.16 and RR: 1.14; 95% CI: 1.07–1.21) and Wave 3 (RR: 1.34; 95% CI: 1.22–1.47 and RR: 1.22; 95% CI: 1.11–1.34) (Model 3, Table 2).

DISCUSSION

Large-scale traumatic events such as Hurricane Ike have an impact on multiple dimensions of mental health in the affected population. In this study, we examined patterns of PTSS and functional impairment exhibited by a representative sample of residents in Galveston County

for approximately eighteen months following the occurrence of Hurricane Ike. The prevalence of PTSD in this sample 2–5 months after the hurricane (6.1%), although lower than the prevalence documented after Hurricane Katrina, was comparable to those previously reported by population-based studies of hurricanes [55]. Participants exhibited higher PTSS symptom levels and functional impairment in the first months after the hurricane and a drop thereafter [16, 30, 37]. Hurricane-related and post-hurricane traumatic events and stressors increased the risk of PTSS and impairment, independent of pre-existing vulnerabilities from lifetime depression, PTSD or prior life events.

Our study makes three novel contributions to our understanding of post-disaster mental health. First, by using latent class growth models, we were able to tease out the relative contribution that acute, hurricane-related exposures made to the short-term post-disaster context, and to the evolution of PTSS and impairment in the long term [7]. In this way, we showed that the immediate emotional reaction to the disaster and acute disaster-related traumatic events and stressors matter most for short-term mental health, rather than for the longitudinal course of mental health. Second, we were able to examine the timing at which each type of traumatic event and stressor exerted an effect on PTSS and impairment. We showed that as the disaster became more temporally distant, post-hurricane ongoing stressors (financial problems, divorce) started to matter more for PTSS and impairment. Third, we extended our study beyond traditional measures of mental health, such as PTSS. Prior to this study, our understanding of the post-disaster profile of functional impairment was limited. In particular, it was uncertain whether functional impairment responded to the same disaster-related and post-disaster traumatic events and stressors as traditional mental health symptom measures. In this study, we identified types of stressors that, if intervened upon, could have an impact not only in PTSS but also in the broader dimension of functional impairment.

Acute hurricane-related traumatic events, such as experiencing the death of a family member or close friend and stressors, such as being without food or water for more than one week post-hurricane, were associated with baseline PTSS and functional impairment symptoms, but they did not have a strong influence on the long-term rate of change in these outcomes over the study period. The relationship between acute hurricane-related traumatic events and stressors and PTSS in particular is supported by a range of prior studies that present PTSD as a disorder caused by the occurrence of events outside the range of normal human experience [10, 13, 14, 15, 47]. The absence of a strong link between acute hurricane-related exposures and the evolution of PTSS and functional impairment over time indicates that while acute exposures may increase symptomatology in the short-term, the long-term course of these symptoms may depend on the persistent exposure to stressors over time [21, 24].

Consistent with prior work on disasters, the acute emotional reaction to the disaster was also strongly associated with initial levels of PTSS and functional impairment [20, 21, 26, 48]. Our findings suggest that the subjective experience of fear or panic during a disaster may be particularly important for immediate mental health status. Screening for such symptoms may be valuable for early identification and diagnosis of populations at risk for mental health problems following a disaster.[9]

Ongoing hurricane-related stressors, particularly continued displacement from home due to the hurricane, and ongoing post-hurricane stressors, such as family drug/alcohol problems or financial concerns, played a critical role in the long-term course of PTSS and functional impairment. Ongoing post-hurricane stressors may actually be consequences of the disaster itself, as massive sources of trauma may increase the sources of strain in daily life in a persistent manner. Prior studies suggest that ongoing sources of stress that emerge in the aftermath of mass trauma may mediate the long-term mental health effects of disasters [29,

43]. A meta-analysis on risk factors for PTSD in trauma-exposed adults also found that factors that operated after the traumatic event, such as additional life stress, had a strong effect on PTSD [12]. The increasing importance of ongoing stressors in later study waves indicates that investing in alleviating ongoing stressors can have an impact on the long-term population distribution of two key areas of mental health: posttraumatic stress symptoms and functional impairment. In addition, this finding can provide insight into potential reasons why certain disasters, such as Hurricane Katrina, had particularly high mental health consequences. The high prevalence of unresolved hurricane-related stressors following a disaster like Katrina, which was the costliest natural disaster to ever occur in the United States, may have played an important role in the documented persistence of high levels of PTSD following the disaster[28].

This study is subject to several limitations. First, in the context of contemporaneously reported symptoms of psychopathology and traumatic events and stressors it is always possible, although unlikely with the application of highly structured measures with extensive history of their application in comparable contexts, that current experience of PTSS and functional impairment symptoms influences reports of traumas and stressors. Second, the relatively small sample size and the complex nature of the models required us to limit the number of covariates in each model—hence, we had to examine counts or presence of any hurricane-related and post-hurricane stressors and traumatic events, rather than specific types of stressors and traumatic events. Third, Ike resulted in a lower rate of exposure to traumatic events such as injuries or death. Hence, studies of more severe disasters may reveal different patterns from what we observed, and this question deserves more research.

Ongoing sources of stress that follow instances of massive trauma have lasting mental health effects that result in dysfunction at home, work and in social settings and thus act as an important health and socio-economic burden in the population. These results illustrate the distinct influence of acute and ongoing peri- and post-hurricane traumatic events and stressors on the short- and long-term course of PTSS and functional impairment. While immediate postdisaster interventions may influence the short-term course of PTSS and impairment, alleviating ongoing post-disaster stressors may play a central role in mitigating the long-term course of posttraumatic stress and in restoring role functioning and quality of life.

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Table 1

Study sample description

	Wave 1	Wave 2	Wave 3
Variables	**n=658**	**n=529**	**n=487**
	Mean (S.E) or Percentage		
Outcome variables			
Sum of Ike-related PTSD symptoms	2.58 (0.27)	1.25 (0.17)	1.75 (0.28)
Sum of functional impairment items in past month	3.06 (0.31)	2.06 (0.24)	2.36 (0.35)
Baseline covariates			
Male	48.50	-	-
Age 18–34	30.70	-	-
35–54	40.30	-	-
55+	29.00	-	-
Race/ ethnicity			
White non-Hispanic	63.50	-	-
Black non-Hispanic	13.60	-	-
Hispanic	18.60	-	-
Other non-Hispanic	4.30	-	-
Education			
Less than high school	16.00	-	-
High school	29.00	-	-
More than high school	55.00	-	-
Marital status			
Married	55.00	-	-
Separated, divorced, or widowed	17.70	-	-
Never married or living with a partner	27.30	-	-
Income year before Ike			
Less than $20,000	19.20	-	-
$20,000–39,999	20.60	-	-
$40,000–59,999	15.40	-	-
$60,000–99,999	23.90	-	-
$100,000+	20.90	-	-
Lifetime history of PTSD	10.30		
Number of traumatic events before Ike	2.77 (0.14)	-	-
Number of stressors before Ike	3.54 (0.19)	-	-
Parent with problems with alcohol and/or drugs	20.00	-	-
Other relative with problems with alcohol and/or drugs	39.60	-	-
Probable major or other depression in lifetime	23.10	-	-
Hurricane Ike-related exposures			
Acute events			
One or more traumatic events related to Ike	10.44	-	-

	Wave 1	Wave 2	Wave 3
Variables	**n=658**	**n=529**	**n=487**
	Mean (S.E) or Percentage		
High peri-event emotional reactions	20.67		
Number of stressors related to Ike	2.06 (0.10)	-	-
Ongoing events			
Displaced from home for over a week since Ike or last interview	36.84	8.90	14.97
Self or household member laid off for more than 1 week since Ike or last interview	21.89	13.23	11.3
Ongoing post-hurricane exposures			
One or more traumatic events since Ike or last interview	10.64	16.71	27.33
Number of stressors since Ike or last interview	0.35 (0.06)	1.02 (0.13)	1.53 (0.13)

Table 2

Influence of lifetime, hurricane-related, and post-hurricane traumatic events and stressors on the trajectories of posttraumatic stress symptoms (PTSS) and functional impairment (FI)

	Model 1[a]				Model 2[b]				Model 3[c]			
	PTSS		Functional impairment		PTSS		Functional impairment		PTSS		Functional impairment	
	Intercept	Slope	Intercept	Slope	Intercept	Slope	Intercept	Slope	Intercept	Slope	Intercept	Slope
Baseline covariates	RR (95% CI)				RR (95% CI)				RR (95% CI)			
Hurricane-related acute exposures												
-One or more traumatic events	1.92 (1.13–3.26)	1.18 (0.89–1.56)	1.76 (1.05–2.97)	1.01 (0.83–1.22)	2.18 (1.36–3.50)		1.58 (0.97–2.59)		2.06 (1.30–3.29)		1.66 (1.02–2.69)	
-Number of stressors	1.62 (1.36–1.94)	1.05 (0.93–1.18)	1.74 (1.46–2.08)	1.09 (1.01–1.19)	1.76 (1.50–2.50)		1.74 (1.46–2.08)	1.09 (1.00–1.18)	1.75 (1.49–2.04)		1.74 (1.46–2.08)	1.09 (0.99–1.19)
-High peri-event emotional reactions	4.28 (2.93–6.23)	0.85 (0.69–1.05)	2.75 (1.86–4.08)	0.89 (0.75–1.05)	4.36 (2.91–6.55)		2.93 (1.86–4.61)		4.3 (2.92–6.32)		2.96 (1.89–4.64)	

	Model 1		Model 2		Model 3	
	PTSS	Functional impairment	PTSS	Functional impairment	PTSS	Functional impairment
Time-varying covariates	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
Ongoing hurricane-related exposures						
At wave 1						
-Displaced from home for >1 week since Ike	1.67 (1.28–2.18)	1.5 (1.11–2.01)	1.39 (1.04–1.86)	1.29 (0.96–1.76)	1.35 (1.01–1.78)	1.28 (0.93–1.75)
-Self or household member laid off >1 week since Ike At wave 2	0.7 (0.68–1.58)	0.64 (0.37–1.10)				
-Displaced from home for >1 week since wave 1	1.43 (1.07–1.90)	1.15 (0.89–1.49)	1.59 (1.19–2.16)	1.13 (0.88–1.47)	1.63 (1.19–2.23)	1.12 (0.88–1.42)
-Self or household member laid off >1 week since wave 1	1.24 (0.92–1.67)	0.93 (0.63–1.37)				
At wave 3						
-Displaced from home for >1 week since wave 2	2.00 (1.02–3.94)	1.42 (0.99–2.04)	1.71 (0.92–3.17)	1.32 (0.95–1.85)	1.78 (0.94–3.37)	1.41 (1.00–2.00)
-Self or household member laid off >1 week since wave 2	1.53 (0.88–2.66)	1.22 (0.85–1.76)				
Ongoing post-hurricane exposures						
At wave 1						
-One or more traumatic events			0.84 (0.57–1.25)	1.14 (0.78–1.67)		
-Number of stressors			0.97 (0.87–1.09)	1.04 (0.92–1.17)		
At wave 2						

	Model 1		Model 2		Model 3	
	PTSS	Functional impairment	PTSS	Functional impairment	PTSS	Functional impairment
Time-varying covariates	**RR (95% CI)**	**RR (95% CI)**	**RR (95% CI)**	**RR (95% CI)**	**RR (95% CI)**	**RR (95% CI)**
-One or more traumatic events since wave 1			0.96 (0.74–1.25)	1.09 (0.91–1.31)		
-Number of stressors since			1.07 (0.98–1.17)	1.15 (1.07–1.23)	1.08 (1.01–1.16)	1.14 (1.07–1.21)
wave 1						
At wave 3						
-One or more traumatic events since wave 2			0.99 (0.57–1.71)	1.08 (0.69–1.70)		
-Number of stressors since wave 2			1.33 (1.19–1.48)	1.23 (1.11–1.35)	1.34 (1.22–1.47)	1.22 (1.11–1.34)

[a] In Model 1, we conditioned the PTSS intercept on sex, age, race/ethnicity, education, marital status, income, lifetime PTSD, lifetime depression, family problems with alcohol/dugs. The PTSS slope was conditioned on age and family problems with alcohol/drugs. The FI intercept was conditioned on sex, age, race/ethnicity, education, marital status, income, lifetime PTSD, lifetime depression. The FI slope was conditioned on sex and age.

[b] In Model 2, we conditioned the two intercepts (PTSS and FI) on sex, age, race/ethnicity, education, marital status, and income. The PTSS slope was conditioned on age. The FI slope was conditioned on sex and age.

[c] In Model 3, we conditioned the two intercepts (PTSS and FI) on sex, age, race/ethnicity, education, marital status, and income. The PTSS slope was conditioned on age. The FI slope was conditioned on sex and age.

*** p-value <.001