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Trends in mental illness and suicidality after Hurricane Katrina

RC Kessler[1], S Galea[2], MJ Gruber[1], NA Sampson[1], RJ Ursano[3] and S Wessely[4]

[1]Department of Healthcare Policy, Harvard Medical School, Boston, MA, USA; [2]School of Public Health, University of Michigan, Ann Arbor, MI, USA; [3]Department of Psychiatry, Uniformed Services University of the Health Sciences (USUHS), Rockville, MD, USA and [4]King's College London, Institute of Psychiatry, London, UK

A representative sample of 815 pre-hurricane residents of the areas affected by Hurricane Katrina was interviewed 5–8 months after the hurricane and again 1 year later as the Hurricane Katrina Community Advisory Group (CAG). The follow-up survey was carried out to study patterns-correlates of recovery from hurricane-related post-traumatic stress disorder (PTSD), broader anxiety-mood disorders and suicidality. The Trauma Screening Questionnaire screening scale of PTSD and the K6 screening scale of anxiety-mood disorders were used to generate DSM-IV prevalence estimates. Contrary to results in other disaster studies, where post-disaster mental disorder typically decreases with time, prevalence increased significantly in the CAG for PTSD (20.9 vs 14.9% at baseline), serious mental illness (SMI; 14.0 vs 10.9%), suicidal ideation (6.4 vs 2.8%) and suicide plans (2.5 vs 1.0%). The increases in PTSD-SMI were confined to respondents not from the New Orleans Metropolitan Area, while the increases in suicidal ideation-plans occurred both in the New Orleans sub-sample and in the remainder of the sample. Unresolved hurricane-related stresses accounted for large proportions of the inter-temporal increases in SMI (89.2%), PTSD (31.9%) and suicidality (61.6%). Differential hurricane-related stress did not explain the significantly higher increases among respondents from areas other than New Orleans, though, as this stress was both higher initially and decreased less among respondents from the New Orleans Metropolitan Area than from other areas affected by the hurricane. Outcomes were only weakly related to socio-demographic variables, meaning that high prevalence of hurricane-related mental illness remains widely distributed in the population nearly 2 years after the hurricane.

Introduction

Hurricane Katrina was the deadliest hurricane in the United States in seven decades and the most expensive natural disaster in US history. More than 500 000 people were evacuated. Nearly 90 000 square miles were declared a disaster area (roughly equal to the land mass of the United Kingdom).[1] More than 1600 deaths were confirmed and more than 1000 people still remain missing.[2] As one might expect based on these facts, epidemiological data have documented an extremely high prevalence of psychopathology in the population affected by Katrina.[3,4] The most representative epidemiological study estimated that nearly half of the pre-hurricane residents of the New Orleans Metropolitan Area and one-fourth of the pre-hurricane residents of the other areas affected by Katrina had a DSM-IV anxiety-mood disorder 5 months after the hurricane, with 30% of those from New Orleans Metro and 12% of those from the remainder of the hurricane area estimated to have post-traumatic stress disorder (PTSD).[3]

The destruction caused by Hurricane Katrina has lingered much longer than that occurring after previous hurricanes.[5] Indeed, many people living in the areas affected by Katrina continue to be without essential services 2 years after the storm. One might expect from this that the typical pattern of recovery from post-disaster mental illness would be delayed. Previous research has documented an inverse J-shaped recovery curve for PTSD after traumatic events, with recovery most rapid in the first year, more gradual in the second year and stabilizing into chronicity after 2 years.[6] Although fewer studies have examined recovery after natural disasters,[7–9] the results are generally consistent with the larger literature in finding that a substantial proportion of post-traumatic mental illness resolves within 1 or 2 years. But there are exceptions. For example, a longitudinal study of victims of the 1992 Hurricane Andrew in Florida carried out 6 and 30

months after the hurricane found that the prevalence of PTSD actually increased slightly over time.[9] A similar pattern has been found in long-term studies of refugees exposed to ongoing severe stress,[10,11] whereas recovery has been much more common in studies of refugees whose objective life situations improved substantially.[12,13] In the case of armed services personnel returning from combat duty in Iraq and Afghanistan, the even more extreme pattern has been found of PTSD symptoms actually increasing over time.[14,15]

It would not be surprising, based on these results, if a similar pattern of slow recovery or perhaps even an increase in mental illness, compared to cases shortly after the hurricane, was found in follow-up studies of survivors of Hurricane Katrina. The current report presents data on this matter from the Hurricane Katrina Community Advisory Group (CAG), a representative sample of pre-hurricane residents of the Federal Emergency Management Agency (FEMA)-defined areas in Alabama, Louisiana and Mississippi directly affected by Katrina[16–18] who agreed to participate in a series of tracking surveys over several years to assess need for mental health services. The baseline survey was carried out 5–7 months after the hurricane and the first follow-up survey of the same sample was carried out 1 year later. Results from this two-wave panel sample are presented here on trends in the prevalence and correlates of hurricane-related anxiety-mood disorders.

Three results from the baseline CAG survey are noteworthy as a backdrop to the current report. First, the estimated prevalence of anxiety-mood disorders in the baseline CAG survey was roughly twice as high as the estimated prevalence found 3 years earlier using the same measures in the sub-sample of the National Comorbidity Survey Replication (NCS-R)[19] residing in areas subsequently affected by Hurricane Katrina.[4] We will present data here on trends in this prevalence over the subsequent year. Second, the socio-demographic correlates of these disorders were largely the same in the CAG and the NCS-R, suggesting that the adverse mental health effects of Hurricane Katrina were equally distributed across broad segments of the population. We will examine whether patterns of change in these disorders over the subsequent year also were consistent or varied across broad socio-demographic segments of the population. Third, the prevalence of suicidality in the baseline CAG sample was much lower than in the NCS-R despite the higher prevalence of anxiety-mood disorders. Subgroup analysis traced this low prevalence of suicidality to widespread feelings of optimism in the affected population that the practical problems of living created by the hurricane would soon be resolved. This optimism turned out to be unrealistic, as the subsequent pace of government reconstruction efforts was slow. This raises the question whether the slow pace of recovery resulted in a rise in the prevalence of suicidality to a level more consistent with the high prevalence of anxiety-mood disorders in the population, a possibility that we evaluate here.

Materials and methods

The sample
The CAG target population was English-speaking adult (aged ≥18) pre-hurricane residents of the counties (in Alabama and Mississippi) and parishes (in Louisiana) defined by FEMA as directly affected by Hurricane Katrina (www.fema.gov/hazard/hurricane/2005katrina). Pre-hurricane residents of these areas were eligible for the sample regardless of whether they were in these areas at the time of the hurricane and regardless of the extent they or their property were affected by the hurricane. Census data suggest that only about 1% of this population was unable to speak English, suggesting that the restriction of the sample to English-speakers did not introduce major bias into the sample.

Respondents were selected from three sampling frames: the telephone numbers (land lines and cell phones) of the roughly 1.4 million families that applied for assistance from the American Red Cross (ARC); a random-digit dial (RDD) telephone frame of households in the areas affected by the hurricane and a supplemental sample of hotels that housed FEMA-supported evacuees. Although the use of RDD might seem impractical in a population where many people evacuated, evacuation was much more common in New Orleans Metro than the remainder of the affected areas. Furthermore, many evacuees had returned as of the time of the survey. RDD was useful in contacting these nonevacuees and returned evacuees. The vast majority of evacuees, in comparison, applied to the ARC for assistance and could be traced through contact information provided in the ARC applications for assistance. Other evacuees could be traced in the RDD sample through a call-forwarding service set up by Bell South in the wake of the hurricane that forwarded calls to phone numbers anywhere in the country requested by the person in whose name the pre-hurricane phone was registered. More details on sampling and adjustment for overlap of the frames are reported at www.HurricaneKatrina.med.harvard.edu.

The baseline CAG survey was carried out between 19 January and 31 March 2006, 5–7 months after the hurricane. A total of 1043 respondents completed the interview, representing an estimated 41.9% of the eligible households we screened. This low cooperation rate is due at least in part to the fact that we required a commitment from respondents for long-term involvement in the CAG in order to participate in the baseline survey, as the main goal of the CAG was to track the progress of recovery over time. An analysis of data obtained from the full screening sample found that those who did not join the CAG were similar to participants on all socio-demographic variables, but had a somewhat higher level of self-reported hurricane-related stress exposure (assessed by asking respondents to rate their hurricane-related stress exposure on a 0–10 scale where 0 meant 'no stress at all' and 10 meant 'the most stress you can imagine a person having') and more psychological

distress (assessed with a short series of questions about frequency of common anxiety-mood symptoms). The median and inter-quartile range (IQR: 25th–75th percentiles) of reported hurricane-related stress exposure were 8.0 (6.0–10.0) among nonrespondents and 7.0 (5.0–9.0) among CAG members. The median and IQR of reported psychological distress on a scale scored to have a 0–10 theoretical range were 2.9 (1.2–4.4) among nonrespondents and 1.7 (0.6–3.5) among CAG members. A weight was applied to the baseline CAG data to adjust for these response biases. A within-household probability of selection weight was also used along with a post-stratification weight to adjust for residual discrepancies between the CAG and the 2000 Census population on a range of social, demographic and pre-hurricane housing variables. The consolidated CAG sample weight, finally, was trimmed to increase design efficiency based on evidence that trimming did not significantly affect the estimated prevalence of anxiety-mood disorders.

Detailed personal contact information (current and permanent addresses, land line and cell phone numbers, email addresses) and tracing information (contact information for three people who would know how to find the respondent if he/she moved) was obtained for all baseline CAG respondents. This information was used to find baseline respondents for a follow-up survey carried out 1 year after the initial interview. Some 815 of the baseline respondents were successfully traced and interviewed in this follow-up survey (78.1% of the baseline sample). Minor differences in the composition of the follow-up sample compared to the baseline sample in socio-demographic characteristics, traumatic stress exposure and mental health were adjusted for by using a propensity score adjustment weight[20] applied to the consolidated baseline weight.

Measures

Anxiety-mood disorders. The K6 scale of nonspecific psychological distress[21] was used to screen for DSM-IV anxiety-mood disorders within 30 days of each interview.[22] Scores range from 0 to 24. Two independent validation studies have shown the K6 has an area under the receiver operating characteristic curve of between 0.86[21] and 0.89[23,24] in predicting DSM-IV anxiety-mood disorders that meet the severity criteria for the Substance Abuse and Mental Health Services Administration's definition of serious mental illness (SMI)[25] when compared to diagnoses generated from comprehensive diagnostic interviews. Based on these K6 validation studies, scores of 13–24 were classified probable SMI, while scores of 8–12 were classified probable mild–moderate mental illness (MMI) and scores of 0–7 were classified probable noncases. The designation of MMI is a residual definition of respondents estimated to meet criteria for a DSM-IV anxiety-mood disorder but not SMI. Previous research has shown that MMI is of

considerable public health importance because of its high prevalence, burden and risk of transition to SMI.[26]

A small clinical reappraisal study of five respondents selected randomly from each of these three K6 categories (SMI, MMI and noncase) was carried out with the structured clinical interview for DSM-IV (SCID).[27] The syndromes assessed were DSM-IV major depressive episode, panic disorder, generalized anxiety disorder, PTSD, agoraphobia, social phobia and specific phobia. Serious mental illness was defined as a DSM-IV diagnosis with a global assessment of functioning[28] score of 0–60 and MMI as a DSM-IV diagnosis with a global assessment of functioning of ⩾61. The SCID interviews confirmed K6 classifications for 14 of 15 respondents. The exception was a respondent classified as having SMI by the K6 but MMI by the SCID based on a global assessment of functioning (GAF) score of 65 (with GAF of 0–60 required to diagnose SMI). These results, although based on only a small sample, suggest that the K6 has excellent psychometric properties (estimated in the SCID sample weighted to adjust for the sample-wide K6 distribution), including sensitivity (1.0 for SMI, 0.90 for MMI and 1.0 for either SMI to MMI) and specificity (1.0).

Given the special importance of PTSD in trauma situations, a separate PTSD screen was included based on the 12-item Trauma Screening Questionnaire (TSQ),[29] a validated screen for PTSD.[30] Our version differed from the original TSQ in using dimensional response options rather than a simple yes–no response format to assess 30-day symptom frequency (never, less than once a week, about once a week, two to four days a week and almost every day). A clinical reappraisal study was carried out to calibrate TSQ responses to DSM-IV PTSD with 30 respondents judging possible cases and 10 randomly selecting others. A cut-point on the factor-based 0–42 scale of TSQ responses (12 items, each scored 0–4) of 20 + was selected to approximate the SCID PTSD prevalence in the weighted (to adjust for over-sampling of screened positives) clinical reappraisal sample. Sensitivity (0.89), specificity (0.93) and area under the receiver operating characteristic curve (0.91) were all excellent for this dichotomous screen.

Suicidality. Suicidality was assessed with questions about the occurrence of suicidal ideation ('seriously thinking about killing yourself'), plans and attempts within the past 12 months using questions originally developed for the National Comorbidity Survey.[31]

Hurricane-related stressors. The baseline survey included 29 structured questions developed based on pilot interviews about hurricane-related stressors. These included traumatic stressors that occurred at the time of the hurricane (for example, death of a loved one, a life-threatening experience that occurred to the respondent), highly stressful experiences that occurred in the aftermath (for example, homelessness,

physical adversity) and chronic stressful experiences that occurred in the first 5–7 months after the hurricane (for example, geographic dislocation, financial adversity). The latter set of questions was repeated in the follow-up survey. In addition, respondents were asked to provide a quantitative rating of the overall stressfulness of their situation by reporting 'how stressful overall' they would say their experiences related to the hurricane and aftermath were on a 0–10 scale 'where 0 means not at all stressful and 10 means the most stressful thing you can imagine.' Based on the finding that responses to the structured questions about specific stressors were strongly related to responses to the global rating question, we focus on trends in responses to the latter question in the current report, distinguishing respondents who reported severe (9–10), serious (7–8), moderate (5–6) or mild (3–4) stress from other respondents (0–2).

Socio-demographics. We examined associations of the mental health outcomes with a number of socio-demographic variables, including the respondent's age, sex, race/ethnicity, family income in the year before the hurricane, education, current health insurance coverage and current living situation. Age was coded 18–39, 40–59 and 60 +. Race/ethnicity was coded non-Hispanic whites, non-Hispanic black and other (largely Hispanics and Asians). Family income was coded in quartiles, where low was defined as less than or equal to 0.5 of the population median on the ratio of per tax income to number of family members, while low-average was defined 0.5 + through 1.0 on the same ratio, high-average 1.0 + through 3 and high 3 + on this ratio. Years of education were coded in four categories: 0–11, 12 (high school graduate), 13–15 and 16 + (college graduate). Health insurance was coded yes–no. Current living situation, finally, was coded in four categories: living in the same house as before the hurricane, in the same county/parish but not the same house, in the same state but not the same county/parish and in a different state.

Analysis methods

Cross tabulations were used to examine patterns of onset, recovery and persistence of estimated DSM-IV anxiety-mood disorders that qualify for the designations of SMI and MMI and of suicidal ideation, plans and attempts. The significance of differences in these prevalence estimates between the baseline and follow-up surveys was evaluated using within-respondent paired comparison tests. The effects of socio-demographic variables and stress measures in predicting trends in these outcomes were estimated using logistic regression analysis.[32] When the baseline value of the outcome variable is included as a control in such equations to predict outcomes at the time of follow-up, as it is here, the regression coefficients can be interpreted as predictors of change in the outcomes.[33] In the absence of estimated interactions

between the substantive predictors and the baseline measure of the outcome, the effects of the predictors on change are assumed to be the same in predicting onset and absence of remission of the outcome. In order to determine whether the associations of the predictors with onset and absence of remission differ, we evaluated the statistical significance of interactions of substantive predictors with baseline measures of each outcome. Logistic regression coefficients and their standard errors were exponentiated to create odds-ratios (ORs) and 95% confidence intervals (95% CI's) for ease of interpretation. Because the data were weighted, the Taylor series linearization method[34] was used to calculate design-based significance tests. Multivariate significance was evaluated using Wald's χ^2 tests based on design-corrected coefficient variance–covariance matrices. Statistical significance was evaluated using two-sided 0.05-level tests.

Results

Trends in DSM-IV anxiety-mood disorders and suicidality

The estimated prevalence of any anxiety-mood disorder did not change significantly between the baseline survey (30.7%) and the follow-up survey (33.9%; $t = 1.9$, $P = 0.06$), although the trend is positive (Table 1). The estimated prevalence of SMI, in comparison, is significantly higher in the follow-up than baseline survey in the total sample (14.0 vs 10.9%, $t = 2.4$, $P = 0.018$) and nearly significant in the sub-sample of respondents who are not from the New Orleans Metropolitan Area (13.2 vs 9.4%, $t = 1.9$, $P = 0.053$). This trend is not significant, in comparison, in the New Orleans Metro sub-sample (16.9 vs 16.5%, $t = 0.3$, $P = 0.81$). The estimated prevalence of PTSD is significantly higher in the follow-up than baseline survey in the sub-sample exclusive of New Orleans Metro (20.0 vs 11.8%, $t = 4.0$, $P < 0.001$), but not in the New Orleans Metro sub-sample (24.1 vs 25.9%, $t = 0.9$, $P = 0.37$). The prevalence of suicidality, finally, is significantly higher in the follow-up than baseline survey both with regard to suicidal ideation (6.4 vs 2.8%, $t = 3.9$, $P < 0.001$) and suicide plans (2.5 vs 1.0%, $t = 3.1$, $P = 0.002$). These trends, unlike those for SMI and PTSD, are significant and relatively comparable in magnitude in both the New Orleans Metro sub-sample and in the remainder of the sample.

We cross-classified baseline and follow-up diagnoses in order to study the composition of the diagnoses with significant trends. The majority of respondents classified as having SMI at follow-up either already had SMI at baseline (39.9%) or progressed from baseline MMI, PTSD or suicidal ideation (31.6%) to SMI, while the remaining 28.5% represent delayed onsets (that is, no MMI, no PTSD and no suicidal ideation at baseline; Table 2, Part I). A similar pattern exists for PTSD, where the majority of follow-up cases either already had PTSD at baseline (47.3%) or progressed from baseline SMI, MMI or suicidal ideation to PTSD (27.1%), while the remaining 26.8%

Table 1 Trends in the estimated prevalence of DSM-IV anxiety-mood disorders (in the 30 days before interview) and suicidality (in the 12 months before interview) in the two surveys

	New Orleans Metro				Remainder of the sample				Total sample			
	Baseline		Follow-up		Baseline		Follow-up		Baseline		Follow-up	
	%	(s.e.)	%	(s.e.)	%	(s.e.)	%	(s.e.)	%	(s.e.)	%	(s.e.)
Anxiety-mood disorders (30-day)												
Serious	16.5	(2.6)	16.9	(2.6)	9.4	(2.2)	13.2	(2.5)	10.9	(1.8)	14.0*	(2.0)
Mild-moderate	27.8	(3.1)	24.9	(3.0)	17.5	(2.7)	18.6	(2.9)	19.8	(2.3)	19.9	(2.4)
PTSD	25.9	(3.1)	24.1	(3.0)	11.8	(2.4)	20.0*	(3.0)	14.9	(2.0)	20.9*	(2.5)
Any	44.3	(3.3)	41.8	(3.3)	26.9	(3.3)	31.7	(3.4)	30.7	(2.7)	33.9	(2.8)
Suicidality (12-month)												
Ideation	3.1	(1.2)	7.9*	(2.0)	2.8	(1.2)	6.0*	(2.0)	2.8	(1.0)	6.4*	(1.6)
Plan	0.8	(0.7)	3.0*	(1.4)	1.0	(0.9)	2.4*	(1.3)	1.0	(0.7)	2.5*	(1.0)
Attempt	0.7	(0.7)	0.9	(0.8)	0.8	(0.8)	0.0	(0.0)	0.8	(0.7)	0.2	(0.2)
(*n*)			(472)				(343)				(815)	

Abbreviation: PTSD, post-traumatic stress disorder.
*Significant difference between baseline and follow-up surveys based on two-tailed within-respondent paired *t*-tests evaluated at the 0.05 level of significance.

Table 2 Decomposition of estimated prevalence of DSM-IV SMI and PTSD and suicidality between the two surveys (*n* = 815)

	SMI		PTSD		Ideation		Plans	
	%	(s.e.)	%	(s.e.)	%	(s.e.)	%	(s.e.)
I. Profiles of follow-up cases[a]								
Persistence	39.9	(7.7)	47.3	(6.7)	16.6	(10.0)	26.0	(22.1)
Progression	31.6	(7.4)	25.9	(6.0)	59.3	(12.9)	27.4	(14.5)
Delayed onset	28.5	(7.3)	26.8	(6.1)	24.1	(11.0)	46.6	(22.0)
(*n*)	(92)		(130)		(37)		(11)	
II. Transitions among baseline respondents[a]								
Persistence	51.1	(9.1)	66.4	(6.5)	37.9	(18.7)	69.8	(29.3)
Improvement	30.8	(8.7)	16.9	(4.9)	49.9	(18.5)	12.2	(16.0)
Recovery	18.1	(6.9)	16.7	(5.0)	12.2	(7.4)	18.0	(21.2)
(*n*)	(74)		(107)		(23)		(4)	

Abbreviations: PTSD, post-traumatic stress disorder; SMI, serious mental illness.
[a]See the text for definitions of the categories.

are delayed onsets (that is, no SMI, MMI and no suicidal ideation at baseline). The proportions of delayed onsets are comparable for suicidal ideation (24.1%) and somewhat higher for suicide plans (46.6%), while the proportions with persistence (16.6 and 26.0% for ideation and plans, respectively) are lower than those for SMI and PTSD. The proportions that represent progressions (that is, from baseline cases with SMI, MMI or PTSD) are higher for suicidal ideation (59.3%) than for SMI or PTSD and

comparable for suicide plans (27.4%) compared to SMI and PTSD.

It is noteworthy that the majority of respondents with baseline SMI (51.1%) continued to have SMI at follow-up, while 30.8% improved (that is, were classified as having MMI, PTSD or suicidal ideation at follow-up but not longer classified as having SMI) and only a relatively small minority (18.1%) recovered (that is, no longer met criteria either for any of the following: SMI, MMI, PTSD, and suicidal ideation; Table 2, Part II). In the case of PTSD, 66.4% of baseline cases continued to have PTSD at follow-up, while an additional 16.9% were classified as having MMI, SMI or suicidal ideation but not PTSD at follow-up, and only 16.7% recovered. Persistence was somewhat lower for suicidal ideation (37.9%), but much higher for plans (69.8%). Improvement, in comparison, was comparatively high for suicidal ideation (49.9%), but not for suicide plans (12.2%). Recovery (that is, no MMI, or SMI, no PTSD and no suicidality at follow-up), finally, was relatively uncommon for either suicidal ideation (12.2%) or plans (18.0%).

Socio-demographic predictors of the trends
Only three of the socio-demographic variables are significant predictors of trends in SMI, PTSD or suicidal ideation: respondent age, family income and current living situation (Table 3; suicide plans, which also increased significantly over time, were too rare to be included in the trend analysis). Respondent age significantly predicts increased prevalence of PTSD (highest increases among respondents ages 40–59) and suicidal ideation (highest increases among respondents ages 18–39). Low family income predicts increased prevalence of all three outcomes. Family

Table 3 The effects of socio-demographic variables in predicting trends in estimated DSM-IV SMI and PTSD and suicidal ideation in the panel sample ($n = 815$)[a]

	SMI		*PTSD*		*Suicidal ideation*	
	OR	*(95% CI)*	*OR*	*(95% CI)*	*OR*	*(95% CI)*
Age						
18–39			1.6	(0.7–3.7)	5.7*	(1.5–22.4)
40–59			4.2*	(1.8–9.5)	2.5	(0.6–10.3)
60 +			1.0	—	1.0	—
χ_2^2			11.9	(0.003)	6.4	(0.040)
Income						
Low	3.7*	(1.4–9.8)	3.5*	(1.3–9.3)	4.9*	(1.4–17.2)
Low-middle	1.6	(0.5–5.2)	2.3	(0.8–6.8)	0.8	(0.2–3.5)
Middle-high	1.2	(0.4–3.6)	1.2	(0.4–3.6)	2.2	(0.5–10.8)
High	1.0	—	1.0	—	1.0	—
χ_3^2	10.6	(0.014)	7.8	(0.049)	12.0	(0.007)
Living situation						
Same town	0.2*	(0.1–0.6)				
Different town	1.0	—				
χ_1^2	9.7	(0.002)				

Abbreviations: CI, confidence interval; OR, odd ratio; PTSD, post-traumatic stress disorder; SMI, serious mental illness.
*Significant association with the trend at the 0.05 level, two-sided test.
[a]Multivariate logistic regression models controlling for baseline values of the outcome variable and for differences between the New Orleans Metro sub-sample and the remainder of the sample. Results are reported only for the total sample, not the two sub-samples, because no significant differences in results were found in the New Orleans Metro sub-sample versus the remainder of the sample (detailed results available on request).

living situation predicts increased prevalence of SMI (higher increases among respondents not living in the same town as before the hurricane, whether or not they live in the same county-parish or state, compared to those living in the same town, whether or not they live in the same house). While significant in statistical terms, these associations are not strong in substantive terms. The significant ORs (in the range 0.2–5.7) explain only between 2.1% (PTSD) about 2.7% (SMI) of the variance in the outcomes based on ϕ^2 tests.

An attempt was made to distinguish the predictors of delayed onset from the predictors of persistence by including interactions between the predictors and the baseline measures of the outcomes in an expanded version of the prediction equations, but none of these models converged due to the sparseness of the data. As a result, we cannot determine whether the significant socio-demographic predictors are predicting delayed onsets of the outcomes, persistence or both.

The effects of hurricane-related stress
One possible explanation for the significant increases in the prevalence estimates of SMI, PTSD and suicidal ideation is that hurricane-related stresses might have increased over time due to the slow pace of recovery efforts. As it turns out, though, this is not the case. A significantly lower proportion of respondents reported hurricane-related stress in the follow-up survey (57.5%) than in the baseline survey (91.7%; $t = 19.5$, $P < 0.001$; Table 4). This significant decrease

exists both in the New Orleans Metro sub-sample (97.9 vs 78.3%, $t = 10.0$, $P < 0.001$) and in the remainder of the sample (90.0 vs 51.7%, $t = 13.8$, $P < 0.001$). The decrease exists not only for stress overall but also for severe stress (32.6 vs 13.2%, $t = 15.8$, $P < 0.001$) and serious stress (27.6 vs 12.9%, $t = 21.4$, $P < 0.001$). It is noteworthy, in light of the fact that the SMI-PTSD increases exist only in the sub-sample exclusive of the New Orleans Metro Area, that the decrease in hurricane-related stress is less pronounced in New Orleans Metro than the remainder of the sample. Indeed, the prevalence of stress in the follow-up survey is significantly higher in the New Orleans Metro sub-sample than in the remainder of the sample (78.3 vs 51.7%, $t = 6.5$, $P < 0.001$). This means that higher levels of residual hurricane-related stress cannot explain the fact that SMI-PTSD prevalence increased over time only among respondents not from the New Orleans Metro Area.

Another possibility is that the psychological effects of hurricane-related stresses increased over time even though the magnitude of the stresses themselves decreased. A comparison of the cross-sectional associations between hurricane-related stresses and the outcomes finds some superficial support for this possibility with regard to SMI, as the ORs linking stress with SMI in the follow-up survey are consistently larger than the parallel ORs in the baseline survey (Table 5). However, these differences are not statistically significant ($\chi_4^2 = 8.1$, $P = 0.09$). Furthermore, the pattern is not less

Table 4 The prevalence of hurricane-related stress in the two surveys

| | New Orleans Metro | | | | Remainder of the sample | | | | Total sample | | | |
| | Baseline | | Follow-up | | Baseline | | Follow-up | | Baseline | | Follow-up | |
	%	(s.e.)	%	(s.e.)	%	(s.e.)	%	(s.e.)	%	(s.e.)	%	(s.e.)
Severe	40.6	(3.3)	18.1*	(2.8)	30.4	(3.5)	11.9*	(2.5)	32.6	(2.8)	13.2*	(2.1)
Serious	38.8	(3.1)	18.8*	(2.5)	24.5	(3.0)	11.3*	(2.3)	27.6	(2.5)	12.9*	(1.9)
Moderate	13.5	(1.8)	26.0*	(2.9)	23.6	(3.0)	15.1*	(2.6)	21.4	(2.4)	17.5	(2.2)
Mild	4.9	(1.1)	15.4*	(2.1)	11.5	(2.2)	13.5	(2.6)	10.1	(1.7)	13.9	(2.1)
Any	97.9	(0.5)	78.3*	(2.4)	90.0	(2.1)	51.7*	(3.6)	91.7	(1.7)	57.5*	(2.9)
(n)			(472)				(343)				(815)	

*Significant difference between baseline and follow-up surveys using two-tailed within-respondent paired *t*-tests evaluated at the 0.05 level of significance.

Table 5 The cross-sectional associations of hurricane-related stresses with estimated DSM-IV SMI and PTSD and suicidal ideation (n = 815)[a]

	SMI				PTSD				Suicidal ideation[b]			
	Cross-sectional		Cross-sectional		Cross-sectional		Cross-sectional		Cross-sectional		Cross-sectional	
	Baseline		Follow-up		Baseline		Follow-up		Baseline		Follow-up	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Severe	23.3*	(2.8–194.0)	59.7*	(16.6–214.8)	65.2*	(11.1–381.4)	37.6*	(9.5–148.8)	7.4*	(1.4–38.7)	3.2*	(1.0–9.7)
Serious	3.6	(0.4–30.7)	45.1*	(12.8–158.7)	20.4*	(3.4–123.7)	18.7*	(4.8–73.4)	7.4*	(1.4–38.7)	3.2*	(1.0–9.7)
Moderate	3.9	(0.3–46.9)	12.7*	(3.6–45.2)	7.5	(1.0–58.5)	5.4*	(1.5–19.5)	—		—	
Mild	1.2	(0.1–20.9)	4.9*	(1.0–23.6)	2.1	(0.2–29.6)	4.6*	(1.2–17.0)	—		—	
χ_4^2 (P-value)	32.7	(<0.001)	51.7	(<0.001)	38.9	(<0.001)	34.0	(<0.001)	5.6	(0.018)	4.0	(0.044)
χ_3^2 difference** (P-value)[c]			8.1 (0.09)				1.2 (0.87)				0.8 (0.37)	

Abbreviations: CI, confidence interval; OR, odd ratio; PTSD, post-traumatic stress disorder; SMI, serious mental illness.
*Significant difference between baseline and follow-up surveys based on two-tailed within-respondent paired *t*-tests evaluated at the 0.05 level of significance.
**Significant difference in cross-sectional associations between the two surveys. None of these differences was significant at the 0.05 level using two-sided tests.
[a]Multivariate logistic regression models controlling for socio-demographics and for differences between the New Orleans Metro sub-sample and the remainder of the sample. No significant differences in results were found in the New Orleans Metro sub-sample versus the remainder of the sample (detailed results available on request).
[b]Due to the rarity of suicidal ideation and the extreme nonlinearity of the association between hurricane-related stress and this outcome, the latter was dichotomized as severe-serious vs all others (that is, moderate through none).
[c]Difference in the set of four ORs between the two surveys.

pronounced in the New Orleans Metro sub-sample than in the remainder of the sample ($\chi_4^2 = 5.1$, $P = 0.28$; detailed results available on request) This means that heightened reactivity to hurricane-related stress cannot explain the fact that the significant increase in SMI is confined to respondents in the sub-sample exclusive of the New Orleans Metro Area. Furthermore, the pattern of higher ORs at follow-up than baseline does not hold either for PTSD or for suicidal ideation. In the case of suicidal ideation, the rarity of the outcome required the stress measures to be dichotomized (severe stress vs all others) to stabilize parameter estimates.

The model was expanded to study the effects of hurricane-related stress on trends in SMI, PTSD and suicidal ideation. This was carried out by adding a control for the baseline value of the outcome to the prediction equation along with measures of stress assessed in both surveys. Baseline stress was not a significant predictor of trends in either SMI ($\chi_4^2 = 4.3$, $P = 0.37$) or PTSD ($\chi_4^2 = 8.0$, $P = 0.09$), while stress at follow-up was significant in both equations ($\chi_4^2 = 31.5$, $P < 0.001$; $\chi_4^2 = 13.0$, $P = 0.011$). No significant interactions were found between baseline stress and follow-up stress or between sub-sample (that is, New Orleans Metro vs the remainder of the sample) and either measure of stress (detailed results available on request). Based on these results, the final model for trends in SMI and PTSD included stress in the follow-up sample as

the only key predictor (Table 6). Stress exposure in this model is associated with substantial variation in both SMI and PTSD at follow-up, with ORs for serious-severe stress in the range 35.8–42.2 for SMI and 12.8–20.3 for PTSD after controlling for baseline SMI and socio-demographics.

A good way to grasp the substantive significance of these results is to examine standardized prevalence estimates of the outcomes SMI and PTSD at follow-up. The latter are prevalence estimates in which adjustments have been made to correct for the associations of stress with baseline values of the outcomes, socio-demographics and sub-sample, so that the effects of stress can be seen distinct from the effects of these other variables. These standardized prevalence estimates are 0.3% SMI and 1.4% PTSD among respondents with no residual hurricane-related stress compared to 29.5–30.6% SMI and 38.8–46.1% PTSD among respondents with moderate-to-severe stress. If we think of these associations as causal, the population-attributable risk proportions of SMI and PTSD due to hurricane-related stress (that is, the proportions of currently existing SMI and PTSD that would be expected to remit if all hurricane-related stress was resolved) are 89.2% for SMI and 31.9% for PTSD. (Detailed results available upon request.)

The best-fitting model is different for suicidal ideation, as baseline stress and stress at follow-up (both dichotomized to severe-serious vs all others due to the rarity of the outcome and the nonlinearity of the association with hurricane-related stress) interact in predicting trends in suicidal ideation ($\chi_4^2 = 7.2$, $P = 0.007$). The best-fitting model is one that distinguishes respondents with severe-serious hurricane-related stress in one or both surveys vs all others.

An additional complication, though, is that the effect of stress in this model differs significantly between the New Orleans Metro sub-sample and the remainder of the sample ($\chi_4^2 = 8.47.2$, $P = 0.007$), with OR substantially higher among respondents not from the New Orleans Metro Area (104.1) than from New Orleans Metro (2.2). The prevalence estimates of suicidal ideation at follow-up among respondents with severe-serious hurricane-related stress are 3.1% in the New Orleans Metro sub-sample and 13.0% in the remainder of the sample compared to 0.3 and 0.0% among respondents without severe hurricane-related stress. If we think of these associations as causal, the population-attributable risk proportion of suicidal ideation associated with severe-serious hurricane-related stress is 61.6% in the total sample. (Detailed results available upon request.)

Discussion

Four principal limitations of the study need to be noted. First, mental disorders were estimated with screening scales rather than with clinical interviews. It should be noted, though, that the K6 screening scale has previously been validated[21,23,24] and that the modified TSQ was found to be valid in our clinical reappraisal study. Nonetheless, screening scales are inevitably less precise than clinical interviews, generally leading to associations being attenuated. Based on this fact, the results reported here about predictors are likely to be conservative. Second, the baseline CAG survey response rate was low and the sampling frame excluded people who were unreachable by telephone. These problems presumably led to the most marginalized segments of the population being under-represented in the sample, making the

Table 6 The effects of hurricane-related stresses in predicting trends in estimated DSM-IV SMI and PTSD and suicidal ideation in the panel sample along with standardized prevalence estimates of the outcomes ($n = 815$)[a]

	SMI			PTSD			Suicidal ideation					
							New Orleans Metro			Remainder of the sample		
	%[b]	OR	(95% CI)	%[b]	OR	(95% CI)	%[b]	OR	(95% CI)	%[b]	OR	(95% CI)
Severe	30.6	42.2*	(11.2–159.3)	46.1	20.3*	(4.9–84.6)	3.1	2.2	(0.5–9.3)	13.0	104.1	(12.6–890.8)
Serious	30.6	35.8*	(9.7–133.0)	46.1	12.8*	(3.0–53.7)	3.1	2.2	(0.5–9.3)	13.0	104.1	(12.6–890.8)
Moderate	29.5	12.9*	(3.6–45.4)	38.8	4.4*	(1.2–16.1)	0.3	1.0	—	0.0	1.0	—
Mild	5.1	4.6	(0.9–22.7)	10.6	3.5	(1.0–12.6)	0.3	1.0	—	0.0	1.0	—
None	0.3	1.0	—	1.4	1.0	—	0.3	1.0	—	0.0	1.0	—
χ_4^2 (*P*-value)		39.0	(<.001)		21.0	(<0.001)		1.1	(0.30)		18.0	(<0.001)

Abbreviations: CI, confidence interval; OR, odd ratio; PTSD, post-traumatic stress disorder; SMI, serious mental illness.
*Significant difference from respondents with no hurricane-related stress (scores of 0–2 on the 0–10 scale) at the 0.05 level of significance.
[a]Multivariate logistic regression models controlling for socio-demographics, baseline values of the outcome variable and differences between the New Orleans Metro sub-sample and the remainder of the sample. No significant differences in results were found in the New Orleans Metro sub-sample versus the remainder of the sample (detailed results available on request).
[b]Standardized prevalence estimates adjusting for the associations of stress levels with all other predictors in the models.

prevalence estimates reported here of anxiety-mood disorders and hurricane-related stress conservative. Third, the ratings of hurricane-related stress were retrospective and subjective, raising concerns about bias related to current emotional functioning. Fourth, even though we interpreted the associations between hurricane-related stress and the outcome measures in causal terms, it is possible that unmeasured common causes (for example, pre-hurricane history of psychopathology that influenced stressor exposure and post-hurricane mental illness) influenced the observed associations. Caution is consequently needed in interpreting these associations.

Within the context of these limitations, the prevalence estimates of anxiety-mood disorders both at baseline and in the follow-up survey in the New Orleans Metro sub-sample are considerably higher than those found in previous surveys of mental illness after natural disasters in the United States, while the prevalence estimates in the remainder of the sample are comparable to those in previous studies.[35,36] Previous reviews have noted that comparisons of prevalence estimates across disasters is challenging due to the wide range of disaster experiences to which people in disasters are exposed. However, broadly speaking, the higher prevalence estimates of anxiety-mood disorders in the New Orleans Metro sub-sample are consistent with the results of studies that considered persons in highly disaster affected areas,[37,38] while the lower prevalence estimates in the remainder of the sample are consistent with the results of previous studies in areas with lower disaster impact.[39,40]

The significant increase in prevalence estimates of SMI, PTSD and suicidal ideation plans are different from the patterns found in other longitudinal surveys of mental illness after natural disasters, where prevalence typically decreases.[7–9] As noted in the Introduction, even in cases where there is no decrease, the typical pattern is for prevalence to remain stable for some time rather than to increase significantly[9] The increasing prevalence of SMI, PTSD and suicidal ideation plans in the CAG is consequently striking.

The fact that the increases in SMI and PTSD are confined to respondents not from the New Orleans Metro Area is difficult to interpret in light of the higher levels of hurricane-related stress both at baseline and at follow-up in the New Orleans Metro sub-sample. It is possible to speculate post hoc that the much greater media attention directed at New Orleans than the other areas affected by Katrina might have led to a greater sense of abandonment among affected people not from the New Orleans Metro Area, but we have no data to evaluate this interpretation. Another possibility is that the increases in SMI, PTSD and suicidality are partly due to increases in stressors that might only be indirectly linked to the hurricane. This possibility is consistent with evidence from several longitudinal studies that low-intensity ongoing stressors significantly predict long-term PTSD, presumably

because these nagging stressors erode the resistance resources that would otherwise promote recovery.[41,42] However, it is unclear why such stressors might be more prevalent among people not from the New Orleans Metro Area than from New Orleans Metro. Finally, there is the possibility that psychological vulnerability to such stressors is higher among people not from the New Orleans Metro Area and that this heightened vulnerability explains why the increases in SMI and PTSD documented here were confined to this sub-sample. Exactly this kind of difference was found in our analysis of the association between residual hurricane-related stress and suicidal ideation. However, caution is needed in interpreting this result due to the small number of respondents with suicidal ideation and the wide confidence interval of the estimated OR in the sub-sample of respondents not from New Orleans Metro.

The findings that young people, people with low socio-economic status and people who were geographically displaced are at comparatively high risk of anxiety-mood disorders and are consistent with previously documented correlates of mental illness after disasters[35,36] and other traumas.[43] Importantly, though, these associations are modest in magnitude, suggesting that the mental illness associated with Hurricane Katrina is distributed across the full range of the socio-demographic spectrum of the affected population. It is noteworthy in this regard that the significant upward trends in SMI, PTSD and suicidality were found to be unrelated to sex, race/ethnicity, education and health insurance status.

These results lead to four conclusions. First, hurricane-related stress clearly is playing a critical role in the high prevalence of hurricane-related anxiety-mood disorders in this population. Second, the fact that the associations between these stresses and the mental health outcomes considered here were stronger among affected people from areas other than the New Orleans Metro Area suggests that undetermined stress and/or vulnerability factors are present among people from areas other than New Orleans Metro that should lead policy makers to focus special attention on the needs of these people. It is noteworthy that the opposite pattern was found in an earlier analysis of anxiety-mood disorders in the baseline survey, where effects of the stressors that occurred during the hurricane and the immediate aftermath were stronger in the New Orleans Metro sub-sample than the remainder of the sample.[3] It is unclear why this geographic variation has reversed in the subsequent year. Third, the observation that these adverse effects are only weakly related to socio-demographic variables means that efforts to address the needs for mental health treatment in this population need to deal with all segments of the population rather than target only specific high-risk population segments. Fourth, the fact that hurricane-related stressors were still quite common in the population at the time of our follow-up assessment, which occurred nearly 2 years after the hurricane, and that

high proportions of the outcomes at follow-up were attributable to these continuing stresses suggests that efforts to address the problem of increased mental illness and suicidal ideation-plans among people affected by Hurricane Katrina will require efficient provision of practical and logistical assistance to deal with the high remaining levels of stress. This may be particularly challenging when it comes to helping pre-hurricane residents of the affected areas who are now living elsewhere in the country, but it is especially important to reach these geographically displaced people because of their comparatively high risk of SMI.

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