Understanding Associations Between Hurricane Harvey Exposure and Mental Health Symptoms Among Greater Houston-Area Residents

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ABSTRACT

Objective Hurricane Harvey made landfall on August 25, 2017 and resulted in widespread flooding in Houston and the surrounding areas. This study aimed to explore the associations between exposure to Hurricane Harvey and various mental health symptoms.

Methods Self-reported demographics, hurricane exposure, and mental health symptomatology were obtained from residents of the greater Houston area through convenience sampling for a pilot study, 5 months after the storm from January 25-29, 2018 (N = 161).

Results Increased hurricane exposure score was significantly associated with increased odds for probable depression, probable anxiety, and probable posttraumatic stress disorder after adjusting for other factors associated with mental health. No significant associations were found between demographic characteristics and risk of mental health difficulties.

Conclusions Mental health difficulties associated with exposure to Hurricane Harvey were still present 5 months after the storm. Future disaster response programs should focus on providing long-term mental health services to hurricane survivors.

Key Words: disaster medicine, hurricanes, mental health, vulnerable populations

On August 25, 2017 Hurricane Harvey made landfall near Corpus Christi, Texas, as a Category 4 hurricane with a diameter of 280 miles and 130 mph winds.[1] Harvey, a 500-year flood event, was unprecedented in its scale and impact.[2] The storm dumped over 27 trillion gallons of water on Texas and Louisiana in 6 days and set a record in the continental United States for rainfall during a storm of 51 inches.[1] The catastrophic flooding left tens of thousands of residents stranded in their homes and damaged hundreds of thousands of structures.[3] Approximately 336 000 people lost power and 30 000 water rescues were conducted.[3] In the first 15 hours of the storm, Houston 911 received 56 000 calls, and emergency services continued to receive an estimated 1000 calls per hour 4 days after the storm.[1] Overall, an estimated 40 000 people were displaced and 68 people killed as a direct result of Hurricane Harvey in the United States.[3]

Harvey was part of an unprecedented hurricane season that included Hurricane Maria, a Category 5 storm that devastated parts of the Caribbean, including much of Puerto Rico, and Hurricane Irma, a Category 4 storm that caused severe damage in Western Florida. The acute and long-term effects of such natural disasters are well established in the literature.[4-14] Previous research has demonstrated that increased exposure to a natural disaster is associated with increased symptoms of anxiety, depression, and/or posttraumatic stress disorder (PTSD) immediately post-disaster and later in life.[4-6,8-14] Experiencing a natural disaster has also been found to be correlated with increased suicidal ideation and attempts, as well as substance use.[4,13] These impacts on mental health have been found to be directly related to the intensity and type of disaster exposure experienced by an individual.[4,7,15-18]

Due to its proximity to the Gulf of Mexico, Houston, nicknamed the "Bayou City," is particularly vulnerable to flooding, and Hurricane Harvey was the third 500-year flood (ie, a flood with a 1-in-500 (0.2%) chance of occurring in any given year) in the city in less than a decade.[4] Houston and its surrounding areas are located on a gulf coastal plain that was once forest, marsh, and swampland, and downtown Houston sits only 50 feet above sea level.[2] The city's vulnerability to flooding is further exacerbated by clay soil that does not absorb water well and the paving and development of over 38 000 acres that were once wetlands.[19] The frequency and severity of floods in Houston make it a unique environment in which to study the impacts of hurricane exposure.

In addition to its unique geographical attributes, Houston is also uniquely diverse. A city of approximately 2.3 million people, 58% of residents identify as White, 22.8% as Black or African American, 6.7% as Asian, and 44.3% as Latino or Hispanic.[20] Houston is home to large immigrant populations, including Vietnamese, Ethiopian, and Indian communities, among others.[21] An estimated 145 languages are spoken in the city, and it is considered the most ethnically diverse metropolitan area in the United States.[22] Research on the impact of natural disasters on certain ethnic minority groups is mixed. While studies have found that minorities may be at higher risk for mental health issues following a natural disaster,[23,24] the literature also suggests that being a member of an ethnic minority group may be a protective factor.[25] In this way, the impacts of Hurricane Harvey should be examined in the context of the city's racial and ethnic makeup.

Preliminary data have been published on the acute mental health impacts of Hurricane Harvey.[26,27] However, this report builds on the existing literature by assessing longer term psychological health at 5 months post-hurricane. The current study aims to assess whether increased negative experiences due to Hurricane Harvey are associated with increased symptoms of PTSD, perceived stress, anxiety, and depression within the context of a highly diverse and geographically unique setting.

Approval for this study was given by the Institutional Review Board of Northwell Health (IRB# 13-499B).

METHODS
Participants
The study enrolled 161 consenting participants living in the greater Houston area during Hurricane Harvey. Study staff used convenience sampling facilitated by community and academic partnerships in the Houston area. Community partners assisted staff in organizing and promoting recruitment events over the course of 1 week in January 2018 at 5 community partner locations, including local libraries and community centers. Efforts were made to recruit a study sample reflective of the ethnic and racial makeup of Houston by holding recruitment events in distinct neighborhoods throughout the Houston metropolitan area. Recruitment and survey administration took place from January 25-29, 2018. Individuals who did not speak English or Spanish or those who had cognitive impairment that might hinder their ability to provide informed consent were excluded from the study. Figure 1 represents the geographic distribution of participants.

Surveys
Pilot Survey
Demographic and lifestyle information were collected from all participants. The pilot survey contained validated measures of symptoms of behavioral and mental health, including alcohol and substance misuse, PTSD, perceived stress, anxiety, and depression. Participants also completed a section specific to exposure to Hurricane Harvey. The survey took approximately 30 minutes to complete, and participants were given the option to complete the survey on paper or on an iPad. All participants were provided US $20 on a rechargeable gift card as compensation for completing the survey.

Independent Variable
The hurricane exposure tool, used in previous research with Hurricane Sandy[5,8,10-12] and informed by previous research conducted during Hurricanes Katrina[28] and Andrew,[29] was tailored to Hurricane Harvey. It included 30 Yes/No items of possible hurricane experiences. Participants were asked, "Did any of the following apply to your experience during Hurricane Harvey?" Items included personal exposure measures such as injury/death of a friend or family member and property exposure such as a damaged/destroyed home.[8] The number of hurricane exposures checked was summed to define a hurricane exposure score.

Outcome Variables
Mental health symptom evaluated included PTSD, perceived stress, anxiety, and depression. PTSD during the last month was measured using the self-reported Post-Traumatic Stress Disorder Checklist Specific (PCL-5), a validated 20-item checklist widely used in previous disaster studies.[30] Each item on the scale was asked specifically in relation to Hurricane Harvey. Perceived stress over the last month was defined using the 10-item Perceived Stress Scale (PSS), which is validated and used earlier in disaster studies.[31] Anxiety and depression symptoms during the previous 2 weeks were measured using the Generalized Anxiety Disorder-7 (GAD-7)[32] and the Patient Health Questionnaire (PHQ-9)[33] instruments. Items from each instrument were summed to create symptom severity scores for PTSD (range = 0-80), PSS (range = 0-40), depression (range = 0-27), and anxiety (range = 0-21). If a participant missed $\geq$ 3 items in a scale, his/her symptom severity score was considered missing and was therefore not included in the analysis. Each mental health symptom severity score was then dichotomized as yes/no indicators of probable PTSD ($\geq$ 30/< 30),[34] probable anxiety (> 10/$\leq$ 10),[32] and probable depression (> 10/$\leq$ 10).[33] As a post-hoc exploratory analysis, a composite measure of overall mental health was created to indicate any elevated symptoms of PTSD, anxiety, or depression.

Substance abuse outcomes measured were alcohol misuse and recreational drug use. Alcohol abuse was defined using criteria for excessive drinking. If in the past year a male drank $\geq$ 5 drinks in a day ($\geq$ 4 drinks for a female) on a monthly basis or more, or drank $\geq$ 15 drinks a week ($\geq$ 8 drinks for a female), she/he was categorized as engaging in alcohol misuse.[35] Recreational drug use was defined as

FIGURE 1

Distribution of Zip Codes of Pilot Sample of Residents in Houston, TX, January 2018.
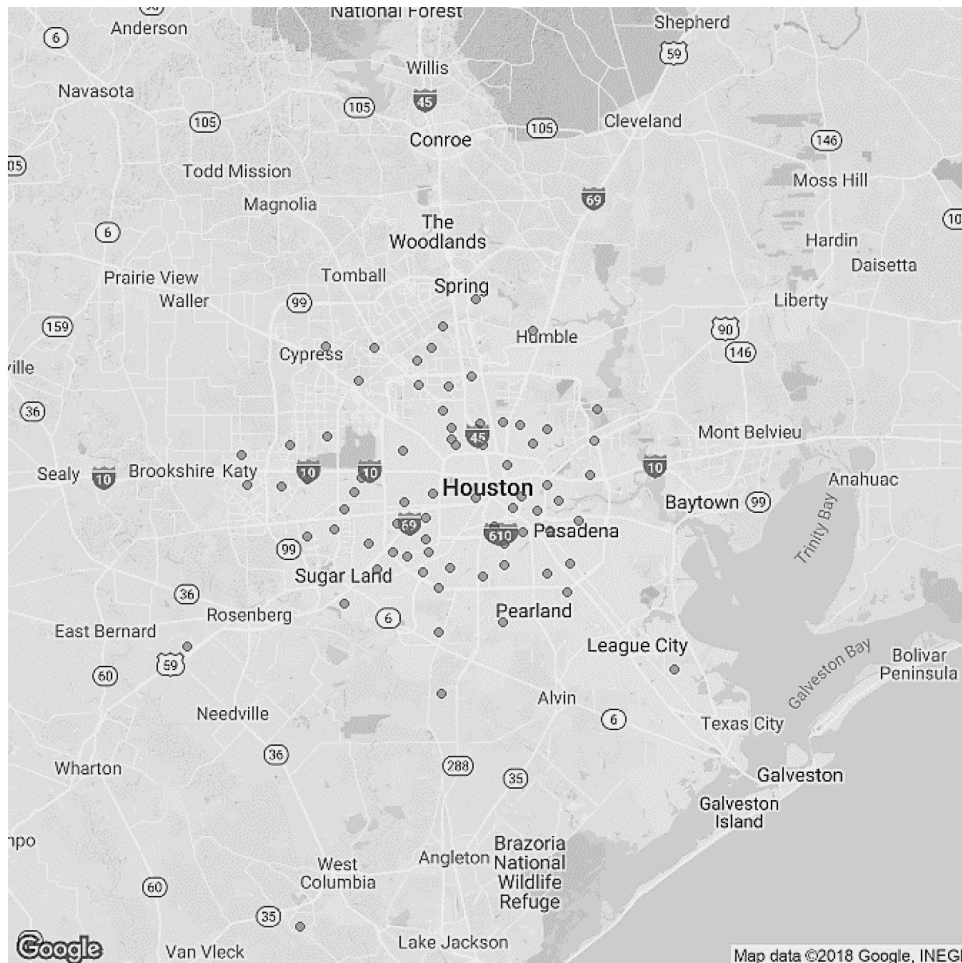
using recreational drugs or using a prescription drug for non-medical use at least once or twice or more frequently within the last year.[36]

Other Study Variables

Demographic variables included age, gender, race (White, American Indian/Alaska Native, Black, Asian, other, multiple races), Hispanic ethnicity (yes/no), level of education (completed high school [HS] or above, some HS or below), being born in the United States (yes/no), and yearly household income (< US $9000, $10 000-$38 000, $39 000-$92 000, $93 000-$192 000, > $193 000).[37] Yearly household income was dichotomized as ≤ US $38 000 and ≥ US $39 000 for analysis. Current tobacco use was assessed based on a question asking about current smoking status.[38] Those who reported having been diagnosed with a mental health condition prior to the hurricane were categorized as having a history of mental illness. Current mental health treatment status was measured

with a yes/no question. Participants were also asked with a yes/no question whether they experienced past hurricanes.

Statistical Analysis

Participants were described by study characteristics overall and by number of hurricane exposure items. Differences between characteristics and the hurricane exposure score were assessed using the Mann-Whitney Rank Sum tests or Kruskal-Wallis test, and Spearman's Rank Correlation (rho) for categorical and discrete study variables, respectively. The distribution of zip codes that participants resided in was generated from R statistical programming language 3.5.1,[39] using the "ggmaps" package.[40]

A multiple linear regression was performed to determine the association between the hurricane exposure score and PSS symptom score. Because the distribution of the residuals for anxiety, depression, and PTSD symptom scores was not

normal and heteroscedastic, the dichotomous variables of probable anxiety, probable depression, and probable PTSD were used as outcomes and modeled using the multivariable exact logistic regression. All models adjusted for variables significantly associated ($P < 0.2$) with outcomes at the univariable level. A multivariable logistic regression was also fitted to evaluate the association between hurricane exposure and substance abuse outcomes, alcohol misuse and current smoking status, with the same adjustments. Recreational drug use was not modeled due to instability of parameter estimates. For logistic regression models, adjusted odds ratios (OR) and 95% confidence intervals (95% CI) are reported. For linear regression models, adjusted parameter estimates (B) are reported. All analyses were conducted using SAS 9.4 (SAS Institute, Cary, NC).

RESULTS

Participants had an average age of 44.58 years (SD = 13.46) (Table 1). Blacks and Whites comprised 43.48% and 32.92% of the sample, and 23.60% identified as Hispanic. About 75% of the sample had greater than an HS education and 80.75% were born in the United States. Approximately 20% of participants indicated that they had a history of mental illness, and 9.94% were currently being treated for mental health issues. Sixty-four percent indicated that they had experienced past hurricanes.

The survey was completed about 5 months after Hurricane Harvey for all participants. Median hurricane exposure score was 4 (interquartile: 2-7). Participants most frequently indicated having difficulty commuting to work/school and losing power/electricity (Figure 2). Death, injury, or missing family members was indicated less than 5% of the time. However, 6.21% of participants had a friend who died, and 7.45% had a friend who was physically harmed.

Greater hurricane exposure was significantly associated with being born in the United States (see Table 1). It was also weakly positively correlated with PSS (rho = 0.257), anxiety (rho = 0.286), and depression symptom severity scores (rho = 0.329), and moderately with PTSD symptom severity scores (rho = 0.524). No other associations with study characteristics were found.

From the multivariable logistic regression models (N = 150, 93.2%), an increased hurricane exposure score (Table 2) was significantly associated with increased odds for probable depression (OR = 1.20, 95% CI: 1.09, 1.34), probable anxiety (OR = 1.18, 95% CI: 1.07, 1.31), and probable PTSD (OR = 1.26, 95% CI: 1.10, 1.45), after adjusting for US born status and history of mental illness (which were significantly associated with the 3 outcomes at the univariable level). Those who had a history of mental illness had increased odds for probable depression (OR = 3.23, 95% CI: 1.19, 8.80) and being a current smoker (OR = 3.09, 95% CI: 1.23, 7.75)

compared to those without a history of mental illness, but it was not significant for the other outcomes. US born status was not associated with any of the outcomes.

From the linear regression (N = 158, 98.1%), an increase in hurricane exposure score was also significantly associated with a 0.33 point increase in PSS symptom score (95% CI: 0.08, 0.58), while adjusting for gender. Female gender was also associated with a 2.55 (95% CI: 0.15, 4.96) point increase in PSS symptom score compared to male gender. No significant associations were found between the hurricane exposure score and substance abuse outcomes. Similar to the main analysis, the post hoc analysis involving the composite measure of overall mental health showed that an increased hurricane exposure score was associated with 1.2 (95% CI: 1.09, 1.33) increased odds of having any elevated mental health symptoms.

DISCUSSION

The present analysis indicates that exposure to Hurricane Harvey is significantly associated with symptoms of PTSD, anxiety, depression, and perceived stress. The association between hurricane exposure and current mental health symptoms remains when adjusting for factors associated with such symptoms on the univariable level in our sample, including having a history of mental health difficulties, which is consistently a strong predictor of current mental health symptoms.[41-44] US born status and history of mental health difficulties were significantly associated with anxiety, depression, and PTSD on the univariable level and were therefore adjusted for in multivariable modeling. Gender was the only demographic variable associated with perceived stress univariably and was therefore adjusted for in the multivariable model. These results suggest that post-disaster intervention should focus not only on the immediate physical safety and well-being of survivors, but also on their long-term mental health.

Interestingly, demographic characteristics typically found to be associated with increased risk of mental health difficulties in the wake of a natural disaster were not associated with increased odds of mental health difficulties in this sample following Hurricane Harvey, with the exception of the association between gender and perceived stress. As mentioned previously, literature on the impact of natural disasters on racial and ethnic minority groups is varied with some studies finding an increased risk of mental health difficulties among minorities post-disaster[23,24] and other studies, suggesting that membership in certain ethnic minority groups, for example, the Vietnamese community in the wake of Hurricane Katrina, may be protective against mental health difficulties post-disaster.[25] Unlike our sample, lower educational attainment has previously been found to be associated with greater mental health difficulties post-disaster,[41] including increased odds of PTSD[5,12] and depression.[12] Finally, literature also

TABLE 1

Characteristics of a Pilot Sample of Residents and Median Hurricane Exposure Score in Houston, TX, January 2018

Characteristic	n	%	Median Hurricane Exposure Score (IQR)	P^b
Age years, mean (SD)	44.58	13.46		
Current gender identity				
Male	40	24.84	3 (1, 5)	0.22
Female	118	73.29	4 (2, 7)	
Race				
White	53	32.92	4 (2, 8)	0.14
American Indian/Alaska Native	2	1.24	0.5 (0, 1)	
Black	70	43.48	5 (2, 7)	
Asian	10	6.21	1.5 (1, 4)	
Other	13	8.07	4 (0, 6)	
Multiple races checked	8	4.97	4.5 (3, 7)	
Hispanic ethnicity				
No	119	73.91	4 (2, 7)	0.45
Yes	38	23.60	4 (1, 7)	
Education				
</= HS graduate	37	22.98	4 (2, 9)	0.45
> HS graduate	122	75.78	4 (2, 6)	
Born in the United States				
No	30	18.63	2 (1, 5)	0.014
Yes	130	80.75	4 (2, 8)	
Yearly household income, binary				
≤ US $38 000	60	37.27	5 (2, 8.5)	0.14
≥ US $39 000	95	59.01	4 (1, 6)	
History of mental health illness				
No	116	72.05	4 (1, 6)	0.25
Yes	35	21.74	4 (2, 8)	
Currently in mental health treatment				
No	145	90.06	4 (1, 7)	0.76
Yes	16	9.94	4 (2.5, 6.5)	
Experienced past hurricanes				
No	57	35.40	3 (1, 6)	0.21
Yes	104	64.60	4 (2, 7)	
Probable depression[a]				
No	127	78.88	3 (1, 6)	<.001
Yes	34	21.12	6 (4, 12)	
Probable anxiety[a]				
No	134	83.23	3 (1, 6)	<.001
Yes	27	16.77	6 (4, 11)	
Probable PTSD[a]				
No	148	91.93	4 (1, 6)	<.001
Yes	13	8.07	8 (5, 12)	
Recreational drug use				
No	146	90.68	4 (1, 7)	0.78
Yes	12	7.45	4.5 (2, 7.5)	
Current smoker				
No	127	78.88	4 (1, 7)	0.89
Yes	34	21.12	4 (2, 6)	
Alcohol misuse				
No	102	63.35	4 (1, 7)	0.86
Yes	59	36.65	4 (2, 7)	

Note. HS = high school; PTSD = posttraumatic stress disorder; SD = standard deviation.

[a]Probable PTSD (≥ 30/≤ 30), probable anxiety (> 10/≤ 10), and probable depression (> 10/≤ 10) are dichotomized indicators based on symptom severity scores from PCL-5, GAD-7, and PHQ-9 instruments, respectively.

[b]P value based on Mann–Whitney rank-sum test or Kruskal–Wallis test to assess the difference in distribution in hurricane exposure score by study variables.

suggests that less-resourced individuals or those of lower socio-economic status may also be more vulnerable to the mental health impacts of a natural disaster.[41,42]

It is possible that our results differ from these aforementioned studies on disparities among survivors due to contextual factors specific to each hurricane, such as policies and messaging

FIGURE 2

Percent Endorsing Hurricane Exposure Items in a Pilot Sample of Residents in Houston, TX, January 2018.
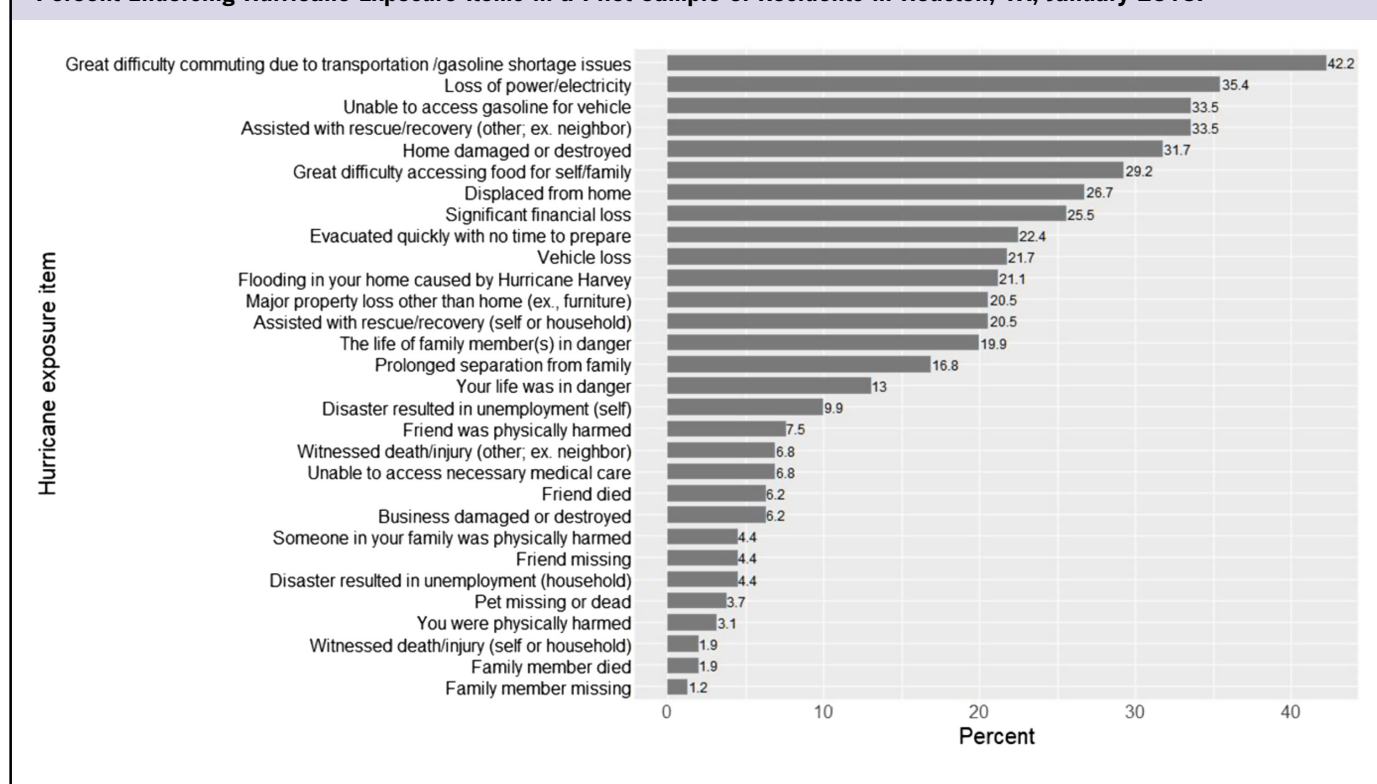
around evacuation. For example, earlier studies have shown that differential impacts of hurricane exposure on mental health can be attributed, in part, to barriers to evacuation faced by vulnerable populations.[23] For a storm of its magnitude, Hurricane Harvey was unique in that no mandatory evacuation was ordered for the area. Our findings could reflect the fact that, because the Houston's 2.4 million residents were not ordered to evacuate,[43] vulnerable groups as well as more well-resourced inhabitants may have been equally exposed to the hurricane and thus were at equal risk for mental health difficulties post-storm. However, longer term impacts of such disasters like exposure to toxins or chemicals,[44] the burden of rebuilding,[22] and the disruption of mental health treatment[24] may still disproportionately affect certain vulnerable subpopulations across different hurricanes and other natural disasters. Such disparities should be examined in future research among Hurricane Harvey survivors.

The association between perceived stress and female gender in our sample supports existing literature, which indicates that women and girls are at increased risk for mental health difficulties post-disaster.[45,46] Past research suggests that women are more likely to evacuate their homes during a hurricane,[45,47,48] possibly due to a heightened perception of risk[45] and familial obligations such as child and parental caregiving.[49] Because displacement has been found to be associated

with mental health difficulties,[10] evacuation may place women at greater risk of such difficulties following a disaster. A post hoc analysis of our sample supported the literature, with more women than men evacuating their homes prior to, during, and after the storm, though our sample size was too small to test for significance. Future research may focus on better understanding the psychosocial risk factors that place women at greater risk of mental health difficulties, and specific vulnerabilities faced by women in a post-disaster context should be considered in the development of any post-disaster mental health intervention.

The results should be interpreted within the context of the study's limitations. Convenience sampling was used to recruit participants, and, while the geographic distribution of participations by zip code in Figure 1 indicates that the sample covered a diverse geographic area, this strategy may have introduced self-selection bias wherein individuals more impacted by Harvey may have been more willing to participate. Although we have a diverse sample, due to convenience sampling, it is not representative of the larger Houston population. Perhaps a greater inclusion of people with fewer resources (lower educational attainment) would have demonstrated greater exposure and potentially greater mental health symptoms, as previous literature has indicated.[5,12,41,42] Another potential limitation is the small pilot sample size of

TABLE 2

Effects Between Increased Hurricane Exposure and Outcomes in a Pilot Sample of Residents in Houston, TX, January 2018

Outcome[a]	Effect of Hurricane Exposure
Probable depression, OR (95% CI)[b]	1.20 (1.09, 1.34)*
Probable anxiety, OR (95% CI)[b]	1.18 (1.07, 1.31)*
Probable PTSD, OR (95% CI)[b]	1.26 (1.10, 1.45)*
Perceived Stress Scale, B (95% CI)[c]	0.33 (0.08, 0.58)*
Composite mental health outcome, OR (95% CI)[b]	1.20 (1.09, 1.33)*
Current smoker, OR (95% CI)[b]	0.96 (0.86, 1.06)
Alcohol abuse, OR (95% CI)[b]	0.98 (0.90, 1.07)

Note. B = beta coefficient; CI = confidence interval; OR = odds ratio; PTSD = posttraumatic stress disorder.

[a]Probable PTSD (≥ 30/≤ 30), probable anxiety (> 10/≤ 10), and probable depression (> 10/≤ 10) are dichotomized indicators based on symptom severity scores from PCL-5, GAD-7, and PHQ-9 instruments, respectively.
[b]Odds ratios are from exact logistic regressions, adjusted for US born status and history of mental health difficulty.
[c]Beta coefficient is from multiple linear regression, adjusted for gender.
*Significance at $P = 0.05$.

161 participants. Future research should attempt to recruit a larger sample of the Houston metropolitan area using a random sampling of residents. Finally, mental health symptomatology was collected via self-reporting using validated measures. Future research could establish mental health burden through diagnosis by a mental health professional in order to reduce potential reporting bias.

CONCLUSIONS

Houston's proximity to the Gulf of Mexico and the continued development of wetlands place the city and its surrounding area at continued risk for severe flooding after future hurricanes. While the physical health and safety of the survivors of natural disasters is often prioritized in the days and weeks following a major weather event, the mental health burden experienced by survivors may last months and years post-disaster.[5,12] Greater public health preparedness planning is needed to develop infrastructure in which mental health services can be rapidly provided in the immediate aftermath of a future hurricane, as well as to provide sustainability for a longer term mental health service provision for individuals with chronic mental health concerns.[50]

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Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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REFERENCES

1. CNN. Hurricane Harvey aftermath. Published August 27, 2017. https://www.cnn.com/specials/us/hurricane-harvey. Accessed January 9, 2019.
2. Garfield L. Business Insider. Houston was a ticking time-bomb for a devastating hurricane like Harvey. Published August 28, 2017. https://www.businessinsider.com/hurricane-harvey-why-houston-flooded-2017-8. Accessed January 9, 2019.
3. Zelinsky B. National Hurricane Center. *Tropical Cyclone Report Hurricane Harvey*; 2018. https://www.nhc.noaa.gov/data/tcr/AL092017_Harvey.pdf. Accessed June 15, 2018.
4. Fergusson DM, Horwood LJ, Boden JM, Mulder RT. Impact of a major disaster on the mental health of a well-studied cohort. *JAMA Psychiatry.* 2014;71(9):1025-1031. doi: 10.1001/jamapsychiatry.2014.652.
5. Lieberman-Cribbin W, Liu B, Schneider S, et al. Self-reported and FEMA flood exposure assessment after Hurricane Sandy: association with mental health outcomes. *PLoS One.* 2017;12(1):e0170965. doi: 10.1371/journal.pone.0170965.
6. Maclean JC, Popovici I, French MT. Are natural disasters in early childhood associated with mental health and substance use disorders as an adult? *Soc Sci Med 1982.* 2016;151:78-91. doi: 10.1016/j.socscimed.2016.01.006.
7. Norris FH, Rosen CS. Innovations in disaster mental health services and evaluation: national, state, and local responses to Hurricane Katrina (introduction to the special issue). *Adm Policy Ment Health Serv Res.* 2009;36(3):159-164. doi: 10.1007/s10488-009-0218-y.
8. Schwartz RM, Liu B, Sison C, et al. Study design and results of a population-based study on perceived stress following Hurricane Sandy. *Disaster Med Public Health Prep.* 2016;10(3):325-332. doi: 10.1017/dmp.2015.157.
9. Schwartz RM, Rothenberg P, Kerath SM, et al. The lasting mental health effects of Hurricane Sandy on residents of the Rockaways. *J Emerg Manag West Mass.* 2016;14(4):269-279. doi: 10.5055/jem.2016.0292.
10. Schwartz RM, Rasul R, Kerath SM, et al. Displacement during Hurricane Sandy: the impact on mental health. *J Emerg Manag West Mass.* 2018;16(1):17-27. doi: 10.5055/jem.2018.0350.
11. Schwartz RM, Gillezeau CN, Liu B, et al. Longitudinal impact of Hurricane Sandy exposure on mental health symptoms. *Int J Environ Res Public Health.* 2017;14(9):957. doi: 10.3390/ijerph14090957.
12. Schwartz RM, Sison C, Kerath SM, et al. The impact of Hurricane Sandy on the mental health of New York area residents. *Am J Disaster Med.* 2015;10(4):339-346. doi:10.5055/ajdm.2015.0216
13. Stein DJ, Chiu WT, Hwang I, et al. Cross-national analysis of the associations between traumatic events and suicidal behavior: findings from the WHO World Mental Health Surveys. *PLoS One.* 2010;5(5):e10574. doi: 10.1371/journal.pone.0010574.
14. Thienkrua W, Cardozo BL, Chakkraband MLS, et al. Symptoms of posttraumatic stress disorder and depression among children in tsunami-affected areas in southern Thailand. *JAMA.* 2006;296(5):549-559. doi: 10.1001/jama.296.5.549.

15. La Greca A, Silverman WK, Wasserstein SB. Children's predisaster functioning as a predictor of posttraumatic stress following Hurricane Andrew. *J Consult Clin Psychol*. 1998;66(5):883-893.

16. Neria Y, Shultz JM. Mental health effects of Hurricane Sandy: characteristics, potential aftermath, and response. *JAMA*. 2012;308(24):2571-2572. doi: 10.1001/jama.2012.110700.

17. Sattler DN, Preston AJ, Kaiser CF, et al. Hurricane Georges: a cross-national study examining preparedness, resource loss, and psychological distress in the U.S. Virgin Islands, Puerto Rico, Dominican Republic, and the United States. *J Trauma Stress*. 2005;15(5):339-350. doi: 10.1023/A:1020138022300.

18. van Griensven F, Chakkraband MLS, Thienkrua W, et al. Mental health problems among adults in tsunami-affected areas in southern Thailand. *JAMA*. 2006;296(5):537-548. doi: 10.1001/jama.296.5.537.

19. Quinn L. Why is Houston so prone to major flooding? Published August 28, 2017. https://www.cbsnews.com/news/harvey-why-is-houston-so-prone-to-major-flooding/. Accessed January 9, 2019.

20. U.S. Census Bureau QuickFacts: Houston city, Texas. United States census. Published 2017. https://www.census.gov/quickfacts/fact/table/houstoncitytexas/PST045217. Accessed January 9, 2019.

21. Mejia B. How Houston has become the most diverse place in America. *Los Angeles Times*. Published May 9, 2017. http://www.latimes.com/nation/la-na-houston-diversity-2017-htmlstory.html#. Accessed June 15, 2018.

22. Klineberg S. The 2018 Kinder Houston Area Survey: tracking responses to income inequalities, demographic transformations, and threatening storms. Houston, TX: Rice University Kinder Institute for Urban Research. 2018. https://kinder.rice.edu/sites/g/files/bxs1676/f/documents/Kinder%20Houston%20Area%20Survey%202018.pdf. Accessed June 15, 2018.

23. Toldson IA, Ray K, Hatcher SS, Straughn Louis L. Examining the long-term racial disparities in health and economic conditions among Hurricane Katrina survivors: policy implications for Gulf Coast recovery. *J Black Stud*. 2011;42(3):360-378. doi: 10.1177/0021934710372893.

24. Wang PS, Gruber MJ, Powers RE, et al. Disruption of existing mental health treatments and failure to initiate new treatment after Hurricane Katrina. *Am J Psychiatry*. 2008;165(1):34-41. doi: 10.1176/appi.ajp.2007.07030502.

25. Fussell E, Sastry N, VanLandingham M. Race, socioeconomic status, and return migration to New Orleans after Hurricane Katrina. *Popul Environ*. 2010;31(1-3):20-42. doi: 10.1007/s11111-009-0092-2.

26. Shultz JM, Galea S. Mitigating the mental and physical health consequences of Hurricane Harvey. *JAMA*. 2017;318(15):1437-1438. doi: 10.1001/jama.2017.14618.

27. Taioli E, Tuminello S, Lieberman-Cribbin W, et al. Mental health challenges and experiences in displaced populations following Hurricane Sandy and Hurricane Harvey: the need for more comprehensive interventions in temporary shelters. *J Epidemiol Community Health*. 2018;72(10):867-870. doi: 10.1136/jech-2018-210626.

28. Harville EW, Xiong X, Smith BW, et al. Combined effects of Hurricane Katrina and Hurricane Gustav on the mental health of mothers of small children. *J Psychiatr Ment Health Nurs*. 2011;18(4):288-296. doi: 10.1111/j.1365-2850.2010.01658.x.

29. Norris FH, Perilla JL, Riad JK, et al. Stability and change in stress, resources, and psychological distress following natural disaster: findings from Hurricane Andrew. *Anxiety Stress Coping*. 1999;12(4):363-396. doi: 10.1080/10615809908249317.

30. Blevins CA, Weathers FW, Davis MT, et al. The posttraumatic stress disorder checklist for DSM-5 (PCL-5): development and initial psychometric evaluation. *J Trauma Stress*. 2015;28(6):489-498. doi: 10.1002/jts.22059.

31. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. *J Health Soc Behav*. 1983;24(4):385-396.

32. Löwe B, Decker O, Müller S, et al. Validation and standardization of the generalized anxiety disorder screener (GAD-7) in the general population. *Med Care*. 2008;46(3):26-274.

33. Martin A, Rief W, Klaiberg A, Braehler E. Validity of the brief Patient Health Questionnaire Mood Scale (PHQ-9) in the general population. *Gen Hosp Psychiatry*. 2006;28(1):71-77. doi: 10.1016/j.genhosppsych.2005.07.003.

34. Weathers FW, Litz BT, Herman DS, et al. The PTSD Checklist (PCL): Reliability, Validity, and Diagnostic Utility. Annual Convention of the International Society for Traumatic Stress Studies, Vol. 462. San Antonio, Texas, October 24, 1993.

35. Services USD of H and H, Agriculture USD of. *Dietary guidelines for Americans 2015-2020*. Washington, DC: Skyhorse Publishing; 2017.

36. SAMHSA. SBIRT: a resource toolkit for behavioral health providers to begin the conversation with federally qualified healthcare centers. n. d. https://www.integration.samhsa.gov/SBIRT_Toolkit_for_working_with_FQHCs.pdf. Accessed June 15, 2018.

37. Pomerleau K. Tax Foundation. 2017 tax brackets. 2016. https://files.taxfoundation.org/20170123140911/TaxFoundation-FF534.pdf. Accessed June 15, 2018.

38. World Health Organization and Centers for Disease Control (U.S.). Tobacco questions for surveys: a subset of key questions from the Global Adult Tobacco Survey (GATS): Global Tobacco Surveillance System. 2011. http://www.who.int/iris/handle/10665/87331. Accessed June 15, 2018.

39. R Core Team. R: a language and environment for statistical computing. Vienna, Austria; n. d. https://www.R-project.org/. Accessed June 15, 2018.

40. Kahle D, Wickham H. ggmap: spatial visualization with ggplot2. *R J*. 2013;5(1):144-161.

41. Sastry N, VanLandingham M. One year later: mental illness prevalence and disparities among New Orleans residents displaced by Hurricane Katrina. *Am J Public Health*. 2009;99(Suppl 3):S725-S731. doi: 10.2105/AJPH.2009.174854.

42. Subaiya S, Moussavi C, Velasquez A, Stillman J. A rapid needs assessment of the Rockaway Peninsula in New York City after Hurricane Sandy and the relationship of socioeconomic status to recovery. *Am J Public Health*. 2014;104(4):632-638. doi: 10.2105/AJPH.2013.301668.

43. Andone D. CNN. Why didn't Houston evacuate? Published August 29, 2017. https://www.cnn.com/2017/08/27/us/houston-evacuation-hurricane-harvey/index.html. Accessed January 9, 2019.

44. Schwartz RM, Tuminello S, Kerath SM, et al. Preliminary assessment of Hurricane Harvey exposures and mental health impact. *Int J Environ Res Public Health*. 2018;15(5):974. doi: 10.3390/ijerph15050974.

45. Fothergill A. The neglect of gender in disaster work: an overview of the literature. In: Enarson EP, Morrow BH, editors. *Gendered Terrain Disaster Women's Eyes*. Westport, CT: Praeger Publishing; 1998:11-25.

46. Neumayer E, Plümper T. The gendered nature of natural disasters: the impact of catastrophic events on the gender gap in life expectancy, 1981-2002. *Ann Assoc Am Geogr*. 2007;97(3):551-566. doi: 10.1111/j.1467-8306.2007.00563.x.

47. Bateman M, Edwards B. Gender and evacuation: a closer look at why women are more likely to evacuate for hurricanes. *Nat Hazards Rev*. 2002;3(3):107-117. doi: 10.1061/(ASCE)1527-6988(2002)3:3(107).

48. Bolin R, Jackson M, Crist A. The gendered terrain of disasters: through women's eyes. In: Elaine E, Morrow BH, eds. *Gender Inequality, Vulnerability, and Disasters: Theoretical and Empirical Considerations*. Westport, CT: Praeger; 1996:27-44.

49. Gladwin H, Peacock WG. Warning and evacuation: a night for hard houses. In: Gladwin H, Peacock WG, editors. *Hurricane Andrew: Ethnicity, Gender, and the Sociology of Disasters*. New York: Routledge; 1997:52-74.

50. Rasul R. Linkage to mental health care in the Rockaways after Hurricane Sandy. Oral presentation presented at the American Public Health Association Annual Meeting, November 6, 2017, Atlanta, GA.