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## The Impact of Hurricane Harvey on the Wellbeing of Hospitalized Children and Their Families

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## INTRODUCTION

Hurricane Harvey (HH) devastated large areas of Texas and Louisiana during August and September 2017. With an estimated \$125 billion in total damages, it ranks as the second costliest tropical cyclone in United States history after Hurricane Katrina. In Texas, this hurricane directly caused 68 fatalities, most of which were drownings.<sup>1</sup> The immediate attention from the media, medical community, relief organizations, and policymakers provided a tremendous amount of support for minimizing the short-term health threats faced by the population devastated by this storm. However, this spike in resource allocation is time-limited, while the health effects of large-scale disasters months and years later may lead to significantly more morbidity and mortality than the immediate disaster.<sup>2,3</sup>

The social and economic vulnerabilities of a community are often magnified in the context of a natural disaster. Although different in many ways, Hurricane Katrina was similar to HH in terms of its impact on a broad range of socioeconomic classes in one large population center. One study conducted in the aftermath of Hurricane Katrina reported that low-income parents in New Orleans had significantly more hurricane-related stressors compared to those with higher baseline resources, and those experiencing more severe stressors were more likely to experience adverse mental and physical health consequences a year or more after the hurricane.<sup>4</sup> Studies have shown that vulnerable groups are not only at greater risk for flood exposure but also at greater risk for related negative health outcomes.<sup>3</sup> Improved understanding is needed about the effects of natural disasters, and flooding such as that caused by HH, on the health and well-being of children and their families.<sup>5,6</sup> Much of the recent data in this area came after Hurricane Katrina in New Orleans and surrounding areas. In contrast, Houston is a much more populous urban area with a younger and more diverse population.<sup>7</sup>

In particular, children's hospitals often care for an economically diverse population, including the most vulnerable and underserved children. For children hospitalized within 3 months after HH, our aims were to a) assess material hardship, disruptions in daily life, disruptions in health maintenance, and health outcomes of those severely affected by HH and b) describe differences in these outcomes based upon family income. The goal of this pilot study is to better inform healthcare organizations in how to best prepare for meeting the needs of families after natural disasters.

## METHODS

**Study Setting and Participants.** This was a cross-sectional study conducted on patients admitted to the pediatric hospital medicine service at a free-standing, urban, quaternary care hospital in Houston, Texas. The hospital had approximately 22,000 pediatric admissions in the most recent year reported. Inclusion criteria included patients  $\leq 18$  years old admitted to the pediatric hospital medicine service. Exclusion criteria included patients in child protective services custody, home residence outside of the Houston metropolitan area (defined as greater than approximately 30 miles from downtown Houston), non-English speakers, and inability to adequately complete the written survey on their own or verbally with the researcher in English. The institutional review board of the study site approved this study. All patients over 8 years of age provided assent, and their primary caregivers provided written informed consent.

**Study Design.** Patients were identified using electronic medical record review. If present in the patients' room during study enrollment, patients' primary caregivers were approached for study enrollment within 2 calendar days of the patients' admission. From October 25 to November 21, 2017, all data were collected using a survey that was administered either on paper or verbally if the subject preferred. The 59-item survey (see Appendix) was administered to caregivers by the study's principal investigator. The survey collected data in 2 areas: baseline sociodemographic characteristics and effects from HH. First, sociodemographic characteristics were collected. This included validated questions to screen for food insecurity and homelessness risk.<sup>8,9</sup> Other questions were newly developed by the authors to assess the effects from HH in 4 main areas: a) direct material losses as described in "Measures" below; b) disruptions in daily living from HH on the participant's immediate family and household, including assessment of change in worry about food for the household, lost employment, missed work, application for relief aid, and disruption of children's school or daycare; c) disruptions in health maintenance, including loss of prescription medications, loss of vaccination records, and difficulty seeking medical care; and d) health impacts, including overall perceptions of the hurricane's impact on the health of the family, change in household stress, and changes in physical and mental health before and after the hurricane with a focus on both the patient and the caregiver surveyed. The survey was initially piloted with 32 caregivers to ensure the questions and answers were read and interpreted as intended. Nine of these caregivers took the survey twice to confirm reliability.

**Measures.** The “low-income” group was defined as those reporting less than \$50,000 in annual household income. The U.S. Department of Housing and Urban Development defined \$50,000 as “low income” for a family of 4 in Texas in 2017.<sup>10</sup> We defined the “severely impacted” group as subjects that either lost >50% of their household material belongings, experienced indefinite displacement from the home, or lost a family vehicle due to the hurricane. The remaining survey respondents were classified as “not severely impacted.” This information was extracted from 2 open-ended prompts: “Describe how you and your family have been impacted by HH” and “If your home flooded during HH, please describe.” The classification “severely impacted” was conceptually driven after review of response patterns and categorizations for these open-ended questions.

**Statistical Analyses.** As a convenience sample, completion of 100 surveys was targeted a priori. The survey was a combination of open-ended and multiple-choice questions. Answers to all open-ended questions from the survey were reviewed by the first author. Open-ended questions supplemented data in the multiple-choice questions. Additionally, 2 variables included in the final analysis utilized categorizations of responses exclusively from open-ended questions (main means of transportation and amount HH impacted health of family members), and these variables are identified in the data tables below. For these, the first author developed categories after reviewing all responses and then tabulated responses into the categories. Analysis involved calculating summary statistics comparing the 2 income groups and the 2 severity-of-impact groups. We used chi-square tests to assess differences between income groups and between severity-of-impact groups. Analyses were performed using Stata software (version MP11.0, Stata Corporation). The level of statistical significance was  $p < 0.05$ .

## RESULTS

Of 108 caregivers who met inclusion criteria and were available for participation during the enrollment period, 100 agreed to complete the survey (93% response rate). Using the definition above, 27% of subjects were “severely impacted” by HH. Table 1 shows that when compared to the remainder surveyed, those “severely impacted” were significantly more likely to report lower family income, screen positive for food insecurity, report accessing charity food within the previous month, and endorse states risk of becoming homeless, and were less likely to have reliable

transportation or primarily use a personal vehicle for transportation. Table 1 also shows that over 20% of respondents were born outside the United States and fewer than two thirds were married.

As shown in Table 2, the “severely impacted” group was more likely to report change in worry about food for the household, applying for relief, disruptions in all factors of health maintenance assessed (loss of prescription medications, loss of vaccine records, and difficulty seeking medical care due to HH), worse impacts of health of family members, endorsement of HH having an impact on the mental health of family members, worse household stress, and worse mental health for the patient.

Overall, those reporting family incomes less than \$50,000 per year (“low income”) were more likely to report increase in worry about food for the household after HH and that someone in the family had lost their job due to HH (Table 3). Of all respondents, 6% lost prescription medications, 6% lost vaccination records, 19% had difficulty seeking needed medical care due to HH, 13% reported that their health or the health of their family members was “very” or “extremely” impacted by the hurricane, and 17% reported mental health impacts on the family attributable to HH.

**Table 1. Sociodemographic characteristics of subjects that were displaced from their home or lost a vehicle due to Hurricane Harvey (“Severely Impacted,” N=27) and all other subjects (“Not Severely Impacted,” N=73).**

	Severely Impacted N (%)	Not Severely Impacted N (%)	P value
<b>Family’s yearly income (US\$)</b>			
Less than 20,000	12 (44)	10 (14)	<b>0.011</b>
20,000 to 50,000	8 (30)	22 (30)	
50,000 to 80,000	4 (15)	15 (21)	
Over 80,000	3 (11)	26 (36)	
<b>Caregiver’s age (y)</b>			
Under 26	8 (30)	15 (21)	0.769
26 to 35	11 (41)	37 (51)	
36 to 45	7 (26)	18 (25)	
Over 45	1 (4)	3 (4)	
<b>Caregiver’s number of children</b>			
1	5 (19)	16 (22)	0.638
2	9 (33)	27 (37)	
3	5 (19)	17 (23)	
4 or more	8 (30)	13 (18)	
<b>Caregiver’s race/ethnicity</b>			
White, not Hispanic	7 (26)	23 (32)	0.274
White, Hispanic	11 (41)	28 (38)	
Black, not Hispanic	7 (26)	18 (25)	
Black, Hispanic	1 (4)	0 (0)	

Asian	0 (0)	4 (5)	
Other	1 (4)	0 (0)	
<b>Caregiver's marital status</b>			
Single	8 (30)	14 (19)	0.669
Married	15 (56)	49 (67)	
Separated	2 (7)	3 (4)	
Cohabitation	2 (7)	6 (8)	
<b>Caregiver's highest level of education</b>			
Some high school	4 (15)	4 (5)	0.053
High school	11 (41)	21 (29)	
Technical or some college	8 (30)	16 (22)	
Bachelor's degree	2 (7)	23 (32)	
Master's degree or higher	2 (7)	9 (12)	
<b>Caregiver's region of birth</b>			
USA	21 (78)	58 (79)	0.142
Mexico	2 (7)	10 (14)	
Central Amer./Caribbean	2 (7)	1 (1)	
Africa	2 (7)	1 (1)	
Asia	0 (0)	3 (4)	
<b>Relationship to patient</b>			
Mother	26 (96)	59 (81)	0.126
Father	1 (4)	13 (18)	
Aunt	0 (0)	1 (1)	
<b>Receives food stamps</b>			
No	12 (44)	42 (58)	0.244
Yes	15 (56)	31 (42)	
<b>Screen for food insecurity</b>			
Negative	16 (59)	59 (81)	<b>0.027</b>
Positive	11 (41)	14 (19)	
<b>Accessed charity food in past month</b>			
No	18 (67)	71 (97)	<b>&lt;0.001</b>
Yes	9 (33)	2 (3)	
<b>Receives WIC</b>			
No	14 (52)	51 (70)	0.094
Yes	13 (48)	22 (30)	
<b>States risk of becoming homeless</b>			
No	23 (85)	72 (99)	<b>0.008</b>
Yes	3 (11)	0 (0)	
<b>Has reliable transportation</b>			
No	6 (22)	2 (3)	<b>0.005</b>
Yes	21 (78)	70 (96)	
<b>Main means of transportation*</b>			
Personal vehicle owned	16 (59)	70 (96)	<b>&lt;0.001</b>
Shared family vehicle	7 (26)	1 (1)	
Rental car	2 (7)	0 (0)	
Public transportation	1 (4)	0 (0)	
No response	1 (4)	2 (3)	

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Some percentages may not add up to 100 given that no response and responses such as “Don’t know,” “Not applicable,” or “Didn’t understand” were not included above unless otherwise noted. P values <0.05 noted in boldface. \*Open-ended question with categorized response (all other questions multiple choice).

**Table 2. Comparison of various factors for subjects that were displaced from their home or lost a vehicle due to Hurricane Harvey (“Severely Impacted,” N=27) and all other subjects (“Not Severely Impacted,” N=73).**

	<u>Severely Impacted</u> N (%)	<u>Not Severely Impacted</u> N (%)	P value
<b><u>Disruptions in Daily Living</u></b>			
<b>Change in worry about food for household</b>			
Less or no change	19 (70)	64 (89)	<b>0.026</b>
More	8 (30)	8 (11)	
<b>Someone in family lost their job due to HH</b>			
No	23 (85)	68 (93)	0.196
Yes	4 (15)	5 (7)	
<b>Applied for relief</b>			
No	8 (30)	64 (88)	<b>&lt;0.001</b>
Yes	19 (70)	9 (12)	
<b>Missed work due to HH</b>			
No	4 (15)	6 (8)	0.329
Yes	23 (85)	67 (92)	
<b>Children’s school/daycare detrimentally impacted by HH</b>			
No	18 (67)	50 (68)	0.801
Yes	9 (33)	22 (30)	
<b><u>Health Maintenance</u></b>			
<b>Lost prescription medications due to HH</b>			
No	21 (78)	72 (99)	<b>0.001</b>
Yes	5 (19)	1 (1)	
<b>Lost vaccine records due to HH</b>			
No	20 (74)	73 (100)	<b>&lt;0.001</b>
Yes	6 (22)	0 (0)	
<b>Had difficulty seeking medical care during HH</b>			
No	13 (48)	65 (89)	<b>&lt;0.001</b>
Yes	13 (48)	8 (11)	
<b><u>Health Impact of HH</u></b>			
<b>Amount HH impacted health of family members*</b>			
None	10 (37)	50 (68)	<b>0.004</b>

Slightly	3 (11)	9 (12)	
Moderately	5 (19)	10 (14)	
Very	6 (22)	3 (4)	
Extremely	3 (11)	1 (1)	
<b>Change in caregiver's health after HH</b>			
No change or Improved	23 (85)	67 (92)	0.265
Worse	4 (14)	6 (8)	
<b>Change in patient's health after HH</b>			
No change or Improved	16 (59)	45 (62)	0.828
Worse	11 (41)	28 (38)	
<b>HH impacted the mental health of family members</b>			
No	18 (67)	62 (85)	<b>0.041</b>
Yes	9 (33)	8 (11)	
Don't know	0 (0)	3 (4)	
<b>Change in household stress after HH</b>			
No change or Improved	15 (56)	58 (79)	<b>0.017</b>
Worse	12 (44)	15 (21)	
<b>Change in caregiver's mental health after HH</b>			
No change or Improved	20 (74)	71 (97)	<b>0.001</b>
Worse	7 (26)	2 (3)	
<b>Change in patient's mental health after HH</b>			
No change or Improved	24 (89)	68 (93)	0.370
Worse	3 (11)	5 (7)	

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HH: Hurricane Harvey. Some percentages may not add up to 100 given that no response and responses such as "Don't know," "Not applicable," or "Didn't understand" were not included above unless otherwise noted. P values <0.05 noted in boldface.

\*Open-ended question with categorized response (all other questions multiple choice).

**Table 3. Comparison of various factors attributable to Hurricane Harvey against household income < \$50,000 (N=52) and ≥ \$50,000 (N=45). Caregivers of 3 subjects did not report annual family income.**

	Reported Annual Family Income		P value
	< \$50,000 N (%)	≥ \$50,000 N (%)	
<b><u>Disruptions in Daily Living</u></b>			
<b>Change in worry about food for household</b>			
Less or no change	39 (76)	42 (93)	<b>0.021</b>
More	12 (24)	3 (7)	
<b>Someone in family lost their job due to HH</b>			
No	43 (83)	45 (100)	<b>0.003</b>
Yes	9 (17)	0 (0)	
<b>Applied for relief</b>			
No	33 (63)	36 (80)	0.073
Yes	19 (37)	9 (20)	
<b>Missed work due to HH</b>			
No	5 (10)	5 (11)	0.534
Yes	47 (90)	40 (89)	
<b>Children's school/daycare detrimentally impacted by HH</b>			
No	35 (67)	32 (71)	0.473
Yes	17 (33)	12 (27)	
<b><u>Health Maintenance</u></b>			
<b>Lost prescription medications due to HH</b>			
No	47 (90)	43 (96)	0.683
Yes	4 (8)	2 (4)	
<b>Lost vaccine records due to HH</b>			
No	46 (88)	44 (98)	0.211
Yes	5 (10)	1 (2)	
<b>Had difficulty seeking medical care during HH</b>			
No	38 (73)	39 (87)	0.201
Yes	13 (25)	6 (13)	
<b><u>Health Impact of HH</u></b>			

<b>Amount HH impacted health of family members*</b>			
None	30 (58)	28 (62)	0.230
Slightly	5 (10)	7 (16)	
Moderately	7 (13)	7 (16)	
Very	8 (15)	1 (2)	
Extremely	2 (4)	2 (4)	
<b>Change in caregiver's health after HH</b>			
No change or Improved	47 (90)	40 (89)	0.534
Worse	5 (10)	5 (11)	
<b>Change in patient's health after HH</b>			
No change or Improved	29 (56)	30 (67)	0.273
Worse	23 (44)	15 (33)	
<b>HH impacted the mental health of family members</b>			
No	40 (77)	37 (82)	0.382
Yes	9 (17)	8 (18)	
Don't know	3 (6)	0 (0)	
<b>Change in household stress after HH</b>			
No change or Improved	37 (71)	33 (73)	0.811
Worse	15 (29)	12 (27)	
<b>Change in caregiver's mental health after HH</b>			
No change or Improved	47 (90)	41 (91)	0.592
Worse	5 (10)	4 (9)	
<b>Change in patient's mental health after HH</b>			
No change or Improved	49 (94)	40 (89)	0.279
Worse	3 (6)	5 (11)	

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HH: Hurricane Harvey. Some percentages may not add up to 100 given that no response and responses such as "Don't know," "Not applicable," or "Didn't understand" were not included above unless otherwise noted. P values <0.05 noted in boldface.

\*Open-ended question with categorized response (all other questions multiple choice).

## DISCUSSION

In this pilot study describing the impact of HH on hospitalized children and their families during the second and third months after the natural disaster, we found that 27% of our study population was "severely impacted." Both the "severely impacted" and low-income groups were more likely to report multiple disruptions in daily living attributable to HH. The "severely impacted" group was also more likely to report multiple disruptions in health maintenance and health impacts attributed to HH. It is also noteworthy that 17% of our total cohort endorsed mental health impacts on the family attributable to HH.

The University of Houston Hobby School of Public Affairs is conducting a longitudinal survey study to assess the ongoing impact of HH on the Houston-area population. Their initial survey of over 2000 respondents in 2017 was conducted largely at the same time as this survey, and they reported similar findings to what is presented here. Twenty-five percent reported applying for relief, compared to 28% in this study. Those reporting "very serious" or "extremely serious" flood damage to a home and flood damage to a car were 18% and 15%, respectively. This is comparable to our finding of over one quarter of respondents being "severely impacted," with a definition that would be inclusive of either flood damage to a home or car.<sup>11</sup>

The impact of large-scale flooding on human health ranges from short-term effects such as drowning, injuries, toxic exposures, and a multitude of infectious diseases<sup>3,12-15</sup> to long-term effects such as exacerbation of chronic illnesses, mental health disorders, malnutrition, and even poor birth outcomes.<sup>3,15-22</sup> Key social determinants of health (eg, displacement and homelessness, social dislocation, disruption of healthcare services, alteration of ecosystems, and economic challenges for individuals and families) are also impacted by floods and hurricanes and have been associated with the degree to which populations are impacted by these events.<sup>14,15,23-26</sup> Policymakers, health care systems, and providers must be prepared to address these social determinants of health needs in both the short and long term after natural disasters. Not only do the data in this study highlight the detrimental impact of HH on social determinants of health, but disruptions in healthcare (most notably almost half of the "severely impacted" group reporting difficulty seeking medical care during HH) also highlight potential areas for intervention that need to be considered during and after future large-scale natural disasters. Telemedicine and community health workers could be particularly helpful to minimize

disruptions in healthcare for high-risk groups such as those severely impacted.

Many disparities of health outcomes exist for hospitalized children, and McKay and Parente recently described the various factors that determine these disparities, including social determinants.<sup>27</sup> Our study begins to describe exposure to the effects of a natural disaster as a major social determinant of health that is highly dynamic over place and time. Exposure to the effects of HH was high in our study population, potentially compounding existing disparities of health. The fact that both the “severely impacted” and low-income groups reported difficulties with a variety of social determinants of health highlights how important it is that providers be aware of these social factors, be ready to identify them, and be able to link patients and their families to resources to address these needs.

Screening for unmet social needs has been shown to be acceptable to caregivers of hospitalized children.<sup>28</sup> This could be an important strategy to employ on pediatric wards in the wake of natural disasters and is an area for future research. Given the results of this study, key social needs to screen for include housing and food insecurity, transportation (especially for accessing health and psychosocial services), and accessing regular and newly prescribed medications. At least in developed countries and during the immediate period of recovery, natural disasters often lead to an influx of public and private support. Physicians, nurses, and social workers should have at least a basic understanding about how to leverage this support for their patients with unmet needs, for example, by understanding who likely qualifies, and how to apply, for assistance from the Federal Emergency Management Agency. Pediatric hospitals can increase direct social services (eg, assistance with procurement of discharge medications, transportation to home, and social work staffing) during the weeks and months after a natural disaster as a means of ultimately mitigating disparities in health. Hospital services need to partner, integrate, and communicate with community resources and community health providers to sustain assistance for needs identified and services initiated during hospitalization. Local, state, and national policies must provide critical input that mitigates disaster risks to human health.

The burden of post-traumatic stress disorder (PTSD) after natural disasters has been well documented overall. Prevalence of PTSD in various studies has ranged from 5% to 60% in the first and second year after natural disasters, with factors such as low social support, post-disaster stress, and degree of exposure demonstrated as strong correlates of PTSD.<sup>3,29-31</sup> After PTSD, depression and anxiety are the next most prevalent mental health disorders faced by populations affected by natural disasters.<sup>3</sup> Our study did

not rigorously assess PTSD, depression, and anxiety symptoms, but worsening household stress was reported by over one quarter of households and a significant portion of the total cohort (17%) endorsed mental health impacts on the family attributable to HH. At least for PTSD, studies demonstrating the time course of onset of symptoms after a natural disaster tend to show maximal symptoms in the 1 to 2 years after the event.<sup>27,28</sup> Given the high reports of general stress and high degree of exposure in our study population, assessed only a few months after the natural disaster, clinicians need to be aware that this population is at increased risk for PTSD onset even in the years after HH. This highlights the importance of healthcare providers refamiliarizing themselves with strategies for screening for conditions such as PTSD, anxiety, and depression and community resources available for those developing mental health conditions.

The broad physical and mental health impacts attributable to HH that this study begins to assess will continue to be detailed over the upcoming years. An important area for future research is the ongoing rigorous assessment of the health impacts of natural disasters and impacts on socially vulnerable populations. This will be needed to refine effective interventions that minimize the impacts from HH and future natural disasters. Hospitalized children and their families are a particularly vulnerable population during natural disasters, given the added stress of the child's illness, separation of family members, and decreased time and energy to deal with the aftereffects. However, they have the advantage of immediate access to medical, social, and legal services while hospitalized, and the hospital team must capitalize on the unique opportunity to intervene. Strong relationships with community providers and integration with community resources, with strong support of these resources at the forefront of post-disaster policymaking, are needed to ensure that individuals and families continue to receive necessary support after hospitalization.

A major limitation of this study was the exclusion of non-English speakers. The non-English-speaking population was potentially prone to the impacts of this hurricane because of generally lower socioeconomic status, difficulty accessing available resources due to language barriers, and possible concerns about revealing undocumented status. The second limitation was that the data was derived solely from caregiver reports, making it susceptible to both reporting and recall bias. Most notably, the definition of "severely impacted" was based on reported factors. The third limitation of this study was its reliance on participants' report of baseline states. This lack of baseline characteristics for study participants is common

in post-disaster analyses because of the unpredictable circumstances.<sup>4,9</sup> Although the surveyor would check multiple times for presence of a caregiver at bedside during a patient's admission, there is concern for selection bias as shorter admissions or caregiver absence may lead to suboptimal coverage of surveys. As noted above, it is important to consider the impacts of a natural disaster over time, and this cross-sectional study notably does not look at longitudinal impacts. Finally, due to the methodology of this study and practical time constraints, data collection was limited to a 1-month period, and this consequently limited the sample size. Our experience with this study cohort demonstrated a broad range of both how, and to what extent, study participants were impacted by HH. A larger sample size would allow for a more nuanced analysis of the diversity of challenges faced by the population after this disaster.

**Conclusions.** In the aftermath of HH, we found disparities in many social determinants of health both in the lower income group and in the more severely impacted group of hospitalized children and their families. After a natural disaster, policymakers, communities, and healthcare providers need to be prepared to recognize and address these needs in vulnerable populations, not just initially but over the months and years after the event. This study also demonstrated that the more severely impacted group experienced more disruptions in healthcare maintenance and was already reporting more mental health effects. This raises concern for compounding health impacts for those severely impacted over time, a key area for ongoing research.

## References

1. Blake ES, Zelinsky DA; National Oceanic and Atmospheric and Administration. National Hurricane Center tropical cyclone report – Hurricane Harvey. <https://www.hssl.org/?abstract&did=807581>. Published January 23, 2018. Accessed January 15, 2021.
2. Shultz JM, Galea S. Mitigating the mental and physical health consequences of Hurricane Harvey. *JAMA*. 2017;318(15):1437-1438.
3. Alderman K, Turner LR, Tong S. Floods and human health: a systematic review. *Environ. Int.* 2012;47:37–47.
4. Rhodes J, Chan C, Paxson C, Rouse CE, Waters M, Fussell E. The impact of Hurricane Katrina on the mental and physical health of low-income parents in New Orleans. *Am J Orthopsychiatry*. 2012;80:237–247.

5. Carroll AE, Frakt AB. Children's health must remain a focus in the recovery from Hurricane Harvey. *JAMA Pediatr.* 2017;171(11):1029–1030. doi:10.1001/jamapediatrics.2017.3851
6. Shultz JM, Galea S. Preparing for the next Harvey, Irma, or Maria — addressing research gaps. *N Engl J Med.* 2017;377(19):1804-1806.
7. QuickFacts. United States Census Bureau website. <https://www.census.gov/quickfacts>. Updated July 1, 2019. Accessed January 15, 2021.
8. Hager ER, Quigg AM, Black MM, et al. Development and validity of a 2-item screen to identify families at risk for food insecurity. *Pediatrics.* 2010;126(1):e26-e32. doi: 10.1542/peds.2009-3146.
9. Garg A, Toy S, Tripodis Y, Silverstein M, Freeman E. Addressing social determinants of health at well child care visits: a cluster RCT. *Pediatrics.* 2015;135(2):e296-e304.
10. US Dept of Housing and Urban Development, Office of Policy Development and Research. Fair market rent and income limit histories. <https://www.huduser.gov/portal/datasets/il/il17/State-Incomelimits-Report-FY17.pdf>. Updated October 1, 2018. Accessed January 15, 2021.
11. ~~Watson K, Granato J, Jones MP, et al. The impact of Hurricane Harvey: survey figures and tables 2017. University of Houston Hobby School of Public Affairs. <https://uh.edu/hobby/harvey/docs/HarveySurveyFiguresTables.pdf>. Published August 24, 2020. Accessed September 16, 2020.~~
11. Hobby School of Public Affairs at the University of Houston. The Impact of Hurricane Harvey: Hurricane Harvey Survey 2017: Survey Figures and Tables 2017. <https://uh.edu/hobby/harvey/>. Published August 24, 2020. Accessed September 16, 2020.
12. Levy K, Woster AP, Goldstein RS, Carlton EJ. Untangling the impacts of climate change on waterborne diseases: a systematic review of relationships between diarrheal diseases and temperature, rainfall, flooding, and drought. *Environ Sci Technol.* 2016;50(10):4905-4922.
13. Lin CJ, Wade TJ, Hilborn ED. Flooding and *Clostridium difficile* infection: a case-crossover analysis. *Int J Environ Res Public Health.* 2015;12(6):6948-6964.
14. Doocy S, Dick A, Daniels A, Kirsch TD. The human impact of tropical cyclones: a historical review. *PLoS Curr.* 2013;9. doi: 10.1371/currents.dis.2664354a5571512063ed29d25ffbce74.
15. Lane K, Charles-Guzman K, Wheeler K, Abid Z, Graber N, Matte T. Health effects of coastal storms and flooding in urban areas: a review and vulnerability assessment. *J Environ Public Health.* 2013;2013:913064. doi: 10.1155/2013/913064.

16. Tempest EL, English National Study on Flooding and Health Study Group; Carter B, Beck CR, Rubin GJ. Secondary stressors are associated with probable psychological morbidity after flooding: a cross-sectional analysis. *Eur J Public Health*. 2017;27(6):1042-1047.
17. Munro A, Kovats RS, Rubin GJ, et al. Effect of evacuation and displacement on the association between flooding and mental health outcomes: a cross-sectional analysis of UK survey data. *Lancet Planet Health*. 2017;1(4):e134-e141.
18. Fernandez A, Black J, Jones M, et al. Flooding and mental health: a systematic mapping review. *PLoS One*. 2015;10(4):e0119929.
19. Kessler RC, McLaughlin KA, Koenen KC, Petukhova M, Hill ED, Who World Mental Health Survey Consortium. The importance of secondary trauma exposure for post-disaster mental disorder. *Epidemiol Psychiatr Sci*. 2012;21(1):35-45.
20. Galea S, Brewin CR, Gruber M, et al. Exposure to hurricane-related stressors and mental illness after Hurricane Katrina. *Arch Gen Psychiatry*. 2007;64(12):1427-1434.
21. Pradhan PMS, Dhital R, Subhani H. Nutrition interventions for children aged less than 5 years following natural disasters: a systematic review. *BMJ Open*. 2016;6(9):e011238.
22. Rodriguez-Llanes JM, Ranjan-Dash S, Mukhopadhyay A, Guha-Sapir D. Flood-exposure is associated with higher prevalence of child undernutrition in rural eastern India. *Int J Environ Res Public Health*. 2016;13(2):210.
23. Shultz JM, Russell J, Espinel Z. Epidemiology of tropical cyclones: the dynamics of disaster, disease, and development. *Epidemiol. Rev*. 2005;27:21–35.
24. Andrewin AN, Rodriguez-Llanes JM, Guha-Sapir D. Determinants of the lethality of climate-related disasters in the Caribbean Community (CARICOM): a cross-country analysis. *Sci Rep*. 2015;5:11972. doi: 10.1038/srep11972.
25. Rath B, Young EA, Harris A, et al. Adverse respiratory symptoms and environmental exposures among children and adolescents following Hurricane Katrina. *Public Health Rep*. 2011;126(6):853-860.
26. Curtis S, Fair A, Wistow J, Val DV, Oven K. Impact of extreme weather events and climate change for health and social care systems. *Environ Health*. 2017;16(suppl 1):128.
27. McKay S, Parente V. Health disparities in the hospitalized child. *Hosp Pediatr*. 2019;9(5):317-325.

28. Colvin JD, Bettenhausen JL, Anderson-Carpenter KD, Collie-Akers V, Chung PJ. Caregiver opinion of in-hospital screening for unmet social needs by pediatric residents. *Acad Pediatr.* 2016;16(2):161-167.
29. Galea S, Nandi A, Vlahov D. The epidemiology of post-traumatic stress disorder after disasters. *Epidemiol. Rev.* 2005;27:78–91.
30. Walker M, Kublin JG, Zunt JR. Trends in mental illness and suicidality after Hurricane Katrina. *Mol Psychiatry.* 2009;42:115–125.
31. Galea S, Tracy M, Norris F, Coffey SF. Financial and social circumstances and the incidence and course of PTSD in Mississippi during the first two years after Hurricane Katrina. *J Trauma Stress.* 2008;21:357-368.

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## Appendix. Study Survey

Study ID \_\_\_\_\_

Thank you for helping us by taking this survey. The answers to these questions will be kept strictly confidential.

We are completing this survey to better understand how Hurricane Harvey impacted the lives of our patients. As Houston and Texas recovers, we hope to be able to partner with our patients and families to rebuild our communities and help all children stay healthy.

This survey should take approximately 20 minutes to complete. Because a number of factors influence child health, we will ask you some questions about your home and family.

### 1. First, can you describe how you and your family have been impacted by Hurricane Harvey?

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**If you feel that you were significantly impacted by the hurricane,**

A. What are your biggest needs now?

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\_\_\_\_\_

B. What has been challenging about reaching resources?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**Now I am going to ask you a few questions about your home.**

2. Did your home flood during Hurricane Harvey?

\_\_\_\_\_ Yes

\_\_\_\_\_ No

\_\_\_\_\_ I don't know/ I prefer not to answer

If yes, please describe:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

3. Did you have to move after Hurricane Harvey?

\_\_\_\_\_ Yes

\_\_\_\_\_ No

\_\_\_\_\_ I don't know/ I prefer not to answer

4. Did anyone move into your home after Hurricane Harvey?

\_\_\_\_\_ Yes > please explain:

\_\_\_\_\_

\_\_\_\_\_ No

\_\_\_\_\_ I don't know/ I prefer not to answer

5. How many people lived with you prior to Hurricane Harvey?

\_\_\_\_\_

a. How many people under 18 years old?

\_\_\_\_\_

b. How many people over 18 years old?

\_\_\_\_\_

6. How many people live with you now?

\_\_\_\_\_

a. How many people under 18 years old?

\_\_\_\_\_

b. How many people over 18 years old?

\_\_\_\_\_

If there is a difference, please explain:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

7. Have you applied for any help from FEMA or another agency?

\_\_\_\_\_ Yes

>Were you: \_\_\_ Approved \_\_\_ Denied \_\_\_ Still waiting for a response

>What agency other than FEMA?

\_\_\_\_\_

\_\_\_\_\_ Only FEMA

\_\_\_\_\_ No

\_\_\_\_\_ I don't know/ I prefer not to answer

8. Do you think you are at risk of becoming homeless?

\_\_\_\_\_ Yes

\_\_\_\_\_ No

\_\_\_\_\_ I don't know/ I prefer not to answer

9. What was the stress level in your home before Hurricane Harvey?

\_\_\_\_\_ Very High

\_\_\_\_\_ Above Average

\_\_\_\_\_ Average

\_\_\_\_\_ Below Average

\_\_\_\_\_ Very Low

10. What was the stress level in your home now?

\_\_\_\_\_ Very High

\_\_\_\_\_ Above Average

\_\_\_\_\_ Average

\_\_\_\_\_ Below Average

\_\_\_\_\_ Very Low

If there is a difference, please explain:

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**Now I am going to ask you a few questions about your access to food.**

11. Within the past 12 months did you worry whether your food would run out before you got money to buy more?

- Yes
- No
- I don't know

12. Within the past 12 months, was there a time when the food you bought didn't last and you didn't have money to buy more?

- Yes
- No
- I don't know

13. Do you currently receive food stamps (SNAP) benefits?

- Yes, I currently receive food stamps
- No, I do not currently receive food stamps
- No, but I have an application pending
- Don't know

14. In the past month, have you ever used a Food Pantry / Soup Kitchen or received a food donation?

- Yes
- No

15. Do you receive WIC for your child?

- Yes
- No

16. Compared with prior to Hurricane Harvey, how worried are you about having enough food for you and your family at this time?

- Much more worried
- More worried

- About the same
- Less worried
- Much less worried

Please explain:

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**Now I am going to ask you about your transportation needs.**

17. Did you lose a car during Hurricane Harvey?

- Yes
- No
- I don't know/ I prefer not to answer

18. Do you have reliable transportation at this time?

- Yes
- No
- I don't know/ I prefer not to answer

19. What is your primary means of transportation?

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20. How did Hurricane Harvey impact your family's ability to travel to work, school, clinic visits, etc.?

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**Now I am going to ask you about your work.**

21. Did you or any family members have to miss work due to Hurricane Harvey?

- Yes
- No
- I don't know/ I prefer not to answer

22. Did you or any family members lose your/their jobs due to Hurricane Harvey?

- Yes
- No

\_\_\_\_\_ I don't know/ I prefer not to answer

23. Please describe the financial impact Hurricane Harvey has had on your family:

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24. Did your child's child care or school situation change due to Harvey?

\_\_\_\_\_ Yes

\_\_\_\_\_ No

If yes, what kind of impact has this had on your family?

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**Now I am going to ask you about the health of you and your family.**

25. How was the health of you and your family impacted by Hurricane Harvey?

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26. How worried are you about how Hurricane Harvey will impact your health or the health of your children in the future?

\_\_\_\_\_ Extremely worried

\_\_\_\_\_ Very worried

\_\_\_\_\_ Moderately worried

\_\_\_\_\_ Slightly worried

\_\_\_\_\_ Not at all

Please explain:

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27. Prior to Hurricane Harvey, would you say that your own physical health is:

- Excellent
- Good
- Fair
- Poor

28. Now, would you say that your own physical health is:

- Excellent
- Good
- Fair
- Poor

29. Prior to Hurricane Harvey, would you say that your child's physical health is:

- Excellent
- Good
- Fair
- Poor

30. Now, would you say that your child's physical health is:

- Excellent
- Good
- Fair
- Poor

31. Did you lose any prescription medications for you or your family members during Hurricane Harvey?

- Yes
- No
- I don't know/ I prefer not to answer

32. Did you lose your child's immunization records during Hurricane Harvey?

- Yes
- No
- I don't know/ I prefer not to answer

33. Did you or your child have any problems seeing your doctor due to Hurricane Harvey?

- Yes
- No
- I don't know/ I prefer not to answer

34. Did your child have to change pediatricians due to Hurricane Harvey?

Yes

No

I don't know/ I prefer not to answer

**Now I am going to ask you about the mental health of you and your family.**

35. Do you think Hurricane Harvey has had an impact on the mental health of you or your children?

Yes

No

I don't know/ I prefer not to answer

Please explain:

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36. Prior to Hurricane Harvey, would you say that your own mental health is:

Excellent

Good

Fair

Poor

37. Now, would you say that your own mental health is:

Excellent

Good

Fair

Poor

38. Prior to Hurricane Harvey, would you say that your child's mental health is:

Excellent

Good

Fair

Poor

39. Now, would you say that your child's mental health is:

Excellent

- Good
- Fair
- Poor

**40. Now, we would like to ask you what we can do (at your doctor's office) to help you and your family after Hurricane Harvey?**

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41. Would you like a handout on how to contact FEMA and other legal resources that can help you recover from Hurricane Harvey?

- Yes
- No
- I don't know

42. Would you like a handout on help with food for you and your family?

- Yes
- No
- I don't know

43. Would you like a handout on mental health resources/ support for you and your family?

- Yes
- No
- I don't know

44. Would you like a handout on help with transportation for you and your family?

- Yes
- No
- I don't know

45. Would you like a handout on help with child care for you and your family?

- Yes
- No
- I don't know

46. Would you use a food pantry here at the clinic if we had one?

- Yes
- No
- I don't know

47. Do you have ideas of what else your doctor's office could do to help families after Hurricane Harvey?

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48. How optimistic are you regarding Houston's future after Hurricane Harvey?

- Extremely optimistic
- Very optimistic
- Moderately optimistic
- Slightly optimistic
- Not at all optimistic

49. How optimistic are you regarding your family's future after Hurricane Harvey?

- Extremely optimistic
- Very optimistic
- Moderately optimistic
- Slightly optimistic
- Not at all optimistic

Please explain:

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50. For this disaster and potential disasters like it in the future, where are you most comfortable accessing help and services if need be?

- School
- Community Center
- Clinic
- Other \_\_\_\_\_
- Church

**The next few questions are about general demographics.**

50. What year were you born? \_\_\_\_\_

51. In what country were you born? \_\_\_\_\_

52. Do you consider yourself to be Hispanic, Latino, or Spanish?

\_\_\_\_\_ Yes

\_\_\_\_\_ No

\_\_\_\_\_ Don't know

53. Which of the following best describes your race or ethnicity? You may circle more than one.

\_\_\_\_\_ Asian

\_\_\_\_\_ Black, not Hispanic

\_\_\_\_\_ Black Hispanic

\_\_\_\_\_ White, not Hispanic

\_\_\_\_\_ White Hispanic

\_\_\_\_\_ American Indian or Native American

\_\_\_\_\_ Other \_\_\_\_\_

54. Which of the following best describes your marital status?

\_\_\_\_\_ Single

\_\_\_\_\_ Married

\_\_\_\_\_ Separated/Divorced/Widowed

\_\_\_\_\_ Cohabitation (living together)

55. What is the highest grade or year of school you have completed?

\_\_\_\_\_ Some high school or less

\_\_\_\_\_ High school graduate or GED

\_\_\_\_\_ Technical school or some college

\_\_\_\_\_ College graduate

\_\_\_\_\_ Master's level or higher

56. How many children to you have? \_\_\_\_\_

57. What is your family's combined annual income, before taxes?

\_\_\_\_\_ Less than \$10,000

\_\_\_\_\_ Equal to or greater than \$10,000

\_\_\_\_\_ Equal to or greater than \$20,000

- \_\_\_\_\_ Equal to or greater than \$30,000
- \_\_\_\_\_ Equal to or greater than \$40,000
- \_\_\_\_\_ Equal to or greater than \$50,000
- \_\_\_\_\_ Equal to or greater than \$60,000
- \_\_\_\_\_ Equal to or greater than \$70,000
- \_\_\_\_\_ Equal to or greater than \$80,000
- \_\_\_\_\_ Equal to or greater than \$90,000

58. What was your zip code prior to Hurricane Harvey? \_\_\_\_\_

59. What is your current zip code? \_\_\_\_\_

**Thank you for taking time to complete this survey.**