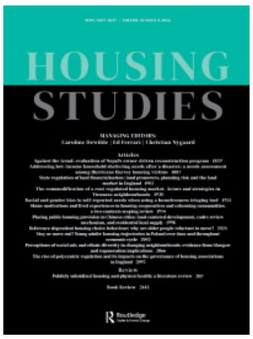

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Addressing low-income household sheltering needs after a disaster: a needs assessment among Hurricane Harvey housing victims

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ABSTRACT

Existing literature suggests many victims of housing loss due to disaster need emergency shelter, and low-income individuals are at risk of becoming chronically homeless without assistance in the transition to conventional housing. In response, FEMA provides Transitional Sheltering Assistance (TSA) to victims of housing loss. However, the extent to which sheltering needs are met by TSA has not been investigated, especially among low-income households. Analyzing FEMA's administrative data including all damaged housing units in Harris and Galveston counties ($N = 283{,}085$), we found that low-income victims of housing loss not only had greater sheltering needs but also were less likely to access TSA than their counterparts not of low-income status. When both groups were in need of shelter, the chance of obtaining TSA for low-income victims of housing loss was much lower than that for their counterparts. Our study highlights the critical sheltering needs of low-income households in a natural disaster, and advocates for a broader and more equitable distribution of TSA.

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Disaster; emergency shelters; homeless; low-income; needs assessment

Introduction

With 52 tornados and the downpour of 30 trillion tons of rain in 100 hours, the second costliest hurricane in the U.S., Hurricane Harvey, wreaked havoc on the Texas Coast, killing 68 people, and causing over $120 billion in property damage (Blake & Zelinsky, 2018; West Gulf River Forecast Center & National Oceanic Atmospheric Administration, 2021). Though this disaster affected more than twenty counties along the coast in the Gulf of Mexico, Harris and Galveston counties were the most impacted. Over half of all deaths (36) were in Harris County alone, and two thirds of the Harvey-flooded residential buildings were in Harris and Galveston counties (Blake & Zelinsky, 2018). To date, the characteristics of the victims of housing loss in these areas has been unstudied.

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Previous literature on disasters has found that low-income households, especially renters, are more likely to experience the more severe levels of home damage in hurricanes or other types of disasters (Hirayama, 2000; Kamel, 2012; Logan, 2006; Williams & Jacobs, 2011). For example, homes occupied by low-income renters were more likely to have been destroyed by Hurricane Maria than their counterparts in Puerto Rico (Ma & Smith, 2020). Especially in urban environments in the U.S., low-income households have been extremely vulnerable to hurricane-induced home damage (Kamel, 2012). For example, in New Orleans, Louisiana, low-income households were more likely to experience home damage at either the 'destroyed' level or so devastated that their homes needed to be demolished after Hurricane Katrina (Logan, 2006; Ma, 2018). As typical in urban settings in the U.S., both Harris and Galveston counties have a large number of low-income residents. According to the U.S. Census Bureau (2018), over 700,000 Harris County residents and more than 100,000 Galveston County residents were living under the federal poverty line on the eve of Hurricane Harvey, accounting for 16% and 20%, respectively, of each county's total population. However, probably due to a lack of administrative records inclusive of all damaged housing units inspected by the U.S. Federal Emergency Administration Agency (FEMA), the prevalence of housing damage at different severities in relation to the victims' household income in Harris and Galveston counties has not been reported.

After disasters, victims of housing loss often rely on emergency shelter or financial assistance to obtain housing (Hirayama, 2000; Quarantelli, 1982, 1995; Williams & Jacobs, 2011). Purchasing insurance prior to disasters, such as flood insurance or homeowners' insurance, would allow victims of housing loss to mitigate their property losses and to pay for temporary housing (Kunreuther, 2015; Ma, 2018; Williams & Jacobs, 2011). However, low-income housing victims are usually not able to afford private insurance (Ma et al., 2021a). In addition to the rising costs of insurance premiums (Nance, 2015), residential properties located in flood hazard areas are often deemed too risky to be covered by private insurance (Taylor, 2020). The properties located in flood prone areas in the Houston-Galveston metropolitan area prior to Hurricane Harvey's landfall were more likely to be owned by low-income households, 'Especially those along the ship channel and adjacent to the petrochemical complex' (Grineski et al., 2015).

Low-income residents are also more vulnerable to unnatural hazards, including exposures to air pollution caused by manufacturing and energy facilities. For example, in the U.S., communities near coke plants have a disproportionate share of poor and non-white residents; oil refineries tend to be operating in communities with a high proportion of Hispanic residents (Graham et al., 1999).

In the aftermath of Hurricane Harvey, many residents in the Houston area were temporarily homeless and sought emergency shelters for their post-disaster transition process (Ward, 2018). While previous studies suggest that low-income residents in urban settings are at risk of becoming chronically homeless if their sheltering needs are not properly addressed (Culhane et al., 2011), the variation in met and unmet demand for transitional shelter assistance by income status has not been investigated.

Home can provide 'a locale in which people can work at attaining a sense of ontological security' which is defined as 'the confidence that most human beings have in the continuity of their self-identity and in the constancy of their social and

material environments' (Dupuis & Thorns, 1998; Giddens, 1990). Given ontological security has its conceptual roots in mental health (Padgett, 2007), people who experience homelessness, especially those of low-income status, usually experience poor mental health and behavioural outcomes (Hawkins & Maurer, 2011; Ma et al., 2021b). In Toronto, homeless and precariously housed individuals accounted for 9% of all 3,319 suicide deaths from 1998 to 2012 (Sinyor et al., 2017). Victims of housing loss due to natural disasters also experience a disruption of their ontological security and suffer from increased mental disorders, as was documented among New Orleans residents after Hurricane Katrina (Hawkins & Maurer, 2011).

To prevent a downward spiral into these detrimental mental health and behavioural outcomes, researchers have proposed providing access to housing subsidies and supportive services to stabilize victims of housing loss (Culhane & Metraux, 2008). FEMA established the Transitional Sheltering Assistance (TSA) program in 2008 in response to lessons-learned in the aftermath of Hurricane Katrina (Bennett, 2008; McCarthy, 2009; Olshansky & Johnson, 2014). TSA provides financial assistance to victims of housing loss who cannot return to their primary residence due to home damage or who are unable to have their housing needs met through other sources, such as insurance (FEMA 2017; 2018a). The total cost of TSA for Hurricane Harvey victims exceeded $410 million (FEMA, 2018b).

This study analyzes administrative data from FEMA to assess how TSA was distributed to victims of housing loss from Hurricane Harvey, and aims to contribute to the literature on disaster risk management among urban residents from two perspectives. From the disaster preparedness perspective, we provide evidence of those who were more or less likely to need emergency shelter as a result of disaster in this major urban area. From the disaster mitigation perspective, we provide evidence as to the equitability with which TSA was distributed to victims of housing loss by household income status.

With these objectives, our study interrogated three research questions.

1. How prevalent were low-income households among the victims of housing loss from Hurricane Harvey?
2. Whether and to what extent did sheltering needs vary among victims of housing loss by household income levels?
3. To what extent were sheltering needs addressed by the Transitional Sheltering Assistance (TSA) program by household income status?

Methods

To answer these research questions, we used the Individuals and Households Program Registrations file (IHPR) published by FEMA (2020), which includes 283,085 primary housing units damaged by Hurricane Harvey in Harris and Galveston counties that were inspected by FEMA staff. In addition to the housing and damage characteristics of these applicants, the IHPR also contains information on sheltering needs and whether they were approved for FEMA's Transitional Sheltering Assistance (TSA), as detailed in the following measures.

Measurement

Outcome variables

The first key outcome variable, sheltering needs, is a dichotomous variable that describes whether an applicant 'reported a need for shelter' (FEMA, 2020), with values '1= yes' and '0 = no'. The second outcome variable, Transitional Sheltering Assistance (TSA), is also a dichotomous variable to capture whether an applicant is qualified for the TSA program, with values '1 = yes' and '0 = no'.

Low-income status

The public use file of IHPR analyzed in this study only disclosed the income data in mutually exclusive categories (of $0; between $0 and $15,000; between $15,001 and $30,000; between $30,001 and $60,000; between $60,001 to $120,000; between $120,00 and $175,000; and higher than $175,000). The existing disaster literature classifies households as being 'low-income' when their incomes are less than the median for a given area, varied from the citywide to the nationwide (Deria et al., 2020; Deryugina et al., 2018). Similarly, using the IHPR applicants' self-reported household incomes and the median household income values estimated by the 2017 American Community Survey as references, we define low-income households in following operational manner.

According to the 2017 American Community Survey 1-year estimate (U.S. Census Bureau, 2018), the median U.S. household income was between $60,250 and $60,442 (90% Confidence Interval [CI]); and that of Houston Metropolitan Statistical Area in which both Harris and Galveston counties are located was between $62,707 and $64,897 (90% CI). Given these estimates and the available income categories released in the IHPR file, applicants were defined as *low-income households* (1 = yes) if their self-reported income was less than or equal to $60,000, and as not low-income if annual earnings were over $60,000 (0 = no).

Other housing and damage characteristics

Renter, a dichotomous variable, is operationally defined with values '1 = yes' and '0 = no' in response to the IHPR record of whether an applicant was a renter of the damaged unit. Existing literature indicates that older adults and the households with older-adult occupants, especially those age 65 and older, are also extremely vulnerable to negative consequences of natural disasters (Aldrich & Benson, 2008; Burton & Cutter, 2008; Ngo Ehren, 2001; Whitman et al., 1997). To better isolate the main effect of low-income in our multiple regressions (detailed in the section of statistical analyses), we controlled for the potential effect of older adult. Thus, a dichotomous variable, older adult, is operationally defined as '1 = yes' if a household has any occupant age 65 years or older, otherwise '0 = no'. Household size, an ordinal variable with values ranging from 1 to 5, represents the number of individuals living in the household at the time of the disaster, as shown in Table 1. As recorded in IHPR (FEMA, 2020), the applicants were asked by FEMA inspectors: 'was the home *destroyed* by the disaster?' Accordingly, we used their dichotomous responses to define a dummy variable, namely destroyed home, with values '1 = yes' and '0 = no'. According to FEMA (2021, n.d.), a destroyed home needs to be demolished or

Table 1. Two-way analyses of prevalence of low-income on housing characteristics and Hurricane Harvey induced damage characteristics: Harris and Galveston Counties, Texas, 2017.

Variables		Low-income			Statistical tests[a]
		No	Yes	Total	
		50,888	232,197	283,085	
		17.98%	82.02%	100%	
Renter					*Chi*2 (1) 22254.60***[b]
	No	40,749	101,136	141,885	
		28.72%	71.28%	100%	
	Yes	10,113	130,843	140,956	
		7.17%	92.83%	100%	
	Subtotal	50,862	231,979	282,841	
		17.98%	82.02%	100%	
Older adult					*Chi*2 (1) 53.59***
	No	41,343	191,815	233,158	
		17.73%	82.27%	100%	
	yes	9,545	40,382	49,927	
		19.12%	80.88%	100%	
	Subtotal	50,888	232,197	283,085	
		17.98%	82.02%	100%	
Household size					*Chi*2 (4) 7660.91***
	One person	8,713	84,866	93,579	
		9.31%	90.69%	100%	
	Two persons	14,553	49,430	63,983	
		22.75%	77.25%	100%	
	Three persons	9,420	34,875	44,295	
		21.27%	78.73%	100%	
	Four persons	9,767	28,510	38,277	
		25.52%	74.48%	100%	
	Five persons or more	3,310	16,147	19,457	
		17.01%	82.99%	100%	
	Subtotal	45,763	213,828	259,591	
		17.63%	82.37%	100%	
Destroyed					*Chi*2 (1) 5.50**
	No	50,863	232,010	282,873	
		17.98%	82.02%	100%	
	Yes	25	187	212	
		11.79%	88.21%	100%	
	Subtotal	50,888	232,197	283,085	
		17.98%	82.02%	100%	
Flood insurance					*Chi2* (1) 22185.71***
	No	32,401	208,264	240,665	
		13.46%	86.54%	100%	
	Yes	18,487	23,933	42,420	
		43.58%	56.42%	100%	
	Subtotal	50,888	232,197	283,085	
		17.98%	82.02%	100%	

[a]*Chi*2 (k) = chi-square with k degrees of freedom.
[b]***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

razed, and rebuilt on the foundation or slab. Finally, coverage by flood insurance, a dichotomous variable is defined as '1 = yes' or '0 = no' to indicate whether the applicant had flood insurance at the time of Hurricane Harvey.

Statistical analyses

To address the first research question, we report the prevalence of low-income households among all Hurricane Harvey housing victims in Harris and Galveston

counties in Table 1. We used two-way cross tabulations with Pearson X^2 tests to describe the housing and damage characteristics in relation to household income status.

To address the second research question as presented in Table 2, two-way cross-tabulations were employed to assess the prevalence of sheltering needs among

Table 2. Two-way analyses of prevalence of sheltering needs on housing characteristics, and Hurricane Harvey induced damage characteristics: Harris and Galveston Counties, Texas, 2017.

Variables		Sheltering needs			Statistical tests[c]
		No	Yes	Total	
		190,263	92,822	283,085	
		67.21%	32.79%	100%	
Low-income					*Chi*2 (1) 402.80***[d]
	No	36,127	14,761	50,888	
		70.99%	29.01%	100%	
	Yes	154,136	78,061	232,197	
		66.38%	33.62%	100%	
	Total	190,263	92,822	283,085	
		67.21%	32.79%	100%	
Renter					*Chi*2 (1) 5712.24***
	No	104,804	37,081	141,885	
		73.87%	26.13%	100%	
	Yes	85,311	55,645	140,956	
		60.52%	39.48%	100%	
	Total	190,115	92,726	282,841	
		67.22%	32.78%	100%	
Older adult					*Chi*2 (1) 88.15***
	No	155,813	77,345	233,158	
		66.83%	33.17%	100%	
	Yes	34,450	15,477	49,927	
		69%	31%	100%	
	Total	190,263	92,822	283,085	
		67.21%	32.79%	100%	
Household size					*Chi*2 (4) 1722.87***
	One person	57,792	35,787	93,579	
		61.76%	38.24%	100%	
	Two persons	44,230	19,753	63,983	
		69.13%	30.87%	100%	
	Three persons	30,711	13,584	44,295	
		69.33%	30.67%	100%	
	Four persons	27,127	11,150	38,277	
		70.87%	29.13%	100%	
	Five persons or more	13,582	5,875	19,457	
		69.81%	30.19%	100%	
	Total	173,442	86,149	259,591	
		66.81%	33.19%	100%	
Destroyed					*Chi*2 (1) 44.32***
	No	190,166	92,707	282,873	
		67.23%	32.77%	100%	
	Yes	97	115	212	
		45.75%	54.25%	100%	
	Total	190,263	92,822	283,085	
		67.21%	32.79%	100%	
Flood insurance					*Chi*2 (1) 123.25***
	No	162,742	77,923	240,665	
		67.62%	32.38%	100%	
	Yes	27,521	14,899	42,420	
		64.88%	35.12%	100%	
	Total	190,263	92,822	283,085	
		67.21%	32.79%	100%	

[c]*Chi*2 (k) = chi-square with k degrees of freedom.
[d]***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 3. Estimating sheltering needs by housing characteristics and Hurricane Harvey induced damage characteristics by using logistic regression: Harris and Galveston Counties, Texas, 2017.

Variables	Model 1 Odds ratio
Low-income	
No^[e]	1
Yes	1.039***[f]
	(1.014–1.064)[g]
Renter	
No^	1
Yes	1.992***
	(1.954–2.031)
Older adult	
No^	1
Yes	1.081***
	(1.056–1.106)
Household size	
One person^	1
Two persons	0.768***
	(0.751–0.785)
Three persons	0.767***
	(0.748–0.786)
Four persons	0.733***
	(0.714–0.753)
Five persons or more	0.785***
	(0.759–0.812)
Destroyed	
No^	1
Yes	2.161***
	(1.630–2.865)
Flood insurance	
No^	1
Yes	1.639***
	(1.598–1.682)
Constant	0.362***
	(0.352–0.372)
Observations	259,350
LR chi2 [9][h]	7,439***

[e]^ stands for a reference category.
[f]*** $p < 0.001$.
[g]95% confidence intervals in parentheses.
[h]likelihood ratio chi-square test with [k] degrees of freedom.

victims of housing loss in relation to the housing and damage characteristics and low-income status. Further, a logistic regression model (Model 1) was developed to assess the probability of sheltering needs for low-income housing victims while controlling for other housing and damage characteristics, as reported in Table 3.

To address the third research question, the prevalence of TSA is calculated and analyzed in relation to each of the housing and damage characteristics, as shown in Table 4. Two logistic regression models (Models 2 and 3) were employed to estimate both the main effect and interaction effect of low-income status and sheltering need on the binary outcome of being granted TSA by FEMA. To visually contrast the differences of income effects between households with sheltering needs or not, their marginal probabilities were calculated and the corresponding results were presented in Figure 1.

In order to account for missing data–renter and household size each have missing values, comprising 1% and 8% of the study sample ($N = 283{,}085$), respectively, we utilized the list-wise deletion method. This method produces unbiased estimates in logistic regression analyses when data are missing at random, and is also able to tolerate

Table 4. Two-way analyses of Prevalence of Transitional Shelter Assistance (TSA) on sheltering needs, housing characteristics and Hurricane Harvey induced damage characteristics: Harris and Galveston Counties, 2017.

		TSA[i]			
Variables		No	Yes	Total	Statistical tests[j]
		157,371	125,714	283,085	
		55.59%	44.41%	100%	
Sheltering needs					*Chi*2 (1) 13747.61***[k]
	No	120,321	69,942	190,263	
		63.24%	36.76%	100%	
	Yes	37,050	55,772	92,822	
		39.92%	60.08%	100%	
	Subtotal	157,371	125,714	283,085	
		55.59%	44.41%	100%	
Low-income					*Chi*2 (1) 3853.36***
	No	21,988	28,900	50,888	
		43.21%	56.79%	100%	
	Yes	135,383	96,814	232,197	
		58.31%	41.69%	100%	
	Subtotal	157,371	125,714	283,085	
		55.59%	44.41%	100%	
Renter					*Chi*2 (1) 1936.16***
	No	73,054	68,831	141,885	
		51.49%	48.51%	100%	
	Yes	84,165	56,791	140,956	
		59.71%	40.29%	100%	
	Subtotal	157,219	125,622	282,841	
		55.59%	44.41%	100%	
Older adults					*Chi*2 (1) 611.29***
	No	132,107	101,051	233,158	
		56.66%	43.34%	100%	
	Yes	25,264	24,663	49,927	
		50.60%	49.40%	100%	
	Subtotal	157,371	125,714	283,085	
		55.59%	44.41%	100%	
Household size					*Chi*2 (4) 797.99***
	One person	55,264	38,315	93,579	
		59.06%	40.94%	100%	
	Two persons	33,719	30,264	63,983	
		52.7%	47.3%	100%	
	Three persons	24,034	20,261	44,295	
		54.26%	45.74%	100%	
	Four persons	20,415	17,862	38,277	
		53.33%	46.67%	100%	
	Five persons or more	11,093	8,364	19,457	
		57.01%	42.99%	100%	
	Subtotal	144,525	115,066	259,591	
		55.67%	44.33%	100%	
Destroyed					*Chi*2 (1) 59.65***
	No	157,309	125,564	282,873	
		55.61%	44.39%	100%	
	Yes	62	150	212	
		29.25%	70.75%	100%	
	Subtotal	157,371	125,714	283,085	
		55.59%	44.41%	100%	
Flood insurance					*Chi*2 (1) 7374.59***
	No	141,892	98,773	240,665	
		58.96%	41.04%	100%	
	Yes	15,479	26,941	42,420	
		36.49%	63.51%	100%	
	Subtotal	157,371	125,714	283,085	
		55.59%	44.41%	100%	

[i]TSA stands for Transitional Sheltering Assistance.
[j]*Chi*2 (k) = chi-square with k degrees of freedom.
[k]***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

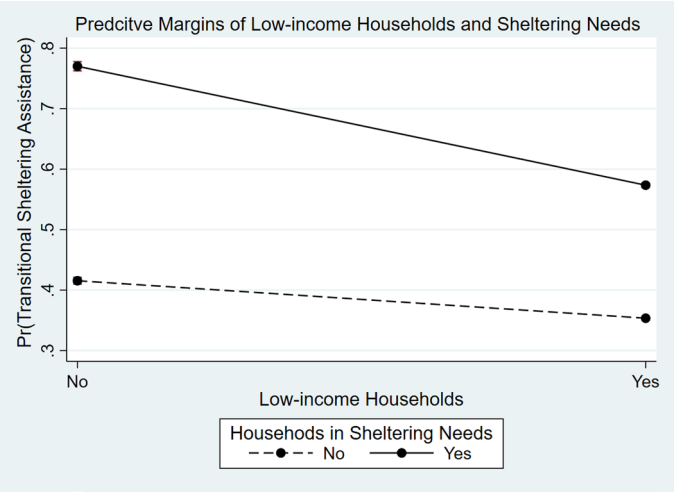

Figure 1. Marginal probabilities of transitional shelter assistance for low-income households and sheltering needs after Hurricane Harvey in Harris and Galveston Counties, Texas, 2017.
Note: Pr = Probabilities. Whiskers indicate 95% confidence intervals.

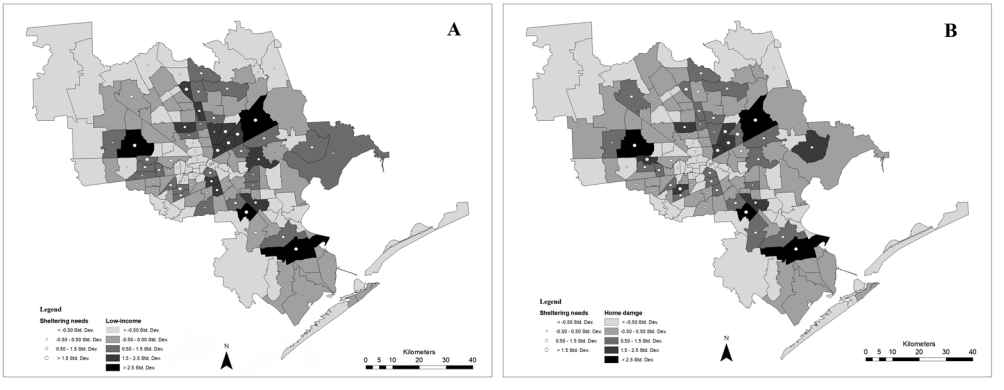

Figure 2. (A. and B). Prevalence of sheltering needs, low-income housing victims, and Hurricane Harvey induced home damage across 155 zip codes in Harris and Galveston counties, 2017.

non-random missingness on the independent variables (Allison, 2002). Therefore, we employed this method in all regression analyses using our reduced sample ($N = 259{,}350$). As an additional check, multiple-imputations ($M = 10$) procedures were applied to estimate each model, which yielded similar results (as in Supplementary Tables A and B). All statistical analyses were conducted by using the Stata 15 MP software package.

Finally, using ArcGIS 10.8, we present the spatial distributions damaged homes, low-income victims of housing loss, and community level sheltering needs. To do so, we first aggregated the counts of the damaged homes, the low-income victims of housing loss, and the sheltering needs for all 155 zip codes that are in or across the boundaries of Harris and Galveston counties. Then, we categorized these zip codes in ordinal levels, according to their standardized scores on these community attributes, as mapped in Figure 2(A) and (B). We further employed Pearson correlation analysis for examining the relationships between each pair of these community attributes, with the results reported in Supplementary Table D.

Results

As presented in Table 1, low-income households comprised more than 82% of the total 283,085 victims of housing loss in Harris and Galveston counties. Households without flood insurance were more likely to be low-income than those with flood insurance. Nearly 90% of low-income households were not covered by flood insurance, which is statistically significant higher (X^2_1 = 22185.71; $p < 0.01$) than coverage among households that were not low-income (64%). Destroyed homes were disproportionately distributed between low-income and not low-income households. (88% vs. 12%; $p < 0.05$). Renters were more likely to be low-income than their homeowner counterparts (93% vs. 71%; $p < 0.01$).

As shown in Table 2, about 33% of all victims of housing loss as a result of Hurricane Harvey were in need of emergency shelter. However, such needs were disproportionally prevalent among subgroups with different housing and damage characteristics. Low-income households had a higher prevalence of sheltering needs than their higher income counterparts (34% vs. 29%; $p < 0.01$). Renters had greater needs than homeowners (40% vs. 26%; $p < 0.01$). Not surprisingly, households whose homes were destroyed by Harvey had greater sheltering needs than those whose homes were damaged but not destroyed (54% vs. 33%; $p < 0.01$).

The results of the first logistic regression model, Model 1, are presented in Table 3. While controlling for other covariates, the odds of sheltering needs for low-income households is 3.9% higher than those not low-income (OR = 1.039; 95% confidence interval [95% CI]: 1.014, 1.064). Renter occupants are more likely to require shelter after the disaster than owner occupants (OR = 1.992; 95% CI: 1.954, 2.031). Households with people aged 65 or older have greater needs than those without such household members (OR = 1.081; 95% CI: 1.056, 1.106).

In terms of TSA prevalence, presented in Table 4, only about 60% of the households in need of shelter were granted TSA. Further, less than 42% of low-income housing victims were granted TSA, in contrast to 57% of recipients not in low-income status ($p < 0.01$). Renter occupants were granted TSA at a rate of 40%, compared to 49% of owner occupants ($p < 0.01$). Additionally, only about 41% of the housing victims without flood insurance were granted TSA, which is disproportionately lower than those with flood insurance at 64% (X^2_1 = 7374.59; $p < 0.01$).

The results in Table 5 compare the main effects of low-income status and sheltering needs (Model 2) and their interaction effect (Model 3) on obtaining TSA. As shown in Model 2, low-income status and sheltering needs each has its own main effect. The chance of obtaining TSA for a low-income household is significantly lower than that of a household not of low-income status (OR = 0.649; 95% CI: 0.634, 0.664), though such a chance is much greater for a household with a sheltering need than one without a sheltering need (OR = 2.757; 95% CI: 2.709, 2.806). As reported in Model 3, low-income status and sheltering needs also have an interaction effect. The chance of having TSA is even lower for a household that is both low income and in need of shelter than a household with a sheltering need but not of low-income status (OR = 0.516; 95% CI: 0.490, 0.544). As plotted in Figure 1 (with detailed parameters reported in Supplementary Table C), among households without sheltering needs, the marginal probability (Pr) of obtaining TSA is more than 6% lower for low-income households than for households who

Table 5. Estimating transitional shelter assistance by sheltering needs, housing characteristics and Hurricane Harvey induced damage characteristics by using logistic regressions: Harris and Galveston Counties, Texas, 2017.

Variables	(Model 2) Odds ratio		(Model 3) Odds ratio
Low-income			
No^[l]	1		1
Yes	0.649***[m]		0.764***
	(0.634–0.664)[n]		(0.744–0.784)
Sheltering needs			
No^	1		1
Yes	2.757***		4.880***
	(2.709–2.806)		(4.646–5.125)
Interaction term			
Low-income ˣ Sheltering needs			0.516***
			(0.490–0.544)
Renter			
No^	1		1
Yes	0.809***		0.809***
	(0.794–0.824)		(0.794—0.824)
Older adult			
No ^	1		1
Yes	1.126***		1.119***
	(1.101–1.151)		(1.095–1.144)
Household size			
One person^	1		1
Two persons	1.182***		1.185***
	(1.157–1.208)		(1.160–1.211)
Three persons	1.182***		1.182***
	(1.154–1.211)		(1.154–1.211)
Four persons	1.214***		1.213***
	(1.184–1.246)		(1.182–1.244)
Five persons or more	1.090***		1.086***
	(1.055–1.126)		(1.051–1.122)
Destroyed			
No^	2.994***		3.009***
Yes	(2.189–4.096)		(2.201–4.114)
Flood insurance			
No^	1.975***		1.981***
Yes	(1.927–2.025)		(1.932–2.031)
Constant	0.712***		0.626***
	(0.693–0.731)		(0.608–0.644)
Observations	259,350		259,350
LR chi2 [df][o]	[10] 22,255***		[11] 22,904***
LR chi2 [1] between model 2 and model 3		649.41***	

[l]^ stands for a reference category.
[m]*** $p < 0.001$.
[n]95% confidence intervals in parentheses.
[o]likelihood ratio chi-square tests with [k] degrees of freedom.

were not low-income (Pr = 0.353 vs. Pr = 0.416; $p < 0.001$). Further, the gap between them is even wider when both groups have sheltering needs: the probability of obtaining TSA for low-income households is about 20% lower than the households not in low-income status (Pr = 0.770 vs. Pr = 0.573; $p < 0.001$).

Finally, Figure 2(A) and (B) provides visual evidence that communities with more low-income victims of housing loss are related to those with greater demands of sheltering needs where home damages were much more prevalent. The results presented in Supplementary Table D further corroborate the positive relationship between each pair of attributes (r (153) > 0.912; $p < 0.001$).

Discussion

Based on administrative data from FEMA, our study first finds that most housing victims of Hurricane Harvey in Harris and Galveston counties (82%) were low-income households, and that the majority of homes destroyed by Harvey (88%) had been occupied by low-income households prior to the disaster. These findings are consistent with the results from a recent survey study conducted within the Houston Metropolitan area ($n = 377$) that suggests the areal extent of flooding around residents' homes was distributed inequitably with respect to socioeconomic status (Collins et al., 2019). In addition, our study suggests most victims of housing loss (87%) who had not purchased flood insurance were of low-income status. This is also consistent with recent literature showing that low-income households are not able to afford disaster insurance which would otherwise mitigate their losses after a disaster (Ma et al., 2021b).

Given that homes destroyed by Hurricane Harvey were much more prevalent among low-income households, a group that is less likely to be able to afford private flood insurance, these low-income housing victims were, not surprisingly, much more reliant on publicly funded transitional housing assistance, TSA, than their counterparts (33% vs. 29%, as in Table 2). More surprising was that their demand for TSA was still significantly higher than their counterparts even after controlling for possible confounding effects [damage at the 'destroyed' level and having flood insurance] as shown in Table 3. These findings indicate that emergency sheltering needs after Hurricane Harvey among the victims in Harris and Galveston counties were not exclusively driven by housing damage severities caused by Harvey itself, but also had been pre-determined by the income sufficiency and insurance preparedness of housing loss victims prior to this catastrophic event. More surprisingly, despite greater demand for TSA from low-income households, access to TSA for this group was disproportionately lower than their higher income counterparts (40% vs. 51%, Table 4). Further, findings also showed that when both income groups need shelter, low-income housing victims are significantly less likely to obtain TSA. The results from both the main effect and interaction effect models indicate that low-income housing victims' sheltering needs were neither sufficiently nor equally addressed by the TSA program, compared to those who were not of low-income.

Analyzing the secondary data collected by FEMA does not tell us *why* the sheltering needs of low-income households in Harris and Galveston counties were not addressed after Hurricane Harvey. However, based on previous literature, we speculate that two interrelated conditions could have limited access to TSA (García, 2022; Mueller et al., 2011). First, low-income disaster housing victims, especially renters, are often not aware of disaster housing assistance programs provided by the federal government (Mueller et al., 2011). Though with greater needs, low-income housing victims in Harris and Galveston counties were probably less aware for their eligibility for TSA than their counterparts who were not in low-income status. Second, a more recent study of Hurricane Maria in Puerto Rico (García, 2022) suggests many low-income applications for housing assistance programs were denied assistance by FEMA because 'governments often fail to provide materials and information in

formats that are accessible to the most vulnerable'. Thus, without data regarding why applications were turned down after Hurricane Harvey, it is difficult to exclude the possibility that 'FEMA inadvertently creates barriers, especially for low-income households, to obtain assistance' (García, 2022).

Nevertheless, our results clearly demonstrate that at the household level, the dearth of flood insurance and dwelling in rental homes are both salient attributes of low-income victims of housing loss. A previous study (Easthope et al., 2017) found that low-income renter households were not able to afford homeownership due to housing prices in many urban settings. Previous research has also found that residents in special flood hazard areas (SFHA) are especially at risk of not being able to afford flood insurance as premiums have been steadily increasing in price (Montgomery & Kunreuther, 2018). Given that Harris and Galveston counties are both in typical urban settings with large residential buildings located on SFHA, it seems reasonable to speculate that prohibitive housing prices in some SFHAs facilitated renting behaviours among low-income households who were also not able to afford flood insurance. Nevertheless, future research should further examine the roles of housing price and flood hazard on household decisions to purchase flood insurance.

Our study has its limitations. First, the results presented in this study are in response to one particular disaster, Hurricane Harvey. Thus, our findings cannot be universally generalized to reflect other natural disasters. Second, the sheltering needs of low-income housing victims might be underestimated using a dichotomous variable, especially when their actual income was above $60,000 but below the arbitrary median thresholds at either the national or Houston MSA levels. Future studies should further investigate the effect of every incremental change in household income on sheltering needs and access to TSA when a continuous variable for income is available. Third, we lack data on other socioeconomic variables, such as educational attainment. Future study should also further explore other socioeconomic conditions, and in particular, how these conditions might be moderating the impact of low-income status on access to TSA. Finally, once geographic information on the distribution of TSA is available, future studies should analyze the spatial distance between the damaged homes where the sheltering needs emerged and the shelters into which the housing victims moved with TSA. The results of such analyses will allow us to understand whether spatial factors effect TSA recipients with different income levels.

In conclusion, low-income households were ultimately and inevitably in greater need of emergency shelter as their rental homes were more vulnerable to housing damage either due to their poor structural quality for wind-resistance in hurricanes (Eaton, 1980), or their high levels of exposure to flood hazard. Yet, they had reduced ability to mitigate damages and their effects due both to limited access to private flood insurance, and to more limited use of TSA, despite their greater need. Future studies should conduct both semi-structured interviews with focus groups of low-income housing victims, and run path analyses once the variables of SFHA, home price, and structural quality are available at the household level.

To our knowledge, this is the first study to examine the impact of a natural disaster on emergency sheltering need and how FEMA's transitional shelter assistance

program addressed such need among victims of housing loss. In addition to future research as noted above, our study provides evidence for policy reformulation and practice. Our findings call for a more equitable distribution of transitional shelter assistance, with a particular attention to the needs of low-income households.

Disclosure statement

No potential conflict of interest was reported by the authors.

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