Coastal Bend Hurricane Evacuation Study: Hurricane Harvey Evacuation Behavior Survey Outcomes and Findings

Prepared by

Texas A&M Hazard Reduction & Recovery Center

University of Washington Institute for Hazard Mitigation Planning and Research

and

Texas A&M Transportation Institute

May 2020

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INTRODUCTION

This report describes results from a survey of households in the Texas Coastal Bend area about their evacuation behaviors associated with Hurricane Harvey, which made landfall at approximately 10 p.m. on August 25, 2017, in Aransas County, Texas. The study builds on previous work by hazards scholars to evaluate actual or intended hurricane evacuation behaviors in the Texas Rio Grande Valley, other areas of the Texas coast, and across the United States, and recently summarized by Lindell et al. (2019). As described by Lindell, et al., (2013):

> A timely and effective evacuation of threatened areas of the Texas Gulf Coast requires accurate information about how risk area residents will respond to a hurricane evacuation warning. One important source of such information is the research on people's responses in previous emergencies…
>
> [P]revious research has identified many general principles about people's behavior in disasters, but it cannot answer all of the questions that arise in connection with developing local and regional evacuation plans. Specifically, people's behavior is affected by their previous experience, local conditions, and the circumstances that they encounter at the time of the event. For example, researchers have found that evacuation is affected by households' perceptions of warning sources, interpretation of warning messages, access to evacuation vehicles, concerns about the safety of persons and property, economic assets, and knowledge of a safe route to an acceptable destination (Lindell & Perry, 2012). Consequently, location-specific surveys are needed to assess these conditions and people's expectations regarding what they will do if a hurricane is predicted to strike their area.

BACKGROUND

The Hurricane Harvey Evacuation Behavior Survey (HHEBS) focused on counties in the Texas Coastal Bend area and was conducted in 2019 by researchers from the Hazard Reduction & Recovery Center (HRRC) at Texas A&M University, the Texas A&M Transportation Institute (TTI), and the University of Washington Institute for Hazard Mitigation Planning and Research. The survey sample area comprises eight Texas Coastal Bend area counties: Matagorda, Jackson, Calhoun, Victoria, Refugio, Aransas, San Patricio, and Nueces (Figure 1). The last six of these counties (the lower six along the Texas coast) are part of a Coastal Bend Hurricane Evacuation Study (CBHES), being conducted by TTI and HRRC in partnership with local communities and the Texas Division of Emergency Management. Other components of the CBHES project include updating evacuation zones, evaluating population vulnerabilities, and estimating evacuation clearance times. These project components are described in separate reports. Funding for the HHEBS was provided by the Federal Emergency Management Agency through the U.S. Army Corps of Engineers, the National Science Foundation through the University of Washington, HRRC, and TTI.
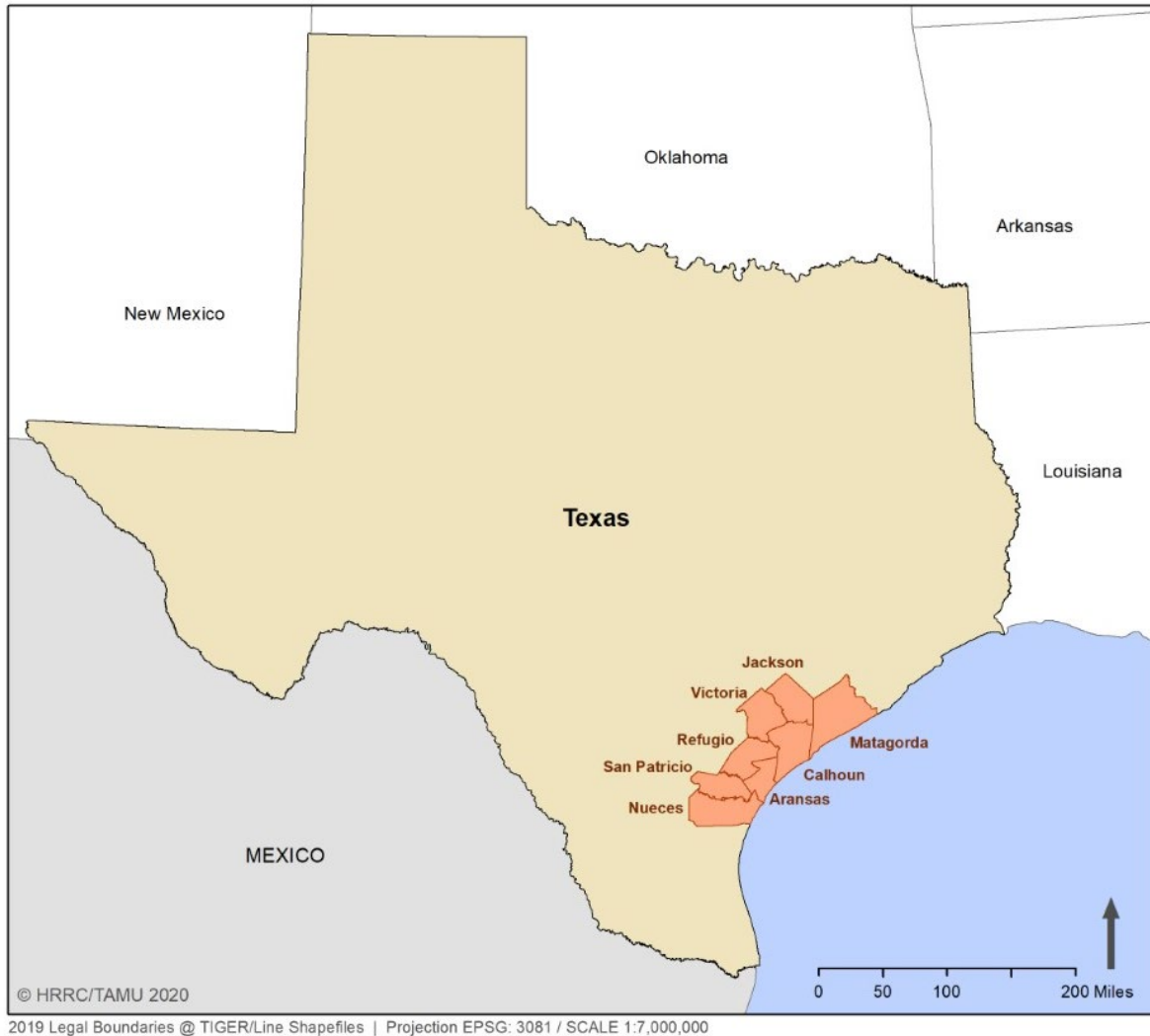
Figure 1. Texas and the Hurricane Harvey Evacuation Behavior Survey counties.

SURVEY OVERVIEW

Survey Topics

The behavioral survey covered four primary topic areas: household evacuation decisions and associated cues, evacuation preparations and logistics, evacuation route choices, and respondent/household demographics and related characteristics. The HHEBS instrument was based upon earlier questionnaires that HRRC staff used in previous Texas hurricane evacuation behavior studies (Lindell et al., 2001; Lindell et al., 2013) along with items from other evacuation studies summarized by Lindell et al. (2019). Altogether, 41 questions comprised the survey. The survey instrument and associated protocols were approved by applicable university and federal institutional review boards. A copy of the survey instrument is in the appendix.

Survey Distribution and Response

The survey distribution was administered in three waves, following a process adapted from Dillman et al. (2014). Households addresses were a randomly selected sample purchased from M-S-G, Inc., a national survey address company. To enhance communications and responses from Hispanic residents, 20% of the sample distribution included Spanish versions of survey documents, and these addresses were selected based on their locations in higher-proportion Spanish-speaking block groups in the study area. Wave 1 of the survey was online only (hosted by Qualtrics, Inc., under license to Texas A&M), and Waves 2 and 3 included paper copies of the survey instrument with postage-paid return envelopes. A reminder postcard was also sent out after Wave 3.

Throughout all survey waves, 1,253 addresses were undeliverable. In addition, some survey participants responded to multiple waves. Accounting for undeliverable addresses and all valid responses (including duplicates), the estimated Wave 1 online-only response rate is 1.8% (98/5,446). The estimated Wave 2 response rate is 10.6% (594/5,602), and the estimated Wave 3 response rate is 4.9% (250/5,105). Across all waves, there were 895 responses from unique addresses (and an additional 5 responses that could not be associated with an address location) and 5,700 addresses for which there was no undeliverable return. Thus, the combined response rate is estimated at 15.7% (895/5,700) across the three survey waves. The response rates of 10.6% and 4.9% from paper questionnaire mailout Waves 2 and 3, respectively, are comparable with survey response rates from Lindell et al. (2013) which had an overall response rate for a mailout survey of 23.3% in the Texas Rio Grande Valley area using three paper questionnaire mailouts, for an average response rate of 8.5% per paper questionnaire mailout.

SURVEY RESULTS

Evacuation from Hurricane Harvey

Table 1 lists summaries of whether or not HHEBS respondents evacuated from Hurricane Harvey, by county, for respondents who indicated they were Coastal Bend area residents at the time of Hurricane Harvey. An additional 23 HHEBS respondents indicated they were not Coastal Bend area residents at the time of Hurricane Harvey. The 'Yes' and 'No' columns in Table 1 show the number of household respondents (Count column) that indicated they did or did not (respectively) evacuate from Hurricane Harvey, and the corresponding percentage of that county's respondents (Row N % column) for each Yes/No answer category. The county with the highest respondent evacuation percentage was Aransas County, which was the location of hurricane landfall (indicated by the red arrow in Figure 2), followed by Calhoun County, which was the first county away from landfall to the east (upper right quadrant or strongest side of the storm). Respondent evacuation percentages in San Patricio County, one county to the west of Aransas County, were close to that of Calhoun County. The lowest HHEBS respondent evacuation percentages were counties with

less coastal exposure (Refugio and Victoria Counties) or to the south of the storm's landfall location (Nueces County).

Respondent Demographics

HHEBS respondent demographic characteristics provide context about who responded to the survey. For comparison, Table 2 lists demographic characteristics of the eight-county survey area downloaded from the U.S. Census Bureau *QuickFacts* data summaries. The combined population of the HHEBS area is over 625,000 across nearly 200,000 households with an average of 2.75 persons per household and a median household income of around $54,000. The population is 50.4% female, and is 90.6% White and 4.7% Black. Over 57% of the population has a Hispanic background, and 19.9% of the population over 25 years of age has a bachelor's degree or higher.

Table 1. Hurricane Harvey Evacuation Choices of HHEBS Respondents, by County.

| | | Household evacuated from Hurricane Harvey | | | | | |
| | | Yes | | No | | Total | |
		Count	Row N %	Count	Row N %	Count	Row N %
Assigned County	Matagorda	66	72.5%	25	27.5%	91	100.0%
	Jackson	45	49.5%	46	50.5%	91	100.0%
	Calhoun	72	76.6%	22	23.4%	94	100.0%
	Victoria	38	40.4%	56	59.6%	94	100.0%
	Refugio	74	55.6%	59	44.4%	133	100.0%
	Aransas	139	83.7%	27	16.3%	166	100.0%
	San Patricio	56	75.7%	18	24.3%	74	100.0%
	Nueces	51	39.2%	79	60.8%	130	100.0%
	Total	541	62.0%	332	38.0%	873	100.0%
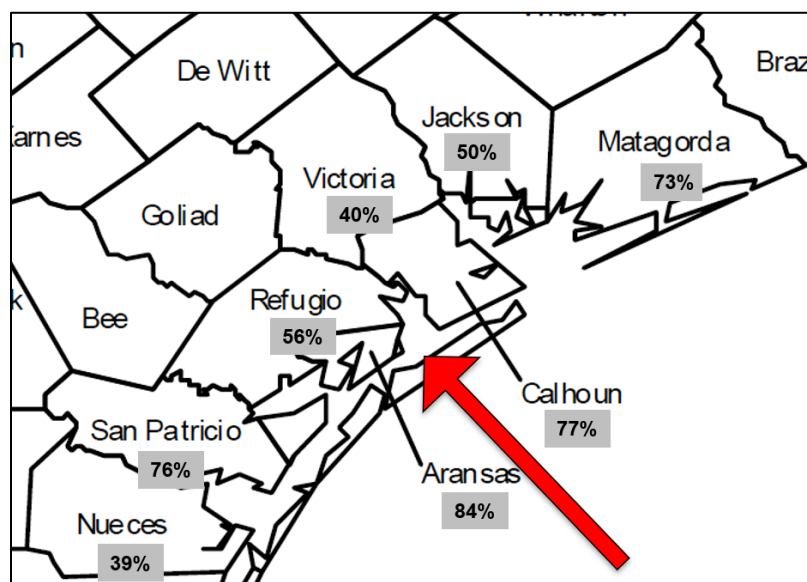
Figure 2. Hurricane Harvey evacuation percentages of HHEBS respondents, by county.

Table 2. HHEBS County-Level Demographic Characteristics.

Population Statistic/County Name	Nueces County	San Patricio County	Aransas County	Refugio County	Victoria County	Calhoun County	Jackson County	Matagorda County	Combined Total
Population estimates, July 1, 2018	362,265	66,893	23,792	7,032	92,035	21,561	14,874	36,552	625,004
Female persons, percent	50.6%	49.7%	50.6%	50.9%	51.0%	48.6%	50.2%	49.6%	50.4%
White alone, percent	90.9%	94.1%	93.1%	89.6%	89.4%	89.1%	89.6%	83.6%	90.6%
Black or African American alone, percent	4.3%	2.0%	1.7%	6.4%	6.6%	3.2%	6.5%	11.3%	4.7%
Hispanic or Latino, percent	64.2%	58.4%	27.4%	50.3%	47.4%	49.1%	34.0%	42.9%	57.1%
Households, 2014-2018	128,926	23.121	9,432	2,577	32,544	7,604	5,237	13,636	199,979
Persons per household, 2014-2018	2.73	2.87	2.58	2.74	2.79	2.83	2.79	2.67	2.75
Bachelor's degree or higher, percent of persons age 25 years+, 2014-2018	21.5%	14.9%	21.7%	11.8%	20.1%	15.0%	16.1%	16.7%	19.9%
Median household income (in 2018 dollars), 2014-2018*	$55,048	$55,229	$44,865	$48,112	$55,631	$55,469	$60,276	$45,500	$ 54,075

*Combined total median household income estimated by averaging county median household incomes weighted by number of households per county.

Source: https://www.census.gov/quickfacts

Analysis of HHEBS self-reported demographic characteristics indicates that 57.5% of survey respondents were female. Although this is a slightly higher proportion than that of the area population, both genders had nearly the same average reported household evacuation behaviors: 63.0% of households with female respondents and 61.7% of households with male respondents reported evacuating from Hurricane Harvey.

On average, HHEBS respondents had higher levels of formal education than the area population; 47.1% of survey respondents reported having a bachelor's degree or higher, compared with 19.9% of the area population. Although education and income are often strongly related (Lindell and Perry, 2004), the reported median income categories from survey respondents tracked relatively closely with the actual median incomes of the individual counties. In seven of the eight counties, the median income category (in increments of $10,000) calculated from the HHEBS responses matched the county's actual median household income (albeit at the lower end of the HHEBS income categories). The exception was Aransas County, where residents have an actual median household income (2014–2018) of just under $45,000, but the median income category for Aransas County HHEBS respondents was $55,000–$64,999.

The median household income estimated for the project area based on Census data was just over $54,000, while the median reported household income category from HHEBS survey responses was slightly higher at $55,000–$64,999. There were no consistent trends by income level for whether or not households evacuated from Hurricane Harvey (Table 3)[1]. The distribution of HHEBS responses by income category also indicates strong extremes: the highest HHEBS response count frequencies are at the high and low extremes of the income category scale, and the median income category has the lowest count frequency for HHEBS responses.

Table 3. Reported Household Incomes and Evacuation from Hurricane Harvey.

Yearly household income at the time of Hurricane Harvey	Household evacuated from Hurricane Harvey			
	Yes	No	Total	
	Count	Count	Count	% Yes
Less than $21,499	72	37	109	66.1%
$21,500–34,999	52	35	87	59.8%
$35,000–44,999	66	32	98	67.3%
$45,000–54,999	50	35	85	58.8%
$55,000–64,999	38	23	61	62.3%
$65,000–74,999	32	30	62	51.6%
$75,000–99,999	62	43	105	59.0%
$100,000 or more	125	70	195	64.1%
Total	497	305	802	62.0%

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[1] Response count totals for different tables in this report vary because not all respondents answered all questions.

Overall, 89.3% of survey respondents indicated they were White, and 3.2% indicated they were Black (Table 4), tracking relatively closely to the population proportions for these races. However, HHEBS respondents underrepresented residents with Hispanic backgrounds: only 18.2% of survey respondents (Table 4) reported having a Hispanic, Latino(a), or Spanish background, compared with over half of the area population. This means that the proportion of White survey respondents is also more heavily White and non-Hispanic than is the overall area population. However, there were no significant differences between Hispanic and non-Hispanic HHEBS respondents for whether their households evacuated from Hurricane Harvey ($X^2_{1, N = 835}$ = 0.116, p = 0.73)[2,3].

Table 4. Race and Ethnic Backgrounds of HHEBS Respondents.

		Informant is of Hispanic, Latino(a), or Spanish origin		
		Yes	No	Total
		Count	Count	Count
Q39. Which of the following best describes your race?	White	105	640	745
	Black	0	27	27
	Native Hawaiian or Pacific Islander	0	14	14
	American Indian or Alaska Native	3	4	7
	Other	34	8	42
	Total	142	693	835

The number of persons per household and their vehicle resources are important components of evacuation demand analyses. There are two ways of estimating household size from the HHEBS data (Table 5). First, respondents who evacuated from Hurricane Harvey were asked to indicate how many people in their household evacuated. Second, all respondents were asked to indicate the number of people in their households that were in three different age categories, less than 18 years, 18–65 years, and more than 65 years, which could then be summed for a total household size across all ages. These calculated totals can be compared for those households that evacuated and those that did not, whereas the directly provided number was only answered by evacuees.

In all counties, the average number of persons per household that evacuated was higher from the more direct estimate than the calculated estimate (Table 5). The overall direct average for HHEBS respondents of 2.72 people/household that evacuated (second from left column in Table 5) was close to that of the study area of 2.75 people/household. Note that this survey response estimate is not weighted for county population). For the more indirect summed measures (right three columns in Table 5), which allow for comparison of evacuee and non-evacuee households, there were no consistent trends in household sizes across counties, and there was not a significant difference in household sizes for evacuees and non-evacuees across the sample ($X^2_{13, N = 851}$ = 13.789, p = 0.39).

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[2] Statistical tests in this report used unweighted cases.
[3] X^2 is the chi-square test statistic, N is the sample size, and p is the significance of the chi-square test.

Finally, survey respondents represented older age groups than the population (Table 6). This is also consistent with respondents acting as representatives of their household.

Table 5. Average HHEBS Respondent Household Sizes and Evacuation Behavior, by County.

Assigned County	Number in household that evacuated from Hurricane Harvey	Household evacuated from Hurricane Harvey		
		Total number of people in household		
		Yes	No	Total
	Mean	Mean	Mean	Mean
Matagorda	2.80	2.48	1.88	2.31
Jackson	2.49	2.13	2.45	2.29
Calhoun	2.43	2.14	1.77	2.05
Victoria	2.78	2.66	2.46	2.54
Refugio	3.00	2.74	2.31	2.55
Aransas	2.51	2.24	2.04	2.20
San Patricio	3.19	2.84	2.72	2.81
Nueces	2.76	2.20	2.48	2.37
Total	2.72	2.40	2.33	2.37

Table 6. HHEBS Respondent Age Categories, by County.

		Informant's reported age at time of Hurricane Harvey (categorized)				
		44 or less	45-54	55-64	65-74	75 or more
		Count	Count	Count	Count	Count
Assigned County	Aransas	11	13	48	52	42
	Calhoun	6	12	33	24	18
	Jackson	10	15	31	18	11
	Matagorda	5	19	36	19	10
	Nueces	20	14	38	40	16
	Refugio	17	32	24	38	24
	San Patricio	8	19	15	21	11
	Victoria	17	12	26	25	12

Hurricane Information Sources, Cues, and Experiences

The questionnaire asked Coastal Bend respondents to report the frequency that they consulted different types of Hurricane Harvey information sources as the storm approached. It used a rating scale of 1 for *0 times/day*, 2 for *1–2 times/day*, 3 for *3–4 times/day*, 4 for *5–6 times/day*, and 5 for *7 or more times/day*. There was substantial variation in the frequency of consulting different sources of information about the approaching hurricane (Figure 3).   The most prominent sources of information that HHEBS respondents consulted about Hurricane Harvey, indicated by the mean score for Coastal Bend respondents (M_{CB}) were local news media ($M_{CB} = 3.54$) and national news media ($M_{CB} = 3.46$). Peers ($M_{CB} = 3.03$) and the internet ($M_{CB} = 2.85$) were less prominent information sources but also important. Social media ($M_{CB} = 2.17$) and local authorities ($M_{CB} = 1.69$) were the

least frequently consulted, but information from local authorities may reach residents via other information channels. Coastal Bend evacuees had significantly higher hurricane information consultation scores than did non-evacuees for peers ($M_{CB\ evacuees}$ = 3.15, $M_{CB\ non-evacuees}$ = 2.84, U = 59,653, $n_{evacuees}$ = 503, $n_{non-evacuees}$ = 291, p = 0.001)[4] and local authorities ($M_{CB\ evacuees}$ = 1.72, $M_{CB\ non-evacuees}$ = 1.63, U = 63,299, $n_{evacuees}$ = 465, $n_{non-evacuees}$ = 277, p = 0.05).

Frequencies that HHEBS respondents consulted sources of information about approaching Hurricane Harvey

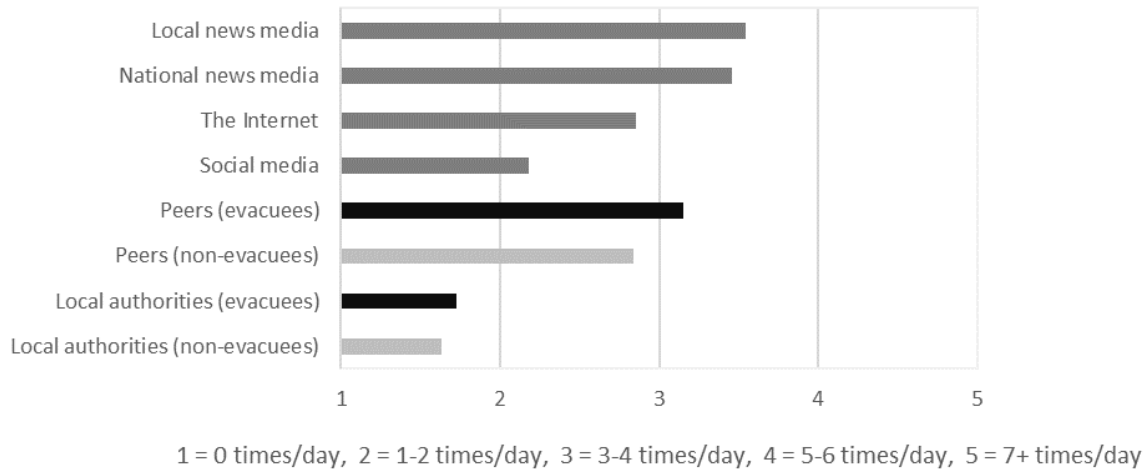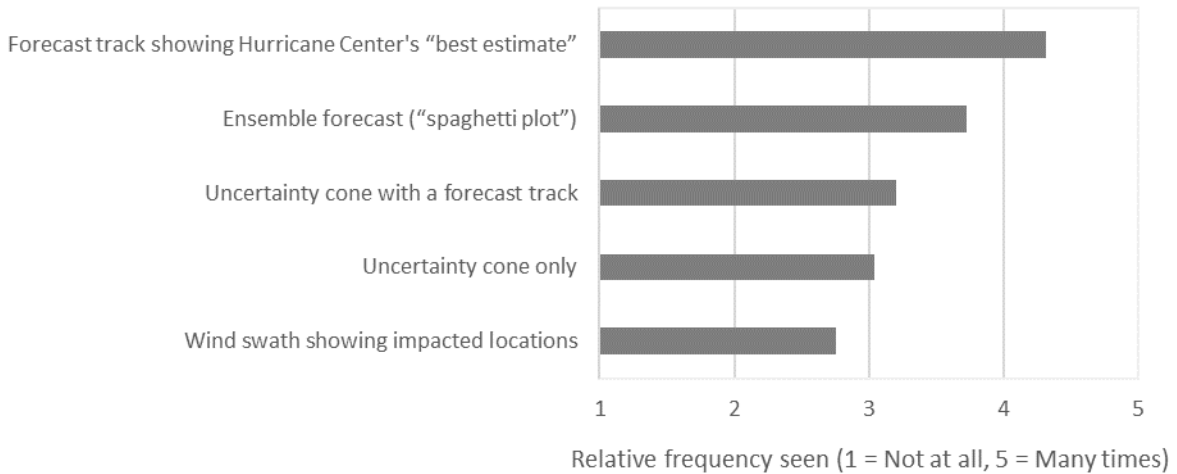1 = 0 times/day, 2 = 1-2 times/day, 3 = 3-4 times/day, 4 = 5-6 times/day, 5 = 7+ times/day

Figure 3. HHEBS information source consultation frequencies.

Overall, the HHEBS data are similar to those from Hurricane Lili (Lindell et al., 2005), where the mean ratings of information sources' *importance* (where 1 is not at all important and 5 is extremely important) were in order of local news (M = 4.27), national news (M = 3.48), peers (M = 2.85), and the internet (M = 1.84). No comparison can be made for social media because Hurricane Lili occurred in 2002 when use of social media was substantially less prevalent.

There was moderate variation in the types of graphical hurricane forecast information that HHEBS respondents indicated having seen on television (Figure 4). Respondents rated the relative frequencies with which they saw different hurricane track graphical information, using a scale between 1 for *Not at all* and 5 for *Many times*. The most common types of track information seen by respondents were the deterministic (best estimate) forecast track (M_{CB} = 4.31) and ensemble forecast (spaghetti plot) (M_{CB} = 3.73). On average, uncertainty cones with (M_{CB} = 3.20) and without forecast tracks (M_{CB} = 3.04) and wind swaths showing expected impact locations (M_{CB} = 2.75) were also seen but not many times. There were no significant differences in observed graphical forecast information between Hurricane Harvey evacuees and non-evacuees.

[4] U is the Mann-Whitney test statistic, n is the sample size, and p is the significance of the Mann-Whitney test.

Figure 4. Relative frequencies of seeing graphical hurricane forecast information on television.

There was variation in the types of personal impacts people expected due to Hurricane Harvey (Figure 5). Measured on a scale between 1 for *Not at all likely* and 5 for *Almost certain*, there was a moderate expectation by Harvey evacuees and non-evacuees that the storm would track through their community ($M_{CB} = 3.38$). Figure 5 shows (in the same order as presented in the following bullets) that Coastal Bend evacuees had significantly higher expectations than did non-evacuees for the following types of impacts from Hurricane Harvey:

- A disruption in basic services ($M_{CB\ evacuees} = 4.47$, $M_{CB\ non-evacuees} = 4.30$, $U = 78,709$, $n_{evacuees} = 527$, $n_{non-evacuees} = 316$, p = 0.10).
- Striking as a major hurricane ($M_{CB\ evacuees} = 3.74$, $M_{CB\ non-evacuees} = 3.50$, $U = 74,103$, $n_{evacuees} = 524$, $n_{non-evacuees} = 315$, p = 0.01).
- Home damaged or destroyed by wind ($M_{CB\ evacuees} = 3.22$, $M_{CB\ non-evacuees} = 2.49$, $U = 53,832$, $n_{evacuees} = 523$, $n_{non-evacuees} = 307$, p = 0.000).
- Job/work disruptions in the household ($M_{CB\ evacuees} = 3.02$, $M_{CB\ non-evacuees} = 2.53$, $U = 65,386$, $n_{evacuees} = 516$, $n_{non-evacuees} = 302$, p = 0.000).
- Household injuries or fatalities ($M_{CB\ evacuees} = 2.95$, $M_{CB\ non-evacuees} = 1.68$, $U = 39,263$, $n_{evacuees} = 520$, $n_{non-evacuees} = 309$, p = 0.000).
- Home inundation by freshwater (inland) flooding ($M_{CB\ evacuees} = 2.17$, $M_{CB\ non-evacuees} = 1.69$, $U = 64,279$, $n_{evacuees} = 518$, $n_{non-evacuees} = 308$, p = 0.000).
- Home inundation by saltwater (storm surge) flooding ($M_{CB\ evacuees} = 2.11$, $M_{CB\ non-evacuees} = 1.46$, $U = 56,509$, $n_{evacuees} = 518$, $n_{non-evacuees} = 311$, p = 0.000).
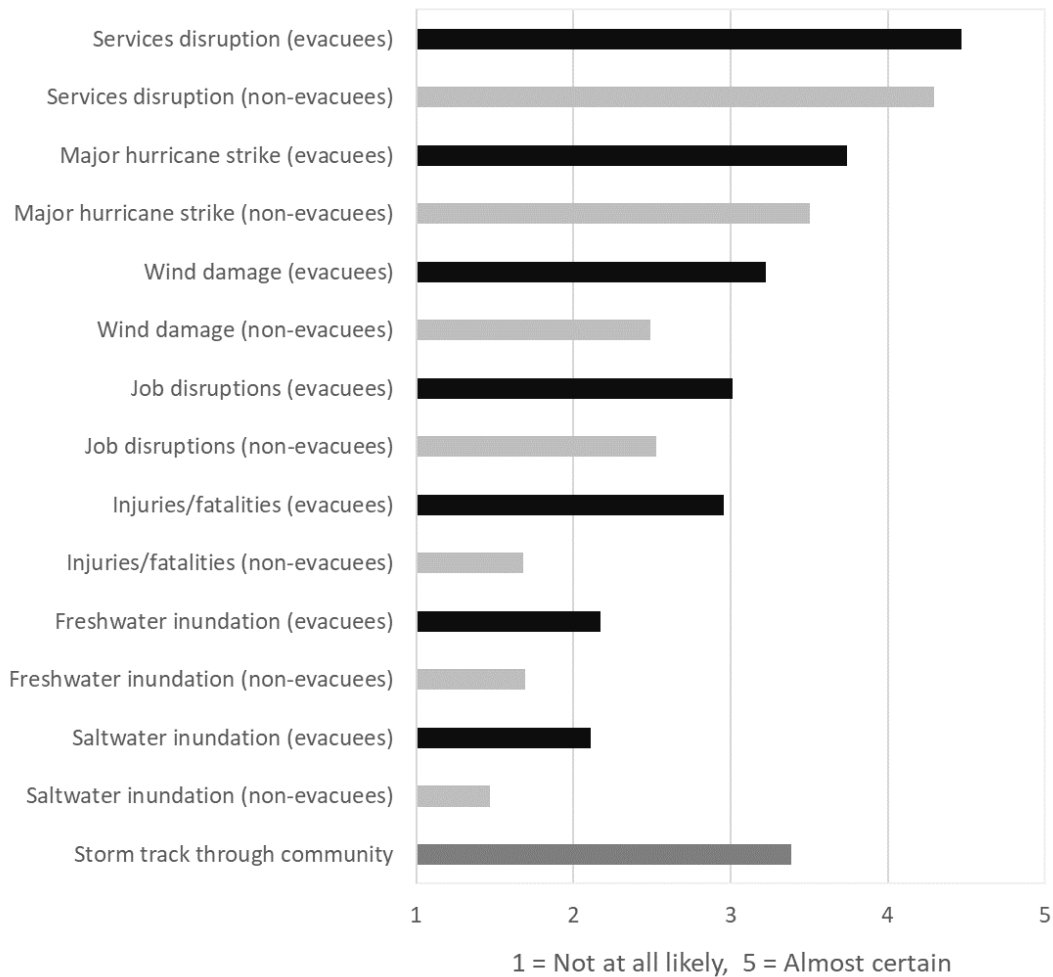
Figure 5. Expected impacts/consequences of Hurricane Harvey.

There was also variation in the extent to which HHEBS evacuees and non-evacuees considered different social cues or personal experiences in their decisions whether to evacuate for Hurricane Harvey (Figure 6). Measured on a scale between 1 for *Not at all* and 5 for *Very great*, there was a shared level of consideration by evacuees and non-evacuees about previous experiences with unnecessary evacuation ($M_{CB} = 2.84$). Even though there was no significant difference between evacuees and non-evacuees in the degree to which this factor was considered, it was however (and perhaps unsurprisingly) toward the lower end of relative importance compared to other factors for evacuees and toward the higher end of relative factor importance for non-evacuees. Figure 6 shows (in the same order as presented in the following bullets) that Coastal Bend evacuees had significantly higher levels of consideration when deciding whether to evacuate for Hurricane Harvey than did non-evacuees for the following types of social cues/experiences:

- Hearing local authorities issue official recommendations to evacuate ($M_{CB\,evacuees}$ = 4.06, $M_{CB\,non\text{-}evacuees}$ = 2.63, U = 37,879, $n_{evacuees}$ = 520, $n_{non\text{-}evacuees}$ = 308, p = 0.000).
- Previous personal experiences with hurricane storm conditions ($M_{CB\,evacuees}$ = 3.55, $M_{CB\,non\text{-}evacuees}$ = 3.10, U = 68,213, $n_{evacuees}$ = 516, $n_{non\text{-}evacuees}$ = 313, p = 0.000).
- Hearing an announcement of a hurricane "watch" or "warning" ($M_{CB\,evacuees}$ = 3.69, $M_{CB\,non\text{-}evacuees}$ = 2.47, U = 43,254, $n_{evacuees}$ = 524, $n_{non\text{-}evacuees}$ = 310, p = 0.000).
- Seeing friends, relatives, neighbors, or coworkers evacuating ($M_{CB\,evacuees}$ = 3.34, $M_{CB\,non\text{-}evacuees}$ = 2.27, U = 47,826, $n_{evacuees}$ = 520, $n_{non\text{-}evacuees}$ = 306, p = 0.000).
- Seeing area businesses closing ($M_{CB\,evacuees}$ = 2.67, $M_{CB\,non\text{-}evacuees}$ = 1.94, U = 58,945, $n_{evacuees}$ = 520, $n_{non\text{-}evacuees}$ = 309, p = 0.000).
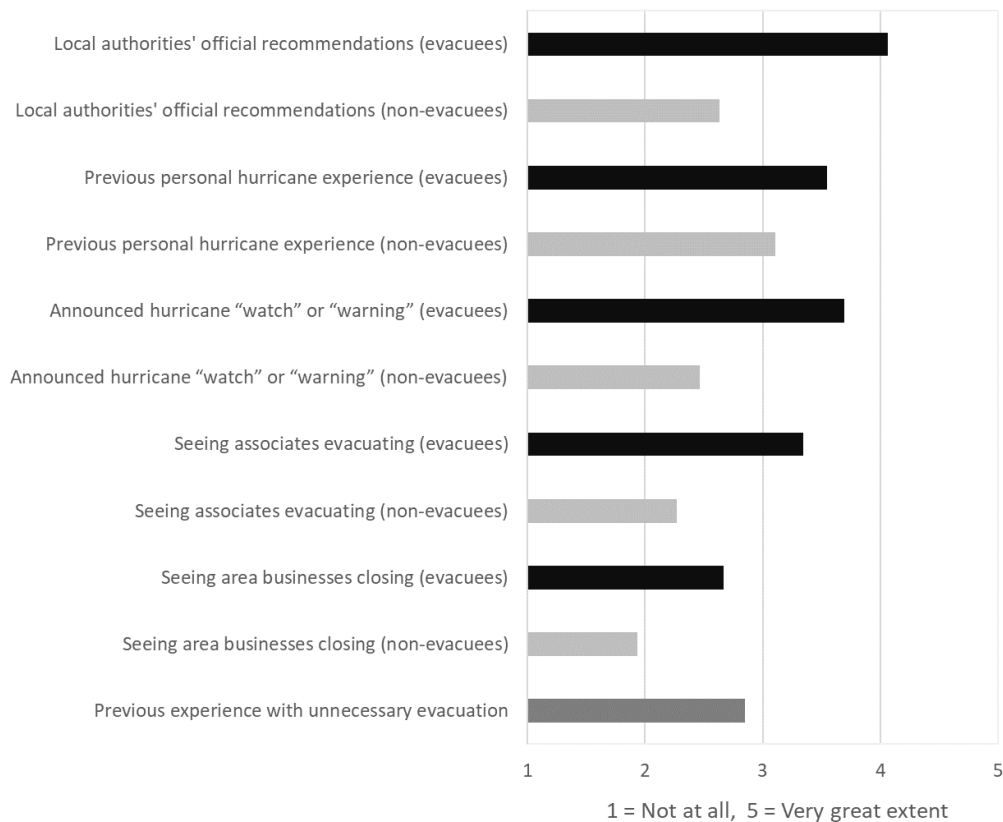

Figure 6. Consideration of cues and experiences in Hurricane Harvey evacuation decisions.

Evacuation Decision Timing

Just under one-third of the respondent households (32%) made their evacuation decisions before the National Hurricane Center (NHC) Hurricane Watch, and just over half (52%) made their evacuation

decision before the NHC Hurricane Warning (Figure 7)[5]. These percentages are similar to the 29% and 60%, respectively, in Hurricane Lili (Lindell et al., 2005). For those households that chose to evacuate from Hurricane Harvey, the decision data are consistent with those from other hurricane evacuations in showing that evacuation decisions were spread over multiple days (Lindell et al., 2019, Chapter 5). Moreover, there was a pronounced tendency to make evacuation decisions during the morning and afternoon hours so evacuation travel could be completed during daylight hours.
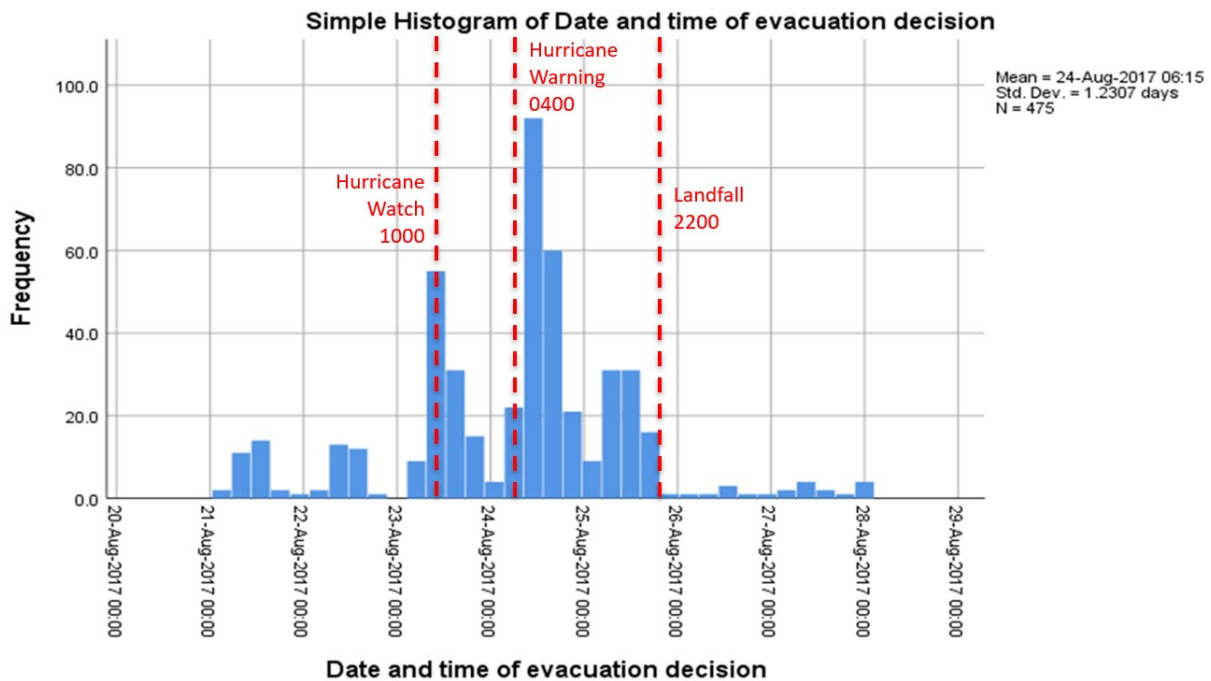
Figure 7. Hurricane Harvey evacuation decision time distribution.

Pre-evacuation Activities

HHEBS evacuee respondents reported the amount of time spent with various pre-evacuation activities (Table 7). Most respondents (over 60%) indicated they did not need to prepare to leave work or travel from work to home. Nearly all respondents spent some time packing needed items, more than one-third spent longer than 60 minutes, and over two-thirds spent longer than 30 minutes packing. Over half of HHEBS evacuee respondents spent more than an hour on activities intended to protect property from storm damage, and over half spent more than a half hour with other home preparations such as shutting off utilities, securing the home, and preparing to leave. Most respondents also spent time gathering persons for the evacuation, but this activity took on average less time than packing, protecting property, or making other home preparations, with 40% spending 30 minutes or less and 28% spending 15 minutes or less on this activity (not including those who did not do this activity).

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[5] Figures 7 and 8 show NHC Hurricane Watch and Warning and Hurricane Landfall times but do not show dates/times of individual community evacuation orders, which varied substantially across the survey area from county to county and city to city.

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Two-thirds of HHEBS evacuee respondents reported spending time preparing pets for evacuation, but this was also a lower time commitment activity for many with over one-third of evacuees spending 30 minutes or less and nearly 20% spending 15 minutes or less (not including those who did not do this activity).

Table 7. Time Spent on Pre-evacuation Activities by HHEBS Respondents.

| | Hurricane Harvey Pre-Evacuation Activity | | | | | | | | | | | | | |
| Number of minutes spent on activity | Prepare to leave work | | Travel from work to home | | Protect property from storm damage | | Gather all persons for evacuation | | Prepare pets for evacuating | | Pack needed items | | Shut off utilities, secure home, and leave | |
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Didn't do	315	62%	305	61%	97	19%	90	18%	169	33%	10	2%	70	14%
1 to 30 minutes	59	12%	124	25%	55	11%	203	40%	185	36%	126	24%	161	31%
31 to 60 minutes	62	12%	47	9%	96	19%	101	20%	82	16%	190	36%	115	22%
61 minutes or longer	69	14%	26	5%	268	52%	113	22%	75	15%	199	38%	167	33%
Total	505	100%	502	100%	516	100%	507	100%	511	100%	525	100%	513	100%

A sizable minority (37.7%, or 204/528) of HHEBS evacuee respondents indicated that they made local trips before their evacuation departures. Table 8 lists the types of activities that 210 respondents indicated they made on local trips. Buying gas and getting money were the most common activities, followed by buying water and food for nearly half of evacuees, suggesting they expected limited access to these resources during or after their evacuation trip. Over a quarter indicated they bought medicines.

Table 8. Local Trip Types of HHEBS Respondents.

	Included in Local Trips		
Local Trip Type	No	Yes	% Yes
Buy gas	42	168	80%
Get money	88	122	58%
Buy water	111	99	47%
Buy food	115	95	45%
Buy property protection materials	145	65	31%
Buy medicine	154	56	27%
Pick up other riders	176	34	16%
Other	167	43	20%

Of those that made local trips, 154 provided information about the number of local trips. Over one-third (34.4%) made one trip, and almost half (48.7%) made two or three trips, while nearly one out of eight respondents (12.3%) made four or five trips.

Evacuation Departure Timing

For those who decided to evacuate from Hurricane Harvey, departure of the first group also followed three peaks, similar to the evacuation decision time. The departure times were on average six hours

after the decision to evacuate for the first or only group (Group 1) that evacuated (Figure 8). Average reported departure time for the first or only evacuation group was August 24 at around 12 p.m.
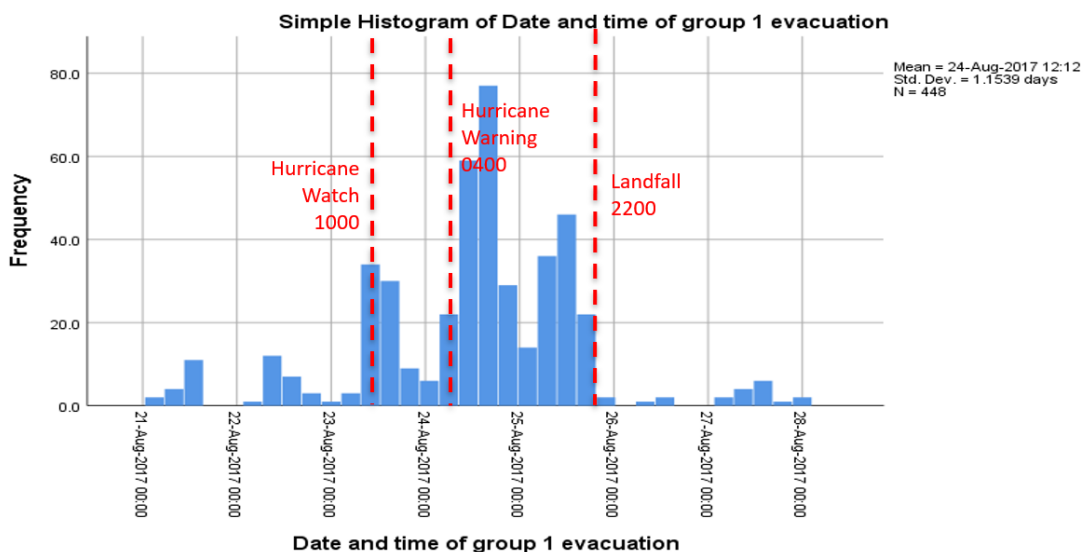

Figure 8. Hurricane Harvey evacuation departure time distribution.

Around 15% (81/535) of evacuee respondents indicated that not everyone in their household left at the same time. Around one-third of those (25/76) provided evacuation departure timing information for only one group, and they did not indicate a timing departure for a second group; presumably, this represents households where one group left and one or more household members remained behind. Around half of respondents with multiple evacuation groups (40/76) indicated that two groups evacuated, and 15% (11/76) indicated that three or more groups evacuated. These data translate into estimates that around 5% of HHEBS evacuee respondents had one group leave and another person or persons stayed behind. Another 8% of HHEBS evacuee respondents had two groups leave at different times, and 2% had three or more groups. Based on data from 48 respondents who indicated that two or more groups evacuated, the average departure time for the second evacuation group was August 24 at around 10 p.m., approximately 10 hours after the first group and 24 hours before Hurricane Harvey's landfall.

Of the HHEBS respondents, 460 provided information that allowed for comparison of evacuation decision times with Group 1 and Group 2 departure times. Of these, 30 (7%) had Group 1 departure times that were prior to the evacuation decision times. For some respondents, this was probably due to respondent difficulties in accurately recalling their actions or understanding the corresponding questions (decision and departure date/time questions were among the more complex in the questionnaire). For some other respondents, this discrepancy might indicate that some groups left before the "household" made the decision to evacuate. These respondents were more likely to indicate their household had groups that left at different times (9/30 or 30%) than did the rest of the HHEBS evacuee respondents (72/505 or 14%). Seven of these nine respondents indicated Group 2

departure times that were after the evacuation decision time. The frequency by categories of time differences between Group 1 departures and evacuation decision time categories were:

- Prior to household evacuation decision time: 30 (7.0%).
- At the same time (0 hours' difference): 161 (37.5%).
- Between 1 and 5 hours' difference: 107 (25.0%).
- Between 6 and 11 hours' difference: 41 (9.5%).
- Between 12 and 23 hours' difference: 38 (8.9%).
- 24 hours' difference or more: 52 (12.1%).

Evacuation Inhibitors

Respondents were asked to judge (on a scale from 1 to 5, where 1 is *Not at all* and 5 is *Very great extent*) the extent to which concerns about traffic accidents, traffic jams, property protection, income loss, evacuation expenses, and looting risks affected their evacuation decisions (Figure 9). Results are described for Coastal Bend (CB) HHEBS respondents, as well as for the hypothetical evacuation scenario for Rio Grande Valley urban (RGVU) and Rio Grande Valley colonias (RGVC) respondents in the 2013 survey (Lindell et al., 2013).
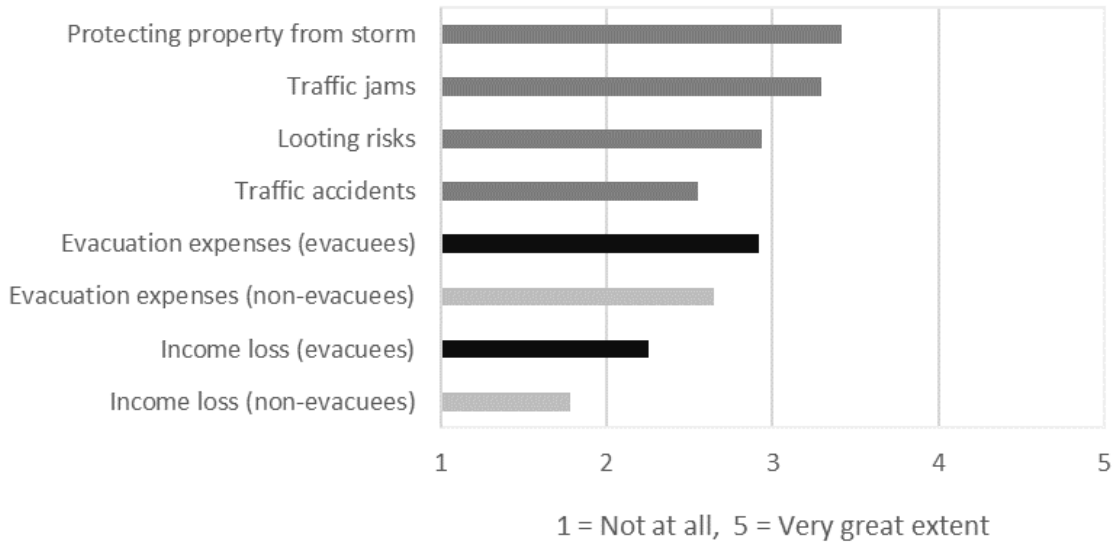
Figure 9 shows that:
- Survey respondents were moderately concerned about protecting their property from the storm (M_{CB} = 3.42, M_{RGVU} = 3.38, M_{RGVC} = 2.99) and being caught in traffic jams (M_{CB} = 3.30, M_{RGVU} = 3.37, M_{RGVC} = 2.95), and were somewhat less concerned about looting risks (M_{CB} = 2.94, M_{RGVU} = 3.28, M_{RGVC} = 2.76) and traffic accidents (M_{CB} = 2.55, M_{RGVU} = 2.60, M_{RGVC} = 2.84). For these factors, there were no significant differences in mean scores between evacuees and non-evacuees in the Coastal Bend area.
- For evacuation expenses ($M_{CB\ evacuees}$ = 2.92, $M_{CB\ non-evacuees}$ = 2.65, U = 72,904, n_{evac} = 524, $n_{non-evac}$ = 309, p = 0.013) and income loss ($M_{CB\ evacuees}$ = 2.25, $M_{CB\ non-evacuees}$ = 1.78, U = 67,387, n_{evac} = 518, $n_{non-evac}$ = 307, p = 0.000), Coastal Bend evacuees had significantly higher concern scores than did non-evacuees. In the Rio Grande Valley, concern scores were also higher for evacuation expenses (M_{RGVU} = 3.06, M_{RGVC} = 2.84) than for lost income (M_{RGVU} = 2.40, M_{RGVC} = 2.53).

Evacuation Impediments

When asked about evacuation impediments, 9.6% of HHEBS evacuees reported that they had household members that required special medical assistance to evacuate. The responses appear to vary by age group with possible generational care factors showing for some age groups (Table 9). From the Rio Grande Valley survey, 16.5% of the urban respondents and 16.8% of the colonias residents reported that they have household members that would need special medical assistance to evacuate. In addition, 40.5% of Coastal Bend evacuees reported having pets that needed to be

evacuated along with other household members, compared with 55.3% of the RGVU respondents and 39.9% of the RGVC residents (Lindell et al., 2013).

Figure 9. Concerns that affected Hurricane Harvey evacuation decisions.

Table 9. Household Medical Assistance Needs, by HHEBS Respondent Age Group.

| | | Household had member(s) who needed special medical assistance to evacuate | | | |
| | | Yes | | No | |
		Count	Row N %	Count	Row N %
Informant's reported age at time of Hurricane Harvey (categorized)	24 or less	0	0%	4	100%
	25-34	0	0%	15	100%
	35-44	4	10%	37	90%
	45-54	6	7%	80	93%
	55-64	20	15%	117	85%
	65-74	11	8%	131	92%
	75-84	6	8%	66	92%
	85 or more	3	30%	7	70%

Evacuation Modes

On average, HHEBS evacuees took around 1.5 vehicles per household, with around two occupants per vehicle (Table 10). The large majority of evacuees, over 95% of survey respondents, took their own personal vehicles; only 23 HHEBS respondents reported riding with someone else (usually family members) or using work vehicles (included in "Other" forms of transportation), and only 2 HHEBS evacuees reported using public transit (Table 11).

The large majority (88%) of HHEBS households that evacuated did not take any trailers, while 9% reported taking one trailer, and 3% reported taking two or more trailers.

Table 10. Number of Vehicles Taken and Number of Occupants per Vehicle by County.

		Number of vehicles taken by household in the evacuation	Average number of occupants per vehicle
		Mean	Mean
Assigned County	Matagorda	1.65	1.94
	Jackson	1.43	1.95
	Calhoun	1.56	1.67
	Victoria	1.46	1.92
	Refugio	1.40	2.26
	Aransas	1.47	1.79
	San Patricio	1.41	2.38
	Nueces	1.41	1.93
	Total	1.48	1.96

Table 11. Alternate Evacuation Transportation Modes Used, by County.

		Q22. If you did not use your own private vehicle, what form of transportation did you use to evacuate? - Selected Choice		
		Rode with someone else	Used public transit	Other (please specify)
		Count	Count	Count
Assigned County	Matagorda	0	0	1
	Jackson	3	1	1
	Calhoun	3	0	1
	Victoria	2	0	0
	Refugio	6	0	6
	Aransas	5	1	3
	San Patricio	1	0	4
	Nueces	3	0	1
	Total	23	2	17

Evacuation Destinations

Figures 10 through 17 show maps indicating where HHEBS respondents spent the first night of their evacuation, ordered from the HHEBS county farthest up the Texas Gulf Coast (Matagorda) to the county farthest down the coast (Nueces). An examination of the general pattern of evacuation destinations indicates a general trend away from the coast for most evacuees although some moved laterally along the coast to the north/east or south/west. Figure 18 shows evacuation destinations for all HHEBS respondents, indicating a predominance of destinations in larger cities directly away from the path of the approaching storm. The median straight-line distance from evacuees' residences to their first-night city destination was 133 miles.

Evacuation Routes

Hurricane Harvey evacuee respondents provided information about which routes they expected or planned to take for their evacuation. They also indicated why they planned to take those routes. Table 12 is a cross tabulation of planned routes with reasons. The most frequently indicated reason why respondents used transportation routes was that they were routes they already knew well. The next most frequently indicated reasons were that routes were designated as evacuation routes and that they were suggested by someone they knew personally (personal contacts). Navigation apps and news media were less frequently indicated, and social media had a very minor influence on respondents' evacuation route choices.

Although 10.4% (50/483) of the respondents indicated their routes changed during the evacuation, there were few differences and no systematic patterns between the HHEBS respondents' expected (intended) transportation routes and those routes they indicated they actually used.

The most frequently used major routes by HHEBS respondents, by county (Table 13), were:
- Matagorda: SH 35, US 59, and US 77.
- Jackson: US 59, US 77, and US 77A/183.
- Calhoun: US 87, SH 35, and US 59.
- Victoria: US 77, US 87, and US 77A/183.
- Refugio: US 77, US 77A/183, and US 181.
- Aransas: SH 35, SH 188, and IH 37.
- San Patricio: IH 37, US 181, and SH 188.
- Nueces: IH 37 and US 77.

When HHEBS respondents indicated they changed routes, visual observations of traffic conditions on the roadways applied to a great or very great extent for nearly 60% of them (Figure 19). The second-most important reason why HHEBS respondents changed routes was reports of traffic conditions through phone calls or cell phone apps.
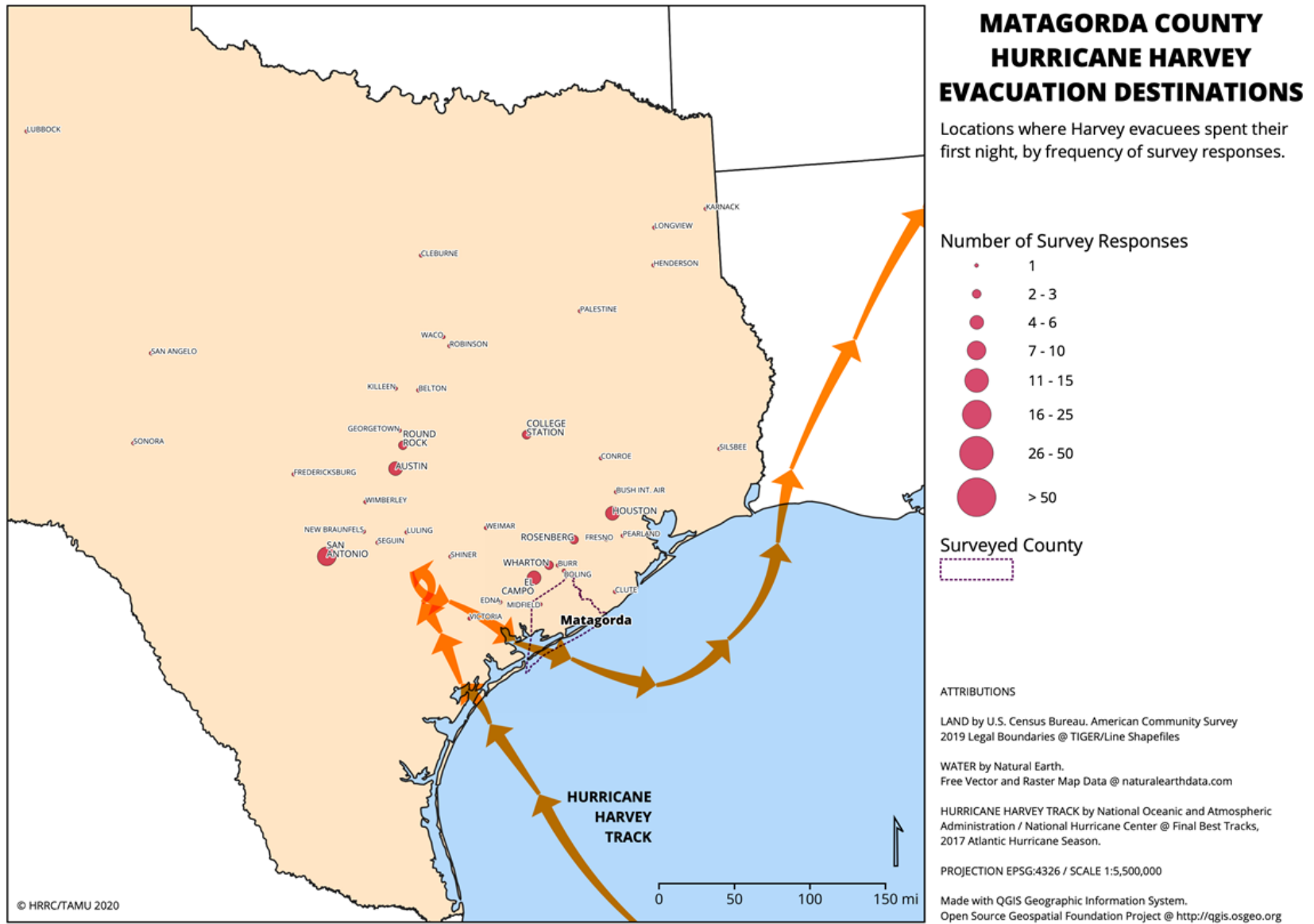
MATAGORDA COUNTY HURRICANE HARVEY EVACUATION DESTINATIONS

Locations where Harvey evacuees spent their first night, by frequency of survey responses.

Number of Survey Responses

1
2 - 3
4 - 6
7 - 10
11 - 15
16 - 25
26 - 50
> 50

Surveyed County

ATTRIBUTIONS

LAND by U.S. Census Bureau. American Community Survey 2019 Legal Boundaries @ TIGER/Line Shapefiles

WATER by Natural Earth. Free Vector and Raster Map Data @ naturalearthdata.com

HURRICANE HARVEY TRACK by National Oceanic and Atmospheric Administration / National Hurricane Center @ Final Best Tracks, 2017 Atlantic Hurricane Season.

PROJECTION EPSG:4326 / SCALE 1:5,500,000

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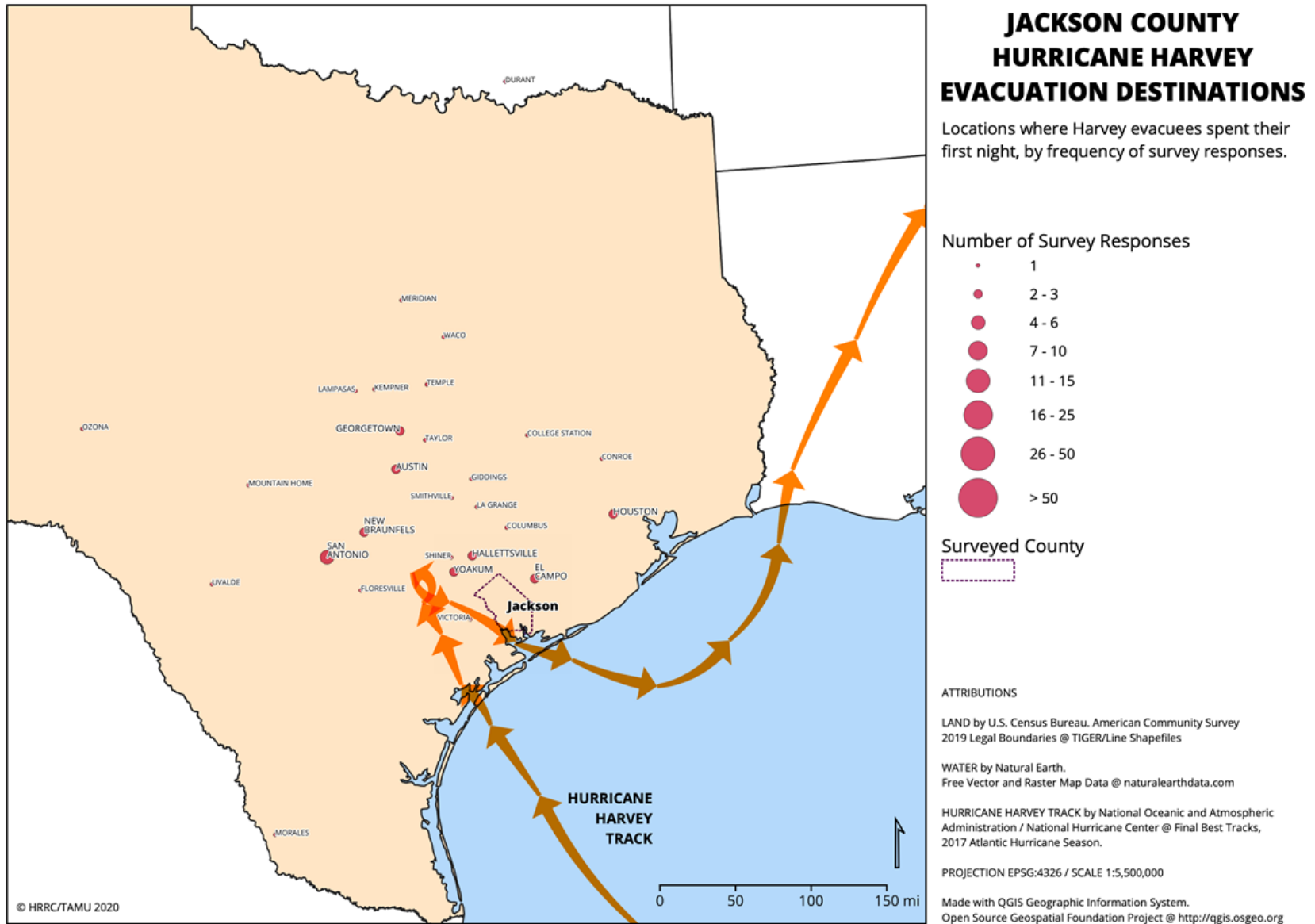
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Figure 10. Evacuation destinations of Matagorda County HHEBS respondents.

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Figure 11. Evacuation destinations of Jackson County HHEBS respondents.
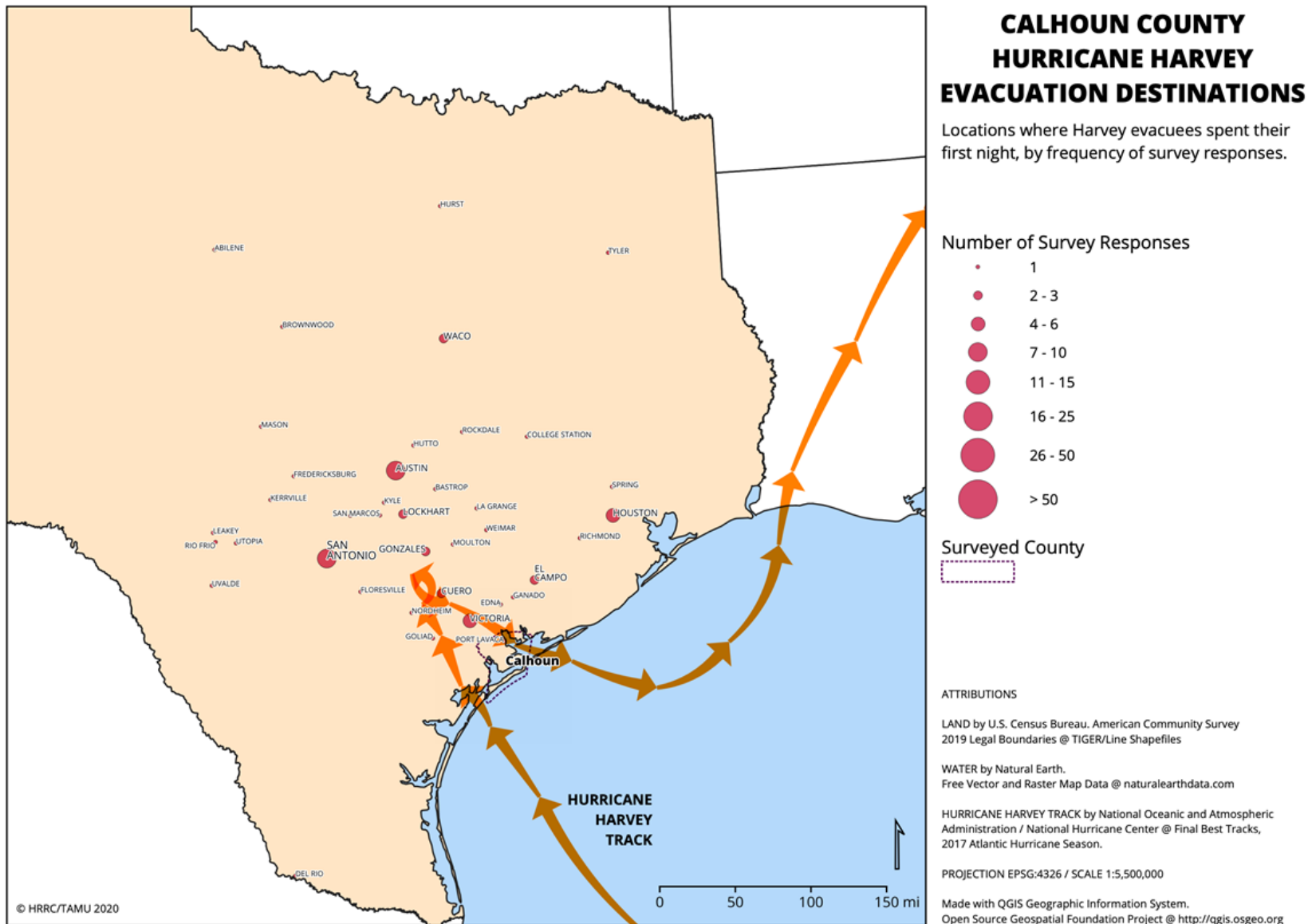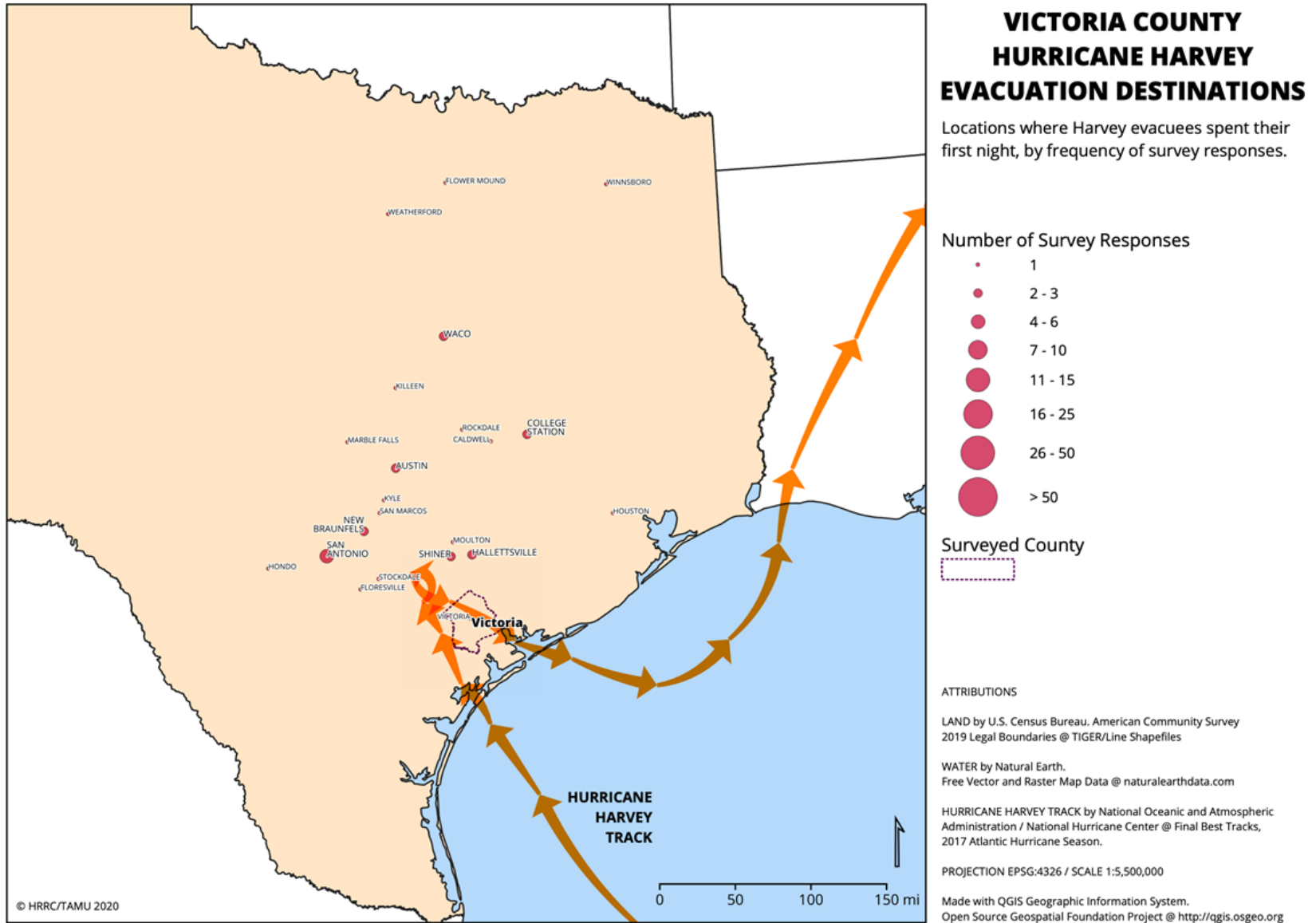
CALHOUN COUNTY HURRICANE HARVEY EVACUATION DESTINATIONS

Locations where Harvey evacuees spent their first night, by frequency of survey responses.

Number of Survey Responses

- 1
- 2 - 3
- 4 - 6
- 7 - 10
- 11 - 15
- 16 - 25
- 26 - 50
- > 50

Surveyed County

HURRICANE HARVEY TRACK

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Figure 12. Evacuation destinations of Calhoun County HHEBS respondents.

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VICTORIA COUNTY HURRICANE HARVEY EVACUATION DESTINATIONS

Locations where Harvey evacuees spent their first night, by frequency of survey responses.

Number of Survey Responses
- 1
- 2 - 3
- 4 - 6
- 7 - 10
- 11 - 15
- 16 - 25
- 26 - 50
- > 50

Surveyed County

ATTRIBUTIONS

LAND by U.S. Census Bureau. American Community Survey 2019 Legal Boundaries @ TIGER/Line Shapefiles

WATER by Natural Earth. Free Vector and Raster Map Data @ naturalearthdata.com

HURRICANE HARVEY TRACK by National Oceanic and Atmospheric Administration / National Hurricane Center @ Final Best Tracks, 2017 Atlantic Hurricane Season.

PROJECTION EPSG:4326 / SCALE 1:5,500,000

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Figure 13. Evacuation destinations of Victoria County HHEBS respondents.

ARANSAS COUNTY HURRICANE HARVEY EVACUATION DESTINATIONS

Locations where Harvey evacuees spent their first night, by frequency of survey responses.

Number of Survey Responses
- 1
- 2 - 3
- 4 - 6
- 7 - 10
- 11 - 15
- 16 - 25
- 26 - 50
- > 50

Surveyed County

HURRICANE HARVEY TRACK

ATTRIBUTIONS

LAND by U.S. Census Bureau. American Community Survey 2019 Legal Boundaries @ TIGER/Line Shapefiles

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HURRICANE HARVEY TRACK by National Oceanic and Atmospheric Administration / National Hurricane Center @ Final Best Tracks, 2017 Atlantic Hurricane Season.

PROJECTION EPSG:4326 / SCALE 1:5,500,000

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Figure 14. Evacuation destinations of Aransas County HHEBS respondents.

24

Figure 15. Evacuation destinations of Refugio County HHEBS respondents.

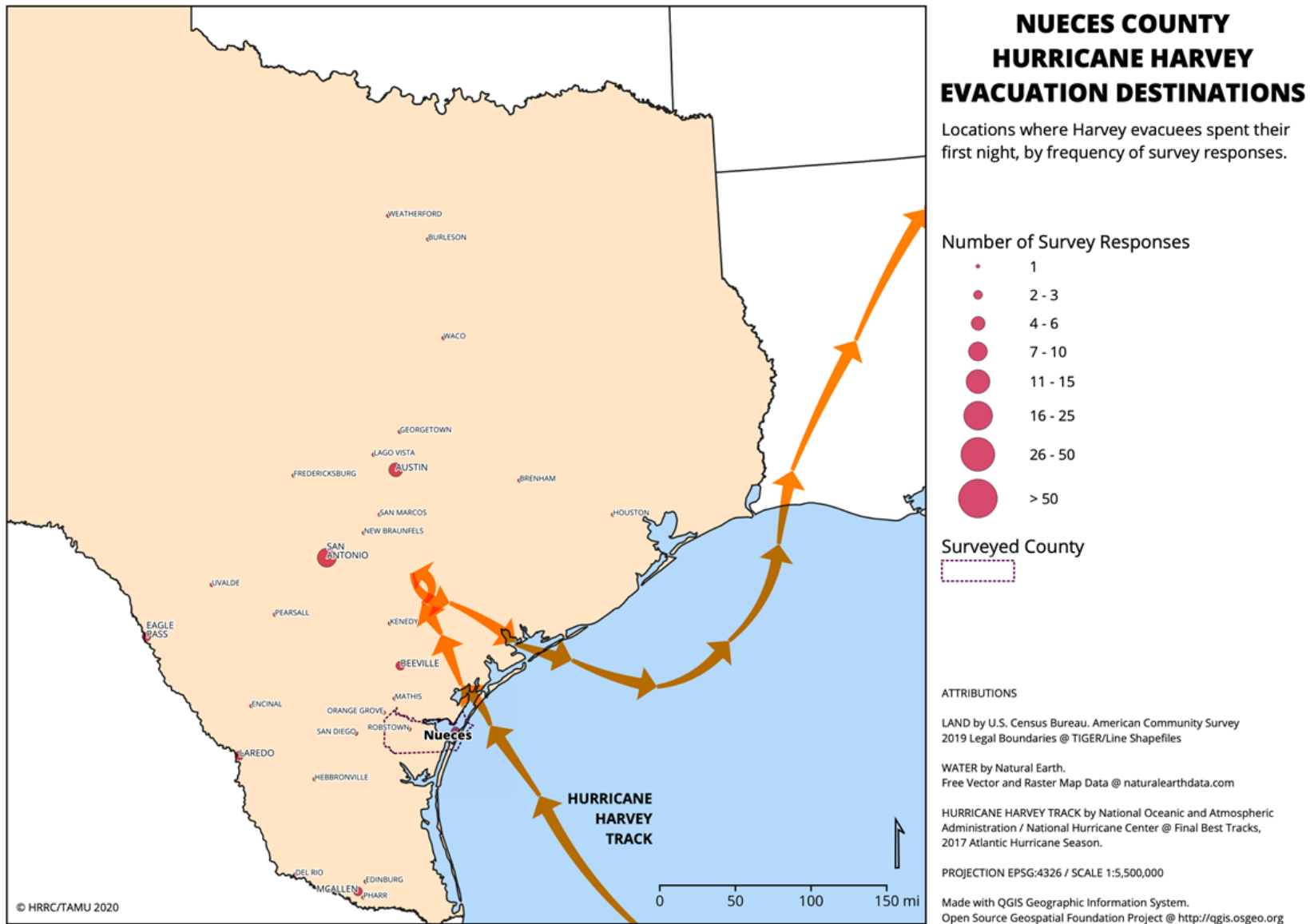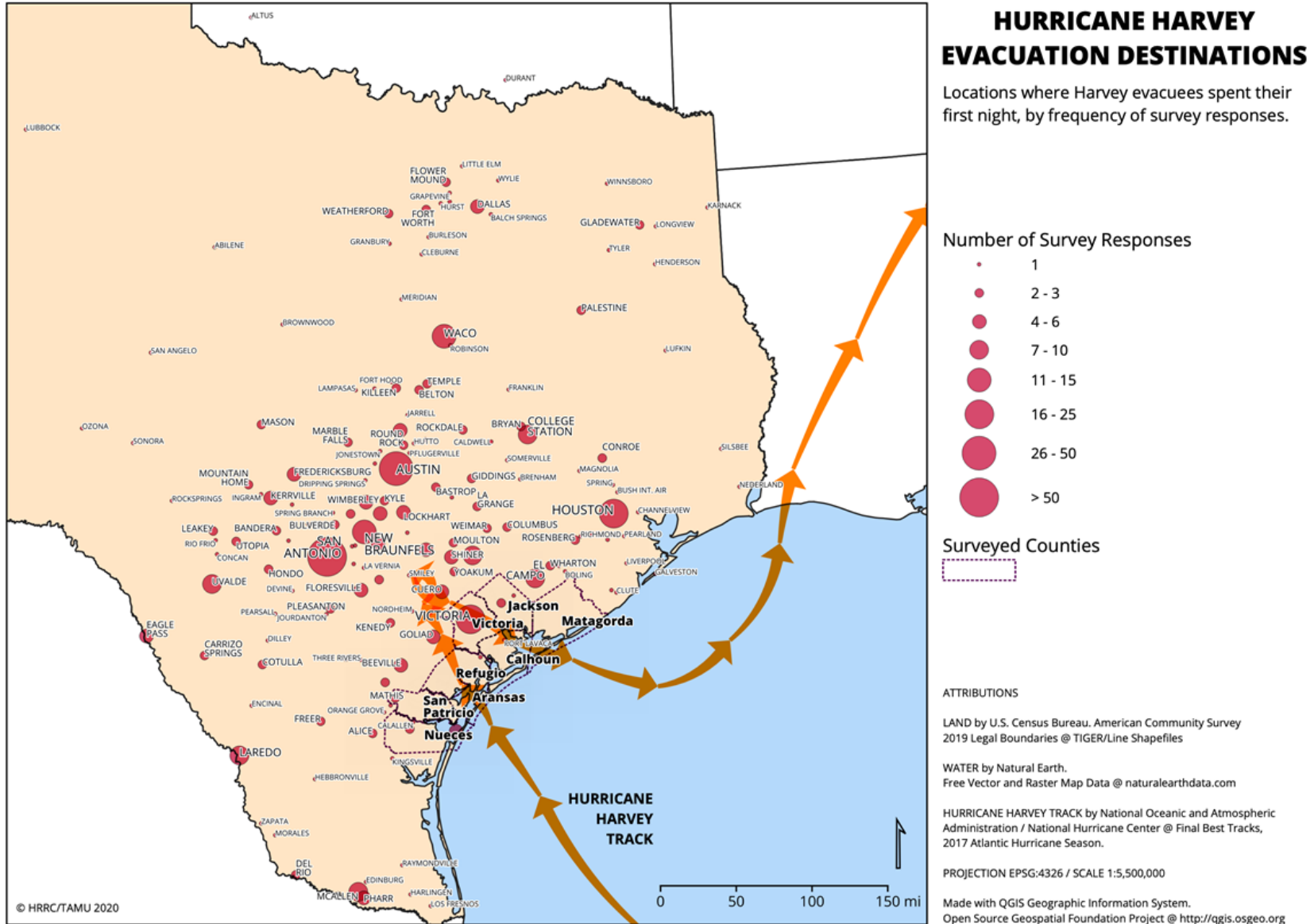**Figure 16. Evacuation destinations of San Patricio County HHEBS respondents.**

NUECES COUNTY HURRICANE HARVEY EVACUATION DESTINATIONS

Locations where Harvey evacuees spent their first night, by frequency of survey responses.

Number of Survey Responses
- 1
- 2 - 3
- 4 - 6
- 7 - 10
- 11 - 15
- 16 - 25
- 26 - 50
- > 50

Surveyed County

HURRICANE HARVEY TRACK

ATTRIBUTIONS

LAND by U.S. Census Bureau. American Community Survey 2019 Legal Boundaries @ TIGER/Line Shapefiles

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0   50   100   150 mi

Figure 17. Evacuation destinations of Nueces County HHEBS respondents.

Figure 18. Evacuation destinations of HHEBS respondents.

Table 12. Reasons for Intended Major Hurricane Harvey Evacuation Route Use.

Major route used	Already knew route		Authorized evacuation route		Route was suggested by…										Other	
					Personal contact		Navigation app		News media		Social media					
	Count	% Resp	Count	% Resp	Count	% Resp	Count	% Resp	Count	% Resp	Count	% Resp			Count	% Resp
US 59	49	83%	5	8%	6	10%	3	5%	4	7%	1	2%			13	22%
SH 35	89	80%	9	8%	10	9%	6	5%	3	3%	2	2%			22	20%
US 87	37	67%	10	18%	8	15%	5	9%	5	9%	2	4%			14	25%
US 77	87	74%	8	7%	16	14%	7	6%	5	4%	1	1%			20	17%
US 77A/183	39	75%	4	8%	5	10%	4	8%	2	4%	1	2%			12	23%
SH 188	42	88%	8	17%	1	2%	6	13%	2	4%	2	4%			4	8%
US 181	33	79%	5	12%	4	10%	2	5%	2	5%	0	0%			8	19%
I-37	68	84%	20	25%	9	11%	5	6%	5	6%	1	1%			9	11%

Table 13. Frequencies of Actual Major Hurricane Harvey Evacuation Route Use.

Assigned County	IH 37		US 181		SH 188		US 77A/183		US 77		US 87		SH 35		US 59	
	Count	% Resp	Count	% Resp	Count	% Resp	Count	% Resp	Count	% Resp	Count	% Resp	Count	% Resp	Count	% Resp
Matagorda	0	0%	0	0%	0	0%	4	6%	10	16%	3	5%	27	42%	10	16%
Jackson	0	0%	1	2%	0	0%	7	17%	8	19%	2	5%	6	14%	12	29%
Calhoun	1	2%	0	0%	0	0%	5	8%	10	16%	37	59%	16	25%	11	17%
Victoria	0	0%	2	6%	0	0%	6	18%	17	52%	10	30%	4	12%	5	15%
Refugio	6	9%	8	13%	0	0%	14	22%	23	36%	1	2%	7	11%	6	9%
Aransas	36	29%	18	14%	36	29%	14	11%	34	27%	7	6%	53	42%	11	9%
San Patricio	19	40%	12	25%	10	21%	3	6%	8	17%	0	0%	6	13%	5	10%
Nueces	21	46%	1	2%	1	2%	2	4%	7	15%	1	2%	2	4%	1	2%
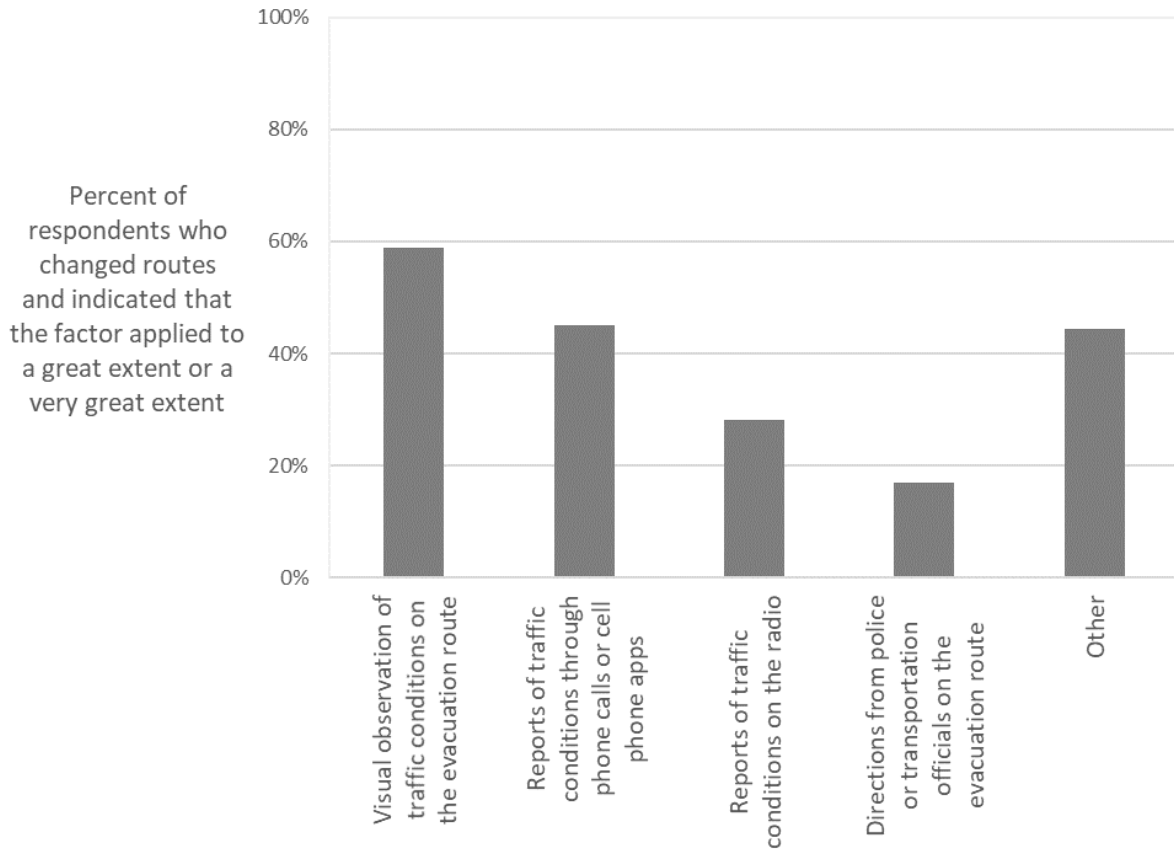
Figure 19. Factors causing transportation route changes of HHEBS evacuees during Hurricane Harvey.

Evacuation Accommodations

HHEBS respondents indicated whether they made prior accommodation arrangements before evacuating, and where they stayed when they reached their destination (Table 14). Over 80% ([378+42]/518) made arrangements prior to arriving at their destinations, while around 20% did not. Of those who made advance accommodation arrangements before they departed for their evacuation (the largest share of HHEBS respondent evacuees), just over two-thirds stayed at the home of a friend or relative. Conversely, of the 8% (42/518) of HHEBS evacuee respondents who did not make prior arrangements before evacuating but did so while on the road, two-thirds stayed at hotel/motel accommodations. For the 20% of HHEBS evacuee respondents who made no prior accommodation arrangements either before leaving or on the road, their lodging choices were split mostly between friends/relatives, hotels/motels, and another property of their family. Around 1% of HHEBS respondent evacuees stayed in public shelters or public facilities.

Table 14. Evacuees' Accommodation Arrangements, Timing, and Types.

Whether evacuees made prior accommodation arrangements and timing of contact	Where evacuee stayed when they reached their evacuation destination										Total
	Home of friend/relative		Hotel/motel		Another property of family		RV/park/ campground		Public shelter/facility		
	Count	Row %	Count	Row %	Count	Row %	Count	Row %	Count	Row %	Count
Yes — they were contacted before evacuee departed	257	**68%**	107	28%	5	1%	8	2%	1	0%	378
Yes — they were contacted while evacuee was on the road	11	26%	29	**69%**	1	2%	1	2%	0	0%	42
No prior accommodation arrangements made	32	**33%**	37	**38%**	20	**20%**	5	5%	4	4%	98
Total	300	58%	173	33%	26	5%	14	3%	5	1%	518

Evacuation Duration and Costs

HHEBS evacuee respondents indicated the duration of their evacuation and the estimated costs for their evacuation by categories of transportation, food, lodging, and lost income. The responses were tallied to generate a total cost estimate, and then compared by informant age categories of 65 or older (Table 15) to compare differences across estimated income losses and other measures for evacuees who are at or near retirement age as well as may have greater likelihood of health vulnerabilities. On average, evacuees who stayed at hotels/motels and at RVs/parks/campgrounds spent 13 days and 23 days, respectively, and there do not appear to be strong differences by age category in duration of stay. Evacuees under 65 stayed at homes of friends or relatives just under 9 days while those over 65 stayed just over 14 days, on average. Evacuees under 65 stayed at another property owned by their family just under 7 days while those over 65 stayed just over 14 days, on average.

As might be expected, income losses averaged higher for HHEBS evacuees under 65 compared with those over 65. On average, lost income accounted for 58% of reported HHEBS evacuee total household costs when respondents were under 65, and accounted for 27% of reported HHEBS evacuee total household costs when respondents were 65 or older. Evacuees who stayed at hotels/motels incurred the greatest overall total household costs, just over $2,300 on average, with an average daily cost across all cost categories of $177. HHEBS evacuees who stayed at homes of friends or relatives, at other family properties, and in/at RVs, parks and campgrounds had substantially lower average total daily costs of $100, $98, and $79 per day, respectively. Few HHEBS evacuee respondents reported staying at a public shelter or other public facility as their evacuation destination, but those who did reported higher costs per capita per day than respondents who stayed at other types of facilities.

Staying at accommodations other than hotels/motels and shelters requires that the resource used is available to the evacuees. To stay with friends or family (even for a few days), the evacuee household must have friends or family within an accessible traveling distance who have space and willingness for those accommodations. To utilize an RV or a second property, those property assets must be owned or accessible. In addition, costs of ownership may not be fully captured in the cost information provided by HHEBS evacuee respondents (e.g. lodging or vehicle, maintenance, and insurance costs

for those who stayed in an RV or at another family property) or allocated to the same cost categories by different respondents (e.g.. different transport and lodging costs for those under and over 65 who stayed in/at an RV/park/campground).

Table 15. Evacuation Durations and Household Evacuation Costs, by Respondent Age and Accommodation Types.

Informant's age at time of Hurricane Harvey	Type of lodging (at evacuation destination)	Number of days informant spent away from home during evacuation		Estimated Household Costs During Evacuation				
		Count	Mean	Transport Mean	Food Mean	Lodging Mean	Lost Income Mean	Total Mean
Under 65	Home of friend/relative	164	8.8	$195	$177	$43	**$867**	$1,278
	Hotel/motel	109	12.8	$266	$299	$555	**$1,237**	**$2,363**
	Another property of family	10	6.9	$599	$213	$0	**$938**	$1,749
	RV/park/campground	8	**24.4**	$520	$379	$300	**$707**	$1,906
	Public shelter/facility	3	5.3	$153	$192	$0	$475	$820
65 or older	Home of friend/relative	136	**14.4**	$163	$175	$159	$178	$678
	Hotel/motel	66	13.4	$263	$409	**$913**	$619	**$2,204**
	Another property of family	18	**14.2**	$95	$72	$0	$0	$167
	RV/park/campground	7	**20.9**	$266	$210	$905	$300	$1,681
	Public shelter/facility	2	4.0	$500	$175	$225	$500	$1,400

SUMMARY OF FINDINGS AND CONCLUSIONS

Information about a population's behaviors for protective action choices—such as decisions about whether and how to evacuate from an approaching hurricane—can help communities and states develop effective emergency and disaster plans. Some information, such as evacuation origin and destination locations, routes, and timing, can be inferred from big data such as transportation system users' mobile device signals. However, behavioral surveys provide additional information about evacuees' perceptions, motivations, and experiences that cannot be duplicated by such big data sources. Both types/sources of information have inherent biases such as technology usage/adoption rates or survey response/participation rates.

This report summarizes responses to a behavioral survey of resident households of eight counties in the Texas Coastal Bend area about whether and how they evacuated from Hurricane Harvey, which made its first U.S. landfall around 10 p.m. on August 25, 2017, in Aransas County. The survey was administered in three waves. The first wave was a letter sent via U.S. Postal Service mail with a printed online address that recipients could enter into their web browser for an electronic version of the survey as the only response option. The second and third waves, also distributed via the U.S. Postal Service, included printed versions of the survey with postage-paid return envelopes; the third wave also included a reminder postcard requesting participation. The response rates for the three

waves were 1.8%, 10.6%, and 4.9%, respectively. After accounting for undeliverable survey packets, the overall response rate was 15.7% (895 responses) out of 5,700 unique and valid addresses.

Representing their households, HHEBS respondents on average reported similar household incomes and household sizes compared to those of the broader area populations. Although Hispanic background respondents were underrepresented in the survey responses compared to the area populations, and White, non-Hispanic respondents were likely overrepresented, there was no significant difference between Hispanic and non-Hispanic respondents for whether or not the household evacuated from Hurricane Harvey. HHEBS survey respondents also had higher levels of education and may have been older than is represented by the overall area population, which might be expected for individuals responding to a survey on behalf of their household.

HHEBS respondents relied mostly on local and national news media for information about Hurricane Harvey, and evacuees were more likely to rely on their peers for information than non-evacuees. Graphical forecast tracks and ensemble forecasts were seen most frequently by respondents. The impacts of Hurricane Harvey most likely to be expected were services disruptions and the strike of a major hurricane, with evacuees having higher impact expectations than non-evacuees. HHEBS evacuees also relied most on local authorities' official recommendations, announcements of hurricane watches/warnings, and previous personal experiences with hurricanes.

HHEBS respondents' decisions to evacuate tracked closely with counties having significant coastal exposures of their populations and that were in either the direct path of the hurricane or close to it. The largest proportions of HHEBS respondent households' evacuations were reported for Aransas (84%), Calhoun (77%), and San Patricio (76%) Counties. The large majority of evacuees made their decision to evacuate and their evacuation departures during the daytimes in the three days (August 23, 24, and 25) prior to Hurricane Harvey's landfall. There was on average a six-hour lag between the decision to evacuate and the departure of the first or only evacuation group. Based on the reported information, researchers estimate that around 5% of HHEBS evacuee respondents had one group leave and another person or persons stay behind. Another 8% of HHEBS evacuee respondents had two groups leave at different times, and another 2% had three or more groups leave at different times. When multiple groups evacuated, there was on average a 10-hour lag between departure of the first group and the departure of the second group. Thus, the average evacuation dates and times for HHEBS respondents are:

- Decision to evacuate: August 24, 0600 hour.
- First or only group evacuation departure (100% of evacuee households): August 24, 1200 hour.
- Second group evacuation departure (10% of evacuee households): August 24, 2200 hour.
- Hurricane Harvey landfall: August 25, 2200 hour.

Nearly all responding evacuees spent at least some time packing, and more than two-thirds reported taking more than 30 minutes to do so. More than half of these evacuees spent more than 60 minutes protecting their property. Four out of ten HHEBS evacuee respondents made local trips before departing, and over three-quarters of these made between one and three trips, with the most frequent trip purposes being for buying gas and getting money, followed by buying food and/or water. On average, the greatest concerns affecting HHEBS respondents' evacuation decisions were protecting property from the storm, traffic jams that might be encountered during the evacuation, looting risks, and evacuation expenses. In addition, around 10% of HHEBS evacuee respondents indicated they had household members who needed special medical assistance to evacuate. Although 40% reported having pets that needed to be evacuated along with other household members, more than two-thirds reported spending at least some time preparing pets for evacuation.

On average, HHEBS evacuee respondents' households took around 1.5 vehicles in the evacuation with an average of almost 2.0 occupants per vehicle. A small fraction did not take their own personal vehicles, and most of these respondents rode with someone else. Only 2 out of over 500 evacuee respondents reported using public transit for the evacuation, which is not altogether surprising given the lower level of public transit services across the HHEBS area.

Most evacuation destinations were inland to more urbanized areas in Texas although some evacuees moved laterally up the Texas Gulf Coast toward Houston or down the coast toward the lower Rio Grande Valley. The median distance to the city where evacuees spent their first night was 133 miles. Visual inspection of evacuation destination maps for each county indicates that evacuees from the upper HHEBS area tended to evacuate to destinations in the central-eastern regions of Texas, while evacuees from the lower HHEBS area tended to evacuate to destinations in the central-southern regions of Texas. The pattern is distinct from reported evacuation locations in Hurricane Rita where evacuation destinations from southeast Texas tended to be more north and east in Texas.

The average reported evacuation duration of HHEBS respondents was 12 days. Respondents who reported staying at hotel/motel accommodations as their evacuation destination had the highest average daily total costs of $177/household, while daily total costs for most other respondents who stayed at homes of friends or relatives or another property of their family were around $100/day. On average, lost wages accounted for 58% of total costs for households of survey respondents who were under 65 years of age at the time of Hurricane Harvey, and 27% of total costs for those 65 years of age or older.

The reason that HHEBS respondents most frequently reported for choosing the routes they took during their evacuation was that they already knew those routes well. The next most frequent reasons were that their chosen routes were designated as evacuation routes, and that the selected routes were suggested by someone they knew personally (personal contacts). Navigation apps and news media were less frequently indicated, and social media had a very minor influence on respondents'

evacuation route choices. The actual routes used corresponded with major routes from their county of residence to inland destinations. Only around 10% of HHEBS evacuees indicated they changed their actual evacuation routes from the routes they had expected to take, and for these respondents, their visual observation of traffic conditions on the roadways was the most important factor cited.

The HHEBS responses suggest that many of the survey participants relied on information they personally observed and absorbed about approaching threats of Hurricane Harvey, and those households that evacuated primarily relied on their own resources to do so. With the rapid intensification of Hurricane Harvey, there was a compressed timeline between evacuation decisions and departures prior to hurricane landfall, reflecting that many evacuees had to adapt (whether by choice or necessity) their protective action choices. Many evacuees chose urbanized destinations that were just outside of projected storm impact areas although some evacuees chose destinations that were farther inland or in rural communities. These findings are consistent with other studies indicating that many evacuees rely on either staying with family/friends or using commercial accommodations. Given population concentrations, these will emphasize evacuation to urbanized areas.

Social media and apps were of limited importance in evacuation decision-making for HHEBS respondents, both in advance of the evacuation decision and during the actual evacuations. Instead, more traditional information channels of news media, peers, and personal contacts, along with personal experience, were more important for HHEBS respondents. Although recent disaster studies may emphasize or focus on the role that evolving technologies play in response behaviors, emergency planners, managers, and local officials should continue to use traditional communication methods while adapting to new information and messaging media as they evolve. Official evacuation warnings continue to be the most important evacuation cues.

ACKNOWLEDGMENTS

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APPENDIX

HURRICANE HARVEY EVACUATION BEHAVIOR SURVEY QUESTIONNAIRE

TEXAS A&M UNIVERSITY
HAZARD REDUCTION
& RECOVERY CENTER
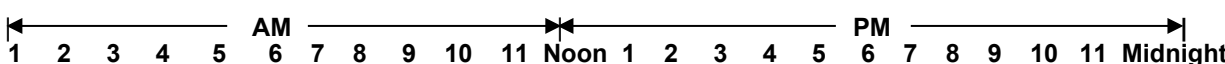
UNIVERSITY OF WASHINGTON
INSTITUTE FOR HAZARD MITIGATION
PLANNING AND RESEARCH

TEXAS A&M
TRANSPORTATION
INSTITUTE

1. On average, how many *times per day* did you consult each of the following
   sources for information about Hurricane Harvey in the three days before landfall?

	0	1-2	3-4	5-6	7 or more
a. Local authorities (e.g., Mayor, Sheriff/Police Chief, Emergency Coordinator)	O	O	O	O	O
b. Local news media (e.g., newspapers, radio stations, television stations)	O	O	O	O	O
c. National news media (e.g., network news, Weather Channel)	O	O	O	O	O
d. The Internet (e.g., National Hurricane Center website)	O	O	O	O	O
e. Social media (e.g., Facebook, Twitter)	O	O	O	O	O
f. Phone or face-to-face contact with peers such as friends, relatives, or neighbors	O	O	O	O	O

2. As the storm was approaching, did you see any of the following
   displays on TV…

	Not at all				Many times
a. a forecast track showing the "best estimate" of the hurricane center?	O	O	O	O	O
b. an uncertainty cone only (also called an error cone)?	O	O	O	O	O
c. an uncertainty cone with a forecast track inside it?	O	O	O	O	O
d. an ensemble forecast ("spaghetti plot") showing the results of different models?	O	O	O	O	O
e. a wind swath showing the locations expected to be affected by hurricane wind?	O	O	O	O	O

3. As the storm was approaching, how likely did you think it was that…

	Not at all likely				Almost certain
a. the eye of the storm would track through your community?	O	O	O	O	O
b. the storm would be a major (Category 3, 4, or 5) hurricane when it struck?	O	O	O	O	O
c. your home would be inundated by (saltwater) storm surge?	O	O	O	O	O
d. your home would be inundated by (freshwater) inland flooding?	O	O	O	O	O
e. your home would be severely damaged or destroyed by storm wind?	O	O	O	O	O
f. you and or household members would be injured or killed if you stayed?	O	O	O	O	O
g. job disruptions would prevent you or household members from working?	O	O	O	O	O
h. there would be disruption to electrical, telephone, and other basic services?	O	O	O	O	O

4. To what extent did you consider the following issues
   when deciding whether or not to evacuate?

	Not at all				Very great extent
a. Seeing area businesses closing	O	O	O	O	O
b. Seeing friends, relatives, neighbors, or coworkers evacuating	O	O	O	O	O
c. Hearing an announcement of a hurricane "watch" or "warning"	O	O	O	O	O
d. Hearing local authorities issue official recommendations to evacuate	O	O	O	O	O
e. Previous personal experience with hurricane storm conditions	O	O	O	O	O
f. Previous experience with an unnecessary evacuation	O	O	O	O	O
g. Concern about protecting your home from looters	O	O	O	O	O
h. Concern about protecting your home from storm impact	O	O	O	O	O
i. Concern about evacuation expenses such as gas, food, and lodging	O	O	O	O	O
j. Concern about lost income from your job	O	O	O	O	O
k. Concern about traffic accidents during evacuation	O	O	O	O	O
l. Concern about traffic jams during evacuation	O	O	O	O	O

5. Did your household evacuate from Hurricane Harvey? ___ **Yes** (How many evacuated? _____, go to Question 6) ___ **No** (Go to Question 29)   ___ **Not applicable** (not Coastal Bend area residents at the time, go to Question 33)

> As a reminder: The National Hurricane Center issued a *Storm Surge Watch* and *Hurricane Watch* at 10 AM CDT on Wednesday, August 23. These were upgraded to a *Hurricane Warning* at 4 AM CDT on Thursday, August 24 and a *Storm Surge Warning* at 10 AM CDT that same day. The hurricane eye made landfall between Port Aransas and Port O'Connor about 10 PM on Friday, August 25.

6. My household made the decision to evacuate on:
   a. Day: __ **Mon 8/21**   __ **Tue 8/22**   __ **Wed 8/23**   __ **Thu 8/24**   __ **Fri 8/25**   __ **Sat 8/26**   __ **Sun 8/27**

   b. Time: |← ———————— AM ———————— →|←———————— PM ————————→|
   1   2   3   4   5   6   7   8   9   10   11   Noon   1   2   3   4   5   6   7   8   9   10   11   Midnight

   Note: Question 6 is asking about the day and time at which you made your <u>decision</u>, not the day and time you were planning to leave. Circle the corresponding time in 6b and in later questions that have a similar scale.

7. After you decided to evacuate, about how
   many *minutes* did it take for you to:

	Didn't do	1-15	16-30	31-45	46-60	61 or more
a. prepare to leave from work?	O	O	O	O	O	O
b. travel from your place of work to your home?	O	O	O	O	O	O
c. gather all of the persons who would evacuate with you?	O	O	O	O	O	O
d. pack the items you would need while gone?	O	O	O	O	O	O
e. protect your property from storm damage (e.g., board up windows)?	O	O	O	O	O	O
f. shut off utilities, secure your home, and leave?	O	O	O	O	O	O
g. prepare household pets for evacuating	O	O	O	O	O	O

8. Did you make any local trips within your community *after* you decided to evacuate but *before* you left?
   ____ **No** (Go to Question 10)   ____ **Yes** (How many trips? _____**,** Go to Question 9)

9. What did you do on those trips (check all that apply): ___ **Buy gas** ___ **Buy water** ___ **Buy food**
   ___ **Buy medicine** ___ **Get money** ___ **Buy property protection materials** ___ **Pick up other riders**
   ___ **Other** _____

10. Did everyone in your household leave at the same time?
    __ **Yes** (Go to Question 12)   __ **No** (Go to Question 11)

11. How many groups/individuals left at different times? ___**One group** ___**Two groups** ___**Three or more groups**

12. The first group (or the only group if there was just one) evacuated on…
    a. Day: __ **Mon 8/21** __ **Tue 8/22** __ **Wed 8/23** __ **Thu 8/24** __ **Fri 8/25** __ **Sat 8/26** __ **Sun 8/27**
    b. Time: |◄———————— **AM** ————————►|◄———————— **PM** ————————►|
    1 2 3 4 5 6 7 8 9 10 11 Noon 1 2 3 4 5 6 7 8 9 10 11 Midnight

> **If your household left in just one group, go to Question 14.**

13. The second group evacuated on…
    a. Day: __ **Mon 8/21** __ **Tue 8/22** __ **Wed 8/23** __ **Thu 8/24** __ **Fri 8/25** __ **Sat 8/26** __ **Sun 8/27**
    b. Time: |◄———————— **AM** ————————►|◄———————— **PM** ————————►|
    1 2 3 4 5 6 7 8 9 10 11 Noon 1 2 3 4 5 6 7 8 9 10 11 Midnight

14. Which highway(s) did the first (or only) group *expect to take* when evacuating? (Check all that apply.)
    __ **FM 236** __ **FM 624** __ **FM 665** __ **SH 35** __ **SH 44** __ **SH 60** __ **SH 71**
    __ **SH 111** __ **SH 141** __ **SH 172** __ **SH 185** __ **SH 188** __ **SH 202** __ **SH 239**
    __ **SH 285** __ **US 59** __ **US 77** __ **US 77A/183** __ **US 87** __ **US 181** __ **I-37**
    __ **Other major roads (list):** _____

15. What were reasons why you planned to take these highways/roads? They were … (Check all that apply.)
    __ suggested in the news media (TV, radio, newspaper).   __ authorized evacuation routes.
    __ suggested by a navigation device or mapping app.   __ routes that I already knew well.
    __ suggested by someone I knew personally.   __ suggested in social media.
    __ other (please describe): _____

16. Did the route change during the evacuation? ___ **No** (Go to Question 19)   ___ **Yes**

17. To what extent was each of the following a reason you changed your route during the evacuation?

	Not at all				**Very great extent**
a. Directions from police or transportation officials on the evacuation route	O	O	O	O	O
b. Visual observation of traffic conditions on the evacuation route	O	O	O	O	O
c. Reports of traffic conditions on the radio	O	O	O	O	O
d. Reports of traffic conditions through phone calls or cell phone apps	O	O	O	O	O
e. Other (please describe)_____	O	O	O	O	O

18. What highway(s) did you **actually take** during your evacuation? (Check all that apply.)
    __ **FM 236** __ **FM 624** __ **FM 665** __ **SH 35** __ **SH 44** __ **SH 60** __ **SH 71**
    __ **SH 111** __ **SH 141** __ **SH 172** __ **SH 185** __ **SH 188** __ **SH 202** __ **SH 239**
    __ **SH 285** __ **US 59** __ **US 77** __ **US 77A/183** __ **US 87** __ **US 181** __ **I-37**
    __ **Other major roads (list):** _____

19. In total, how many vehicles did your household take in the evacuation? _____ **vehicles**

20. How many registered vehicles did your immediate household have at that time? _____ **vehicles**

21. How many trailers (including boats & campers) did your household take in the evacuation? _____ **trailers**

22. If you did not use your own private vehicle, what form of transportation did you use to evacuate?
    ____ **Rode with someone else**   ___ **Used public transit**   ___ **Other** (please specify)_____

> Please answer the last set of questions on the next page.

23. In (or near) what city did you spend your first night after evacuating? _____

24. Did you arrange a place to stay before you reached your evacuation destination? ___ **No**
___ **Yes, I contacted them before evacuating** ___ **Yes, I contacted them while on the road**

25. Where did you stay when you got to your destination? _____ **Home of friend/relative**
_____ **Hotel/motel** _____ **Public shelter** _____ **Other** (please specify) _____

26. During your evacuation, how many days did you spend away from home?
_____ **days or** _____ **Have not been able to return home** (please go to Question 28).

27. How much do you estimate it cost for your household to evacuate? $_____ **Transportation (e.g., gas)**
$_____ **Food** $_____ **Lodging** $_____ **Lost income**

28. Did your household have…   **No**   **Yes**
    a. household members who needed special medical assistance to evacuate? .... O   O
    b. pets that needed to be evacuated with other household members? .... O   O

29. Did you rent or own the home where you lived at the time Harvey struck? _____ **Rent** _____ **Own**

30. Was this your primary or secondary residence? _____ **Primary** _____ **Secondary**

31. Which of the following best describes the type of structure in which you lived at the time of Hurricane Harvey?
_____ **Detached single family home** _____ **Multi-family, 1-2 stories** _____ **Multi-family, 3 or more stories**
_____ **Mobile or manufactured home** _____ **Other** (please specify) _____

32. Was that place located in a…   **No**   **Unsure**   **Yes**
    a. hurricane risk area? .... O   O   O
    b. Federal Emergency Management Agency (FEMA) flood zone .... O   O   O

For answering Questions 33 through 37, begin each question with: "*At the time of Hurricane Harvey, …*"

33. …what was your age? _____ **years old**

34. …what was your marital status?_____ **Married** _____ **Single** _____ **Divorced** _____ **Widowed**

35. …how many people in your household were:
_____ **Less than 18 years** _____ **18-65 years old** _____ **Over 65 years**

36. …what was your highest level of education? _____ **Some high school** _____ **High school graduate/GED**
_____ **Some college/vocational school** _____ **College graduate** _____ **Graduate school**

37. …what was your *yearly* household income?_____ **Less than $21,499** _____ **$21,500–34,999**
_____ **$35,000–44,999** _____ **$45,000–54,999** _____ **$55,000–64,999**
_____ **$65,000–74,999** _____ **$75,000–99,999** _____ **$100,000 or more**

38. What is your sex? _____ **Male** _____ **Female**

39. Which of the following best describes your race? _____ **White** _____ **Black**
_____ **Asian or Pacific Islander** _____ **American Indian or Alaskan Native** _____ **Other**

40. Are you of Hispanic, Latino(a), or Spanish origin? _____ **Yes** _____ **No**

41. Considering what happened in Hurricane Harvey, would you respond differently to a similar storm in the future?
_____ **No** _____ **Yes** (What would you do different?) _____
_____

If you have any additional comments about your Hurricane Harvey experience, please write them below.
_____
_____

Thank you for the time you have taken to fill out this questionnaire. Please return it in the provided envelope.