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Perception of Hurricane and COVID-19 Risks for Household Evacuation and Shelter Intentions

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The COVID-19 pandemic presented new challenges for scholars and government officials to predict people's evacuation decisions under a conflicting natural disaster. In this study, we examined households' evacuation and shelter intentions given the potential conflicts between the perceived risks from a hurricane and the coexisting public health crisis. We surveyed households living inside hurricane evacuation zones in Florida during the 2020 hurricane season. Data were first used to examine the evacuation and shelter intentions before and during the pandemic. We then measured respondents' hurricane and COVID-19 risk perception, respectively. The impacts of both risk perceptions on respondents' hurricane evacuation intentions were explored. We found that when people felt unsafe to stay home for a Category 2, 3, or 4 hurricane, their intended evacuation was about the same before and during the pandemic regardless of their COVID-19 risk perception. The COVID-19 risk perception, however, significantly lowered the evacuation intention for a Category 1 hurricane. It also significantly influenced evacuees' preference for nontraditional shelters such as government-contracted hotels. The results of our study have practical implications for emergency management and public health governance. Our study also provides insights into decision-making under the conflict between natural hazards and infectious diseases. **Key Words: evacuation, hurricane, natural hazards, risk perception, SARS-CoV-2.**

Among many known factors that influence the individual decision-making of hurricane evacuation, risk perception is one of the most important (S. K. Huang, Lindell, and Prater 2016; Murray-Tuite et al. 2018). The perceived degree of hurricane threats to people's lives and their properties usually directly translates into their behavioral responses such as whether and where to evacuate. During the ongoing COVID-19 pandemic, people's evacuation decisions are expected to be more complicated due to their perceived risk of contracting the coronavirus (Collins et al. 2021; Parida, Moses, and Rahaman 2021). Without a thorough understanding of the interrelation between hurricane and COVID-19 risk perceptions, existing hurricane evacuation planning (Hill et al. 2021; Whytlaw et al. 2021) will fall short of its intended objectives.

To fill this important research gap, we conducted a household survey in Florida to research residents' hurricane evacuation intentions and shelter preference given the coexistence of hurricane and COVID-19 risks in 2020. The main objectives of this study are to examine (1) whether the COVID-19 risk perception discouraged hurricane evacuation for people who were concerned about hurricane threats; and (2) if it did, how strong the hurricane threats would have to be for people to consider evacuation. We are also interested in how people's intended shelter use changed with their COVID-19 risk perception as the pandemic presented a new situation for evacuees to evaluate their evacuation destination and accommodation.

In this study, hurricane risk perception is measured as a person's belief that it is unsafe (or safe) to stay home if a hurricane with a certain strength hits the area in which he or she lives. The COVID-19 risk perception is measured as the likelihood that a person thinks he or he would be infected with COVID-19 by the end of 2020. It aligns with the definition used in the recent public health literature. For example, scholars defined COVID-19 risk perception as an individual's intuitive evaluation of being exposed to the new coronavirus (Cori et al. 2020; Xiu et al. 2021) or perceived likelihood of contracting or catching the coronavirus/COVID-19 over the next six months (Dryhurst et al. 2020). The six-month time period was similar to the time frame used in our study, for which survey questionnaires were mailed in July 2020 so that there were approximately six months until the end of 2020.

The major contributions of our study are as follows. First, results of our study provide insights into the poorly understood decision-making under multiple, conflicting disasters (Shultz et al. 2020; Cutter 2021; Simonovic, Kundzewicz, and Wright 2021). The situation of evacuation decisions under COVID-19 is particularly challenging, as little is known about how people make decisions with limited information about the risk of contracting the virus. Second, our study also provides empirical evidence of evacuation compliance and shelter needs for hurricane evacuation planning during a public health crisis. For example, understanding residents' evacuation intention and shelter choice helps emergency management agencies plan and distribute disaster relief resources (Chen 2008; Karaye et al. 2019; Palinkas et al. 2021). Third, the data collected through the household survey on residents'

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responses toward whether, where, and how to evacuate provide inputs for the modeling of COVID-19 transmission related to evacuation due to natural disasters (Pei et al. 2020; Zhai et al. 2021) or further research on evacuation behaviors given the disproportional socioeconomic and health burden on populations of different groups (Davidson et al. 2020; Tribby and Hartmann 2021; X. Huang et al. 2022).

Literature Review and Conceptual Framework

Evacuation Intention under Dual Crises

In the absence of other crises, hurricane evacuation decisions are known to be complicated. Awareness of an evacuation order is one of the strongest predictors for evacuation decisions because people are more likely to leave if they know government officials have ordered them to evacuate (Baker 1995; Kulkarni et al. 2017). Mobile home residents are more likely to evacuate than site-built home residents because of concerns about wind damage. In many posthurricane surveys, researchers found the perceived hurricane risk is one of the most important reasons for people to evacuate (Baker 1991; Lazo et al. 2015). In addition, environmental conditions such as the predicted storm intensity, social cues such as peer evacuation (Li et al. 2010; Jiang, Li, and Cutter 2019), information sources (Morss et al. 2018; Zou et al. 2018), confidence in emergency management agencies (Paul 2012; Kim and Oh 2015), previous hurricane experiences (Basolo, Steinberg, and Gant 2017; M. A. Meyer et al. 2018), socioeconomics, and demographics all contribute to evacuation decisions. In terms of household shelter decisions, research has documented influencing factors such as the presence of elderly family members with special needs (Kocatepe et al. 2018), presence of pets (Farmer and DeYoung 2019), safety concerns such as fear of crime in public shelters (Connolly, Klofstad, and Uscinski 2021), and concerns about infrastructure service disruptions (Coleman, Esmalian, and Mostafavi 2020).

In fact, many of these factors could affect hurricane risk perception and subsequently influence people's evacuation decisions (Figure 1). Additionally, the risk of contracting COVID-19 might be an influential factor during the pandemic. If people concerned about getting COVID-19 also have a higher level of perceived risk for hurricanes, tension is created between the decision to evacuate (due to risks of the hurricane) or to stay in their home (due to risks of COVID-19). It is unclear, however, how both hurricane and COVID-19 risk perceptions work together to influence people's evacuation decisions, which include not only whether to evacuate but also where to evacuate. A recent study across Florida found that concerns over COVID-19 outweighed people's perceived flood risk due to hurricanes and discouraged evacuation (Botzen et al. 2021). Another survey-based study showed that public shelters were deemed more dangerous than enduring hurricane hazards (Collins et al. 2021). Although both studies provided new insights into evacuation decision-making under conflicting risks, many of their survey respondents lived outside any

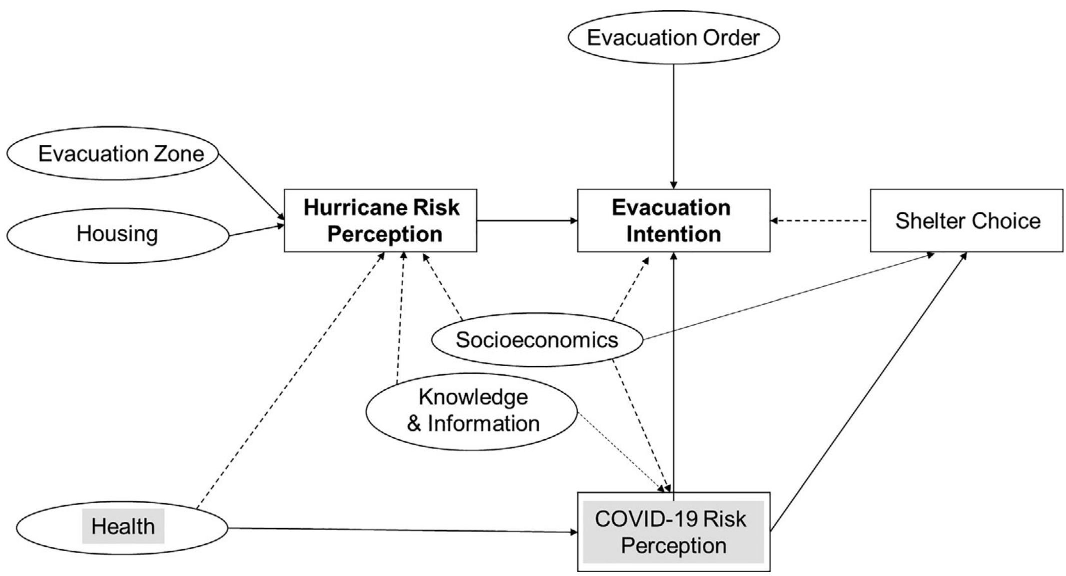

Figure 1 *Conceptual model of hurricane evacuation intention. Shaded factors are new to literature under the COVID-19 pandemic. Solid arrow indicates the expected relatively strong relationship and dashed arrow indicates the expected relatively weak relationship.*

of the hurricane evacuation zones. Their results might not reflect the risk perception and evacuation intention of residents in the evacuation zones. Our study focused on individuals living inside hurricane evacuation zones where evacuation orders are normally issued when a hurricane is approaching. These people, compared to their counterparts, are the most vulnerable population to hurricane hazards. They are expected to experience the strong, direct conflicts between the hurricane and COVID-19 risks.

In this study, we are not aiming at constructing comprehensive models for evacuation decision-making. Instead, we focus on two main factors—hurricane risk perception and COVID-19 risk perception—and their impacts on hurricane evacuation and shelter intentions (Figure 1). The main objective of our study is to understand how these two risk perceptions influence residents' intention of evacuation in an approaching hurricane when an evacuation order has been issued. Our hypotheses are as follows: (1) Hurricane risk perception is positively related to evacuation intention, and (2) COVID-19 risk perception is negatively related to evacuation intention. We also hypothesize that (3) COVID-19 risk perception is negatively related to the intended use of public shelters.

Hurricane Risk Perception

Risk perception can be defined as people's expectation of specific threats from a hazardous event that include death, injury, property damage, and disruption of daily activities in a normal situation (Lindell and Perry 2012). It can also be treated as the perceived likelihood of being influenced negatively by an approaching hazard or the perceived severity of its consequences (Morss et al. 2020). In addition, scholars also have used this term to represent the perceived likelihood of harm from a storm in hypothetical situations (Rickard et al. 2017). In our study, we integrated these definitions and defined hurricane risk perception as a person's belief that it is unsafe (or safe) to stay home if a hurricane with a certain strength hits the area in which he or she lives.

Hurricane risk perception can be determined by people's belief about storm surge, inland flooding, and storm wind (Baker 1991; R. J. Meyer et al. 2014), as well as the probability of any of these occurring (Burton and Kates 1964; Trumbo et al. 2016). People can be influenced by many factors (Figure 1), including traits of a hurricane such as the projected category of landfall (Villegas et al. 2013) and distance of projected track to land (Saunders and Senkbeil 2017); hazard proximity such as the distance of residents' location to shore (Lindell and Perry 2012; Siebeneck and Cova 2012) and areas subjected to flooding or wind damage (Peacock, Brody, and Highfield 2005; Shao, Gardezi, and Xian 2018; Allan et al. 2020); hazard experience such as experience of loss of life or property damage in past hurricane events (Lindell and Hwang 2008; Gotham et al. 2018); and knowledge levels such as the professionals against the general public (Bostrom et al. 2018) or residents versus tourists (Matyas et al. 2011).

COVID-19 Risk Perception

Following the concurrent public health literature (Cori et al. 2020; Dryhurst et al. 2020; Xiu et al. 2021), we measured the COVID-19 risk perception as the likelihood that a person thinks he or she would be infected with COVID-19 by the end of 2020. To measure the COVID-19 risk perception, we avoided asking directly whether a respondent thinks evacuation would increase their risk to be infected with COVID-19. The rationale was that the perceived likelihood of a respondent to be infected with COVID-19 during evacuation depends not only on one's disease risk perception, but also on methods of evacuation such as shelter (e.g., public shelter vs. staying with family or friends) and transportation (public transit vs. personal vehicle). Therefore, we believe a measure of the disease risk perception as used in our study is necessary because it is an indicator that is independent of the actions or situation of evacuation.

We also avoided asking a direct question about whether a respondent is more concerned about COVID-19 than hurricane threats. Our rationales followed the literature of choice modeling or conjoint judgment in the fields of economics and mathematical psychology (Louviere 1988; Green and Srinivasan 1990). This body of literature indicates that a person's implicit evaluation (i.e., whether hurricane or COVID-19 is more dangerous) toward multiattribute compositions (i.e., hurricane threats and COVID-19 threats, respectively) needs to be inferred indirectly because, for most people, estimating trade-offs is difficult when evaluating several attributes together.

Methods

Study Area

The study area was located in Florida. Florida was one of the U.S. COVID-19 epicenters in July 2020 (Prasad 2020; Wootson, Stanley-Becker, and Rozsa 2020). This provides a unique opportunity for scholars to understand people's hurricane risk perception and their evacuation intention during the alarming public health crisis. In addition, the research on evacuation intention under dual crises is particularly important for geographic regions with a high

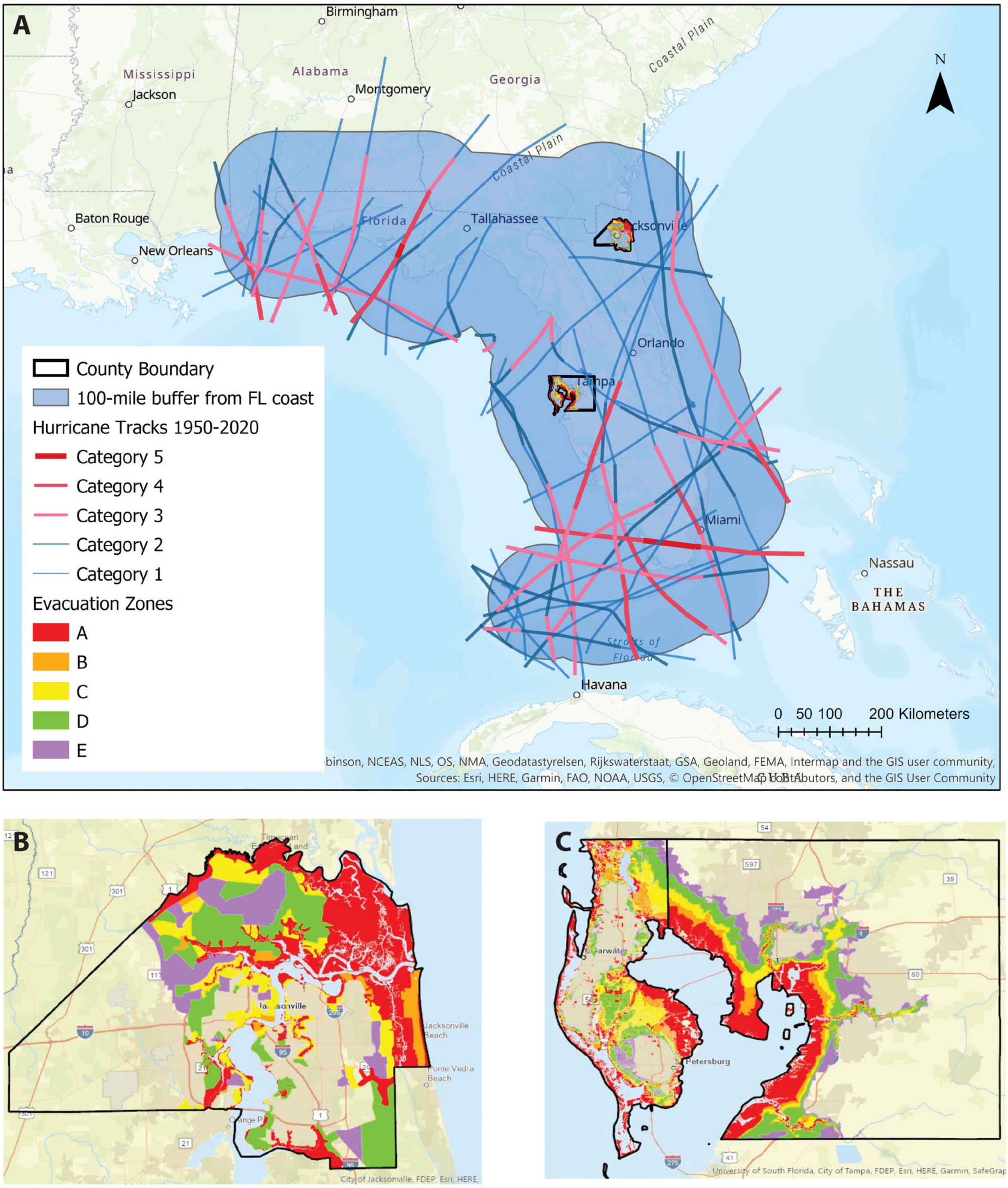

Figure 2 *(A) Study area included three counties in Florida, which are prone to hurricane threats. Survey samples were stratified using the hurricane evacuation zones in (B) Duval County in the Jacksonville region, and (C) Pinellas County and Hillsborough County in the Tampa region.*

percentage of senior population, like Florida, because seniors are the most vulnerable to COVID-19.

We chose two of the largest metropolises in Florida, Jacksonville and Tampa, for our study. Jacksonville and Tampa are the most populous cities in Florida after Miami. They have been less researched in the hurricane evacuation literature than the latter. Three counties are included in our study area (Figure 2A). Duval County, home to Jacksonville, is located in northeastern Florida. Pinellas County and Hillsborough County are adjacent counties located on the west central coast of the state; they are part of the Tampa–St. Petersburg–Clearwater Metropolitan Statistical Area.

Neither the Jacksonville nor the Tampa region has been directly hit by any major hurricane since 1950 (Figure 2A). Both areas, however, have been within the forecasted range of several major hurricanes. During the last decade, Duval County issued mandatory evacuation orders for Matthew (2016), Irma (2017), and Dorian (2019). Pinellas County and Hillsborough County issued mandatory evacuation orders for Irma (2017).

Household Survey

We sent a household mail survey to residents of the Jacksonville and Tampa regions in Florida between July and September 2020. Our survey only targeted residents who live in one of the designated hurricane evacuation zones (Figure 2B and 2C). This is important because, in Florida, evacuation orders are typically issued for these people and exclude people living outside of the evacuation zones. In addition, by using the resident's physical street address, we can tell the exact hurricane evacuation zone based on where each survey respondent lives. This allows us to compare people's evacuation decisions across different evacuation zones for a hurricane threat. In our study area, evacuation zones A and B are more susceptible to hurricane-induced surge and wind than zones C, D, or E.

A questionnaire (Appendix A) designed with thirty-two questions was distributed by mail. Our survey asked about people's evacuation decisions for hurricanes before 2020, their perceived hurricane risk, and their evacuation intention and shelter preference in the 2020 hurricane season. It also included questions about people's perceived COVID-19 risk and their self-reported health conditions. Socioeconomic data and data on people's trust in government regarding the hurricane or COVID-19 information were also collected.

We drew our sample from the most recent Florida voter registration list using the stratified random sampling method. The sampling was conducted in two stages. We conducted a disproportionate stratified sampling in the first stage to ensure we have adequate respondents in each stratum and then a random sampling from each stratum in the second stage. The strata for each city were created based on hurricane evacuation zones, where one stratum is evacuation zones A and B combined; and the other is zones C, D, and E combined. Zones A and B are more prone to hurricane damage, especially storm surge, than zones C, D, and E. For each city, the final sample included 2,000 residents living in hurricane evacuation zone A/B and 2,000 for zone C/D/E (Figure 2B and 2C). In total, we received 592 valid survey completions out of 8,000 mail surveys, with 304 in the Jacksonville region and 288 in the Tampa region (Appendix B).

Key Variables and Analyses

Hurricane Evacuation Decisions and Shelter Choices before and during the Pandemic We asked the survey respondents this question: What was the most recent hurricane that made threats to your area? The options included Dorian (2019), Irma (2017), Matthew (2016), other, and don't know (Appendix A, Q4). We also asked the question about whether they left their home when this hurricane threatened (Appendix A, Q5). In addition, for those who said yes, we asked where they went in terms of shelter choice, including public shelter, hotel or motel, staying with family or friends, and so on (Appendix A, Q6).

The evacuation intention during the pandemic was measured using the following question: If a hurricane threatens your area this year (2020) and the COVID-19 pandemic is still present, how likely would you be to evacuate if the government issues an evacuation order for your area? A respondent was given the options of *very likely*, *likely*, *unlikely*, *very unlikely*, or *no opinion* for a Category 1, Category 2, Category 3, Category 4, and Category 5 hurricane (Appendix A, Q15). We combined the *very likely* and *likely* responses into evacuate, and *unlikely* and *very unlikely* into stay. Therefore, the hurricane evacuation intention was measured as evacuate (or stay) for a certain category hurricane. To compare the shelter choice before and during the pandemic, we also asked respondents if they decided to evacuate in 2020, where they plan to go in terms of shelter choice (Appendix A, Q16).

Hurricane Evacuation Intention during the Pandemic The relationship between people's hurricane risk perception and evacuation intention was examined with the cross-tabulation analysis and significance was evaluated with the Pearson chi-square test. Hurricane risk perception was measured using the following question: If a hurricane of Category 2, 3, or 4 hits your area, would you think it is safe for you to stay in your home, considering possible damages from both wind and water? Respondents were given the options of *yes*, *no*, or *don't know* for a Category 2, Category 3, and Category 4 hurricane, respectively (Appendix A, Q3). Therefore, the perceived hurricane risk was measured as feeling unsafe (or safe) to stay home for a Category 2, 3, or 4 hurricane. We calculated the relative risk, a measure of the strength of the association between the presence of a factor and the occurrence of an event. A value of 1 indicates no difference between the two groups (IBM SPSS Statistics 27 2020).

We also examined people's evacuation intention related to the presence or absence of their self-reported underlying health conditions. The underlying health conditions in this study refer to one or multiple conditions of the following diseases: cancer, kidney disease, chronic respiratory disease, cardiovascular disease, immune disorder, and diabetes. All of them are COVID-19 risk factors according to the guidance of the Centers for Disease Control and Prevention (CDC 2021).

We then examined relationships between people's COVID-19 risk perception and their hurricane evacuation intention. COVID-19 risk perception was measured with the answer to this question: How likely do you think the chance for yourself to be sick with COVID-19 by the end of the year 2020. Respondents were given the options *very unlikely*, *unlikely*, *likely*, *very likely*, and *no opinion* (Appendix A, Q23). We applied two approaches to compare the groups. First, we combined *very unlikely* and *unlikely* into low self-reported risk, and *likely* or *very likely* into high self-reported risk. We checked the cross-tabulation and Pearson chi-square statistics for evacuation intention against COVID-19 risk perception by the high versus low groups. Second, we only compared the difference between the two extreme groups, the very unlikely and the very likely groups, with the same statistical tests. In addition, we examined the COVID–evacuation relationships by hurricane risk perception groups; that is, people who feel unsafe versus safe for a certain category of hurricane. We also examined this relationship by types of evacuation zones and by the two metropolitan regions.

Finally, we conducted binary logistic regression analyses. The dependent variable was evacuation intention for a Category 3 hurricane. The independent variables included risk perception for a Category 3 hurricane, COVID-19 risk perception, hurricane evacuation zones, type of housing, length of residence, trust in government officials, and other socioeconomic and demographic variables.

Shelter Preferences during the Pandemic In the survey, we had a question about whether people would be more likely to go to a public shelter if it is a smaller shelter such as government-contracted hotels. Options were provided using a five-point Likert scale (Appendix A, 18a). This variable was examined with the COVID-19 risk perception variable using the cross-tabulation and Somers's *d* test for ordinary variables.

Table 1 *Respondents' evacuation decisions for the most recent hurricanes for which mandatory evacuation orders were issued in the study area*

Hurricane		Evacuated	Stayed	Total
Dorian (2019)	Count	51	99	150
	%	34%	66%	100%
Irma (2017)	Count	147	167	314
	%	47%	53%	100%
Matthew (2016)	Count	23	18	41
	%	56%	44%	100%

Results and Discussion

Evacuation before and during COVID-19

Before the pandemic began in late 2019 and early 2020, approximately 34 percent of the survey respondents reported they evacuated for Hurricane Dorian in September 2019 (Table 1). This hurricane was projected to be a Category 2 hurricane when it approached Florida along the east coast (National Weather Service 2019). Approximately 47 and 56 percent of the respondents evacuated for Irma (2017) and Matthew (2016), respectively. Irma (2017) was a Category 4 hurricane but the projected track was over the Florida peninsula when the mandatory evacuation order was issued in Jacksonville (Action News Jax 2017). It was later projected to aim at Tampa Bay when the mandatory evacuation order was issued in the Tampa regions ("Hurricane Irma takes aim at Tampa Bay" 2017). Matthew (2016) was a Category 3 hurricane along the east coast of Florida when Duval County issued the mandatory evacuation order for their zone A/B residents (Weather.gov 2016).

Additional attention was given to residents living in evacuation zone A/B because they are the group most likely to be affected by hurricanes and, hence, receive evacuation orders (Table 2). Our survey indicated that approximately 38 percent of the Duval County respondents evacuated for Dorian (2019), a Category 2 storm, for which the county issued a mandatory evacuation order in its zones A and B (FloridaDisaster.org 2019). Approximately 43 percent of the Jacksonville zone A/B respondents reported they evacuated for Hurricane Irma in 2017 (Table 2). Irma (2017) was a Category 4 hurricane when Duval County issued the mandatory evacuation order for their zone A/B residents, but the projected track was over the Florida peninsula (Action

Table 2 *Prepandemic evacuation decisions of residents living in hurricane evacuation zone A/B*

		Jacksonville				Tampa		
Hurricane		Evacuated	Stayed	Total		Evacuated	Stayed	Total
Dorian (2019)	Count	33	53	86	Count			
	%	38%	62%	100%	%			
Irma (2017)	Count	27	36	63	Count	76	37	113
	%	43%	57%	100%	%	67%	33%	100%
Matthew (2016)	Count	15	9	24	Count			
	%	63%	38%	100%	%			

Table 3 *Likelihood to evacuate for a hurricane in 2020*

	Hurricane		Very likely	Likely	Unlikely	Very unlikely	No opinion	Total
Jacksonville	Category 1	Count	26	9	44	93	3	175
		%	14.9	5.1	25.1	53.1	1.7	100.0
	Category 2	Count	35	17	45	73	4	174
		%	20.1	9.8	25.9	42.0	2.3	100.0
	Category 3	Count	63	35	27	48	2	175
		%	36.0	20.0	15.4	27.4	1.1	100.0
	Category 4	Count	100	35	19	14	4	172
		%	58.1	20.3	11.0	8.1	2.3	100.0
	Category 5	Count	129	26	7	7	3	172
		%	75.0	15.1	4.1	4.1	1.7	100.0
Tampa								
	Category 1	Count	28	19	25	48	2	122
		%	23.0	15.6	20.5	39.3	1.6	100.0
	Category 2	Count	40	20	24	37	2	123
		%	32.5	16.3	19.5	30.1	1.6	100.0
	Category 3	Count	58	22	17	21	4	122
		%	47.5	18.0	13.9	17.2	3.3	100.0
	Category 4	Count	82	20	8	10	3	123
		%	66.7	16.3	6.5	8.1	2.4	100.0
	Category 5	Count	93	13	6	7	3	122
		%	76.2	10.7	4.9	5.7	2.5	100.0

Note: The reported statistics are for respondents who lived in the hurricane evacuation zone A/B.

News Jax 2017); therefore, Irma (2017) can be treated as a Category 1 or 2 hurricane for the zone A/B Jacksonville residents.

When asked how likely these Jacksonville respondents would be to evacuate for a Category 1 hurricane if they were ordered in 2020, approximately 20 percent of the respondents said they would very likely or likely consider evacuation; the rate was approximately 30 percent for a Category 2 hurricane (Table 3). Thus, the rates of intended evacuation were significantly ($p < 0.001$) lower for a Category 1 hurricane, compared to the Irma (2017) evacuation in Duval County. The rates of intended evacuation were lower, but not statistically significant ($p = 0.079$ compared to Irma [2017], $p = 0.212$ compared to Dorian [2019]), for a Category 2 hurricane during COVID-19 than before.

In contrast, approximately 67 percent of the Tampa residents (Table 2) had evacuated for the westward-shifting Irma (2017) under evacuation orders ("Hurricane Irma takes aim at Tampa Bay" 2017); 66 percent of the same group of respondents indicated they would very likely or likely consider evacuation for a Category 3 hurricane and 83 percent for Category 4 (Table 3). For Hurricane Matthew (2016), which was a Category 3 hurricane when Duval County issued the mandatory evacuation order for their zone A/B residents (Weather.gov 2016), the evacuation rate was 63 percent (Table 2). The rate of intended evacuation (very likely and likely combined) for those Duval County residents was 56 percent for a Category 3 hurricane during COVID-19 (Table 3), slightly lower but not significantly ($p = 0.587$) different compared to the pre-COVID rate. In other words, the rates of intended evacuation for a Category 3 or 4 hurricane were not reduced compared to those in the pre-COVID era.

Evacuation Intention under COVID-19

How would people with underlying health conditions have made their evacuation decision when they were issued an evacuation order under the COVID-19 pandemic during the 2020 hurricane season? The factor of underlying health conditions by itself did not appear to decrease people's evacuation intention according to the Pearson chi-square analysis (Table 4). Similarly, none of the COVID-19 risk perception variables significantly influence people's evacuation intention for a Category 2, 3, or 4 hurricane (Table 4). The missing link was true when adding other controlling variables such as hurricane risk perception (i.e., hurricane risk = unsafe vs. safe), evacuation zones (i.e., A/B vs. C/D/E), or metropolitan regions (i.e., Jacksonville vs. Tampa). In particular, when people felt unsafe to stay for a hurricane, their intended evacuation showed no difference between the higher or lower COVID-19 risk groups (Table 4).

In contrast, hurricane risk perception is significantly related to people's evacuation intention (Table 4). This hurricane risk–evacuation relationship remains statistically significant regardless of people's self-reported risk of contracting COVID-19. For a Category 3 hurricane, the logistic regression analysis showed that the risk perception was the only statistically significant variable for respondents' evacuation intention (Appendix C).

Our results indicate that, for people who live in a hurricane risk area (such as those residing in one of the designated evacuation zones), evacuation intention is significantly influenced by their perceived hurricane risk. This continues to be true even under the COVID-19 pandemic. This result is corroborated by the AAA (2020) survey in Florida during May 2020. Approximately 71 percent of the respondents ($n = 401$) said they would evacuate in

Table 4 *Impacts of hurricane risk perception, underlying health conditions, and COVID-19 risk perception on evacuation intention for a Category 2, 3, or 4 Hurricane*

	Category 2 hurricane						Category 3 hurricane						Category 4 hurricane					
	Valid cases		Resp.	Evacuate			Valid cases		Resp.	Evacuate			Valid cases		Resp.	Evacuate		
Risk factor	**No.**	%	**No.**	**No.**	%	**Relative risk**	**No.**	%	**No.**	**No.**	%	**Relative risk**	**No.**	%	**No.**	**No.**	%	**Relative risk**
Hurricane risk	527	89.0					479	80.9					459	77.5				
Unsafe			114	99	86.8	4.904***			238	221	92.9	4.223***			376	350	93.1	2.579***
Safe			413	73	17.7	Reference			241	53	22.0	Reference			83	30	36.1	Reference
Underlying health	567	95.8					567	95.8					561	94.8				
Yes			178	66	37.1	1.110			177	106	59.9	1.066			177	145	81.9	1.031
No			389	130	33.4	Reference			390	219	56.2	Reference			384	305	79.4	Reference
COVID risk[a]	451	76.2					416	70.3					394	66.6				
High			103	29	28.2	0.817			99	53	53.5	0.922			91	79	86.8	1.056
Low			348	120	34.5	Reference			317	184	58.0	Reference			303	249	82.2	Reference
COVID risk,[b] when hurricane risk = unsafe	97	16.4					203	34.3					322	54.4				
High			17	15	88.2	0.993			43	41	95.3	1.030			77	75	97.4	1.046
Low			80	71	88.8	Reference			160	148	92.5	Reference			245	228	93.1	Reference
COVID risk[a]	132	22.3					118	19.9					118	19.9				
Very likely			20	7	35.0	0.933			18	10	55.6	0.959			21	17	81.0	1.007
Very unlikely			112	42	37.5	Reference			100	58	58.0	Reference			97	78	80.4	Reference
COVID risk[b], when hurricane risk = unsafe	28	4.7					55	9.3										
Very likely			3	3	100.0	1.120			9	8	88.9	0.929	94	15.9	17	16	94.1	1.005
Very unlikely			25	28	89.3	Reference			46	44	95.7	Reference			77	72	93.6	Reference

Note: For COVID risk, high = very likely or likely to be infected with COVID-19 by the end of 2020; low = unlikely or very unlikely to be infected with COVID-19 by the end of 2020. The relative risk is a measure of the strength of the association between the presence of a factor (e.g., presence vs. absence of hurricane risk) and the occurrence of an event (e.g., evacuate vs. stay for a Category 3 hurricane); the value of 1 indicates no difference between the factor's two groups

[a]COVID-19 risk perception for the entire sample.

[b]COVID-19 risk perception for the group of respondents who think it is unsafe to stay home for a certain category of hurricane.

*Asymptotic significance (2-sided) $\leq$ 0.05.

**Asymptotic significance (2-sided) $\leq$ 0.01.

***Asymptotic significance (2-sided) $\leq$ 0.001.

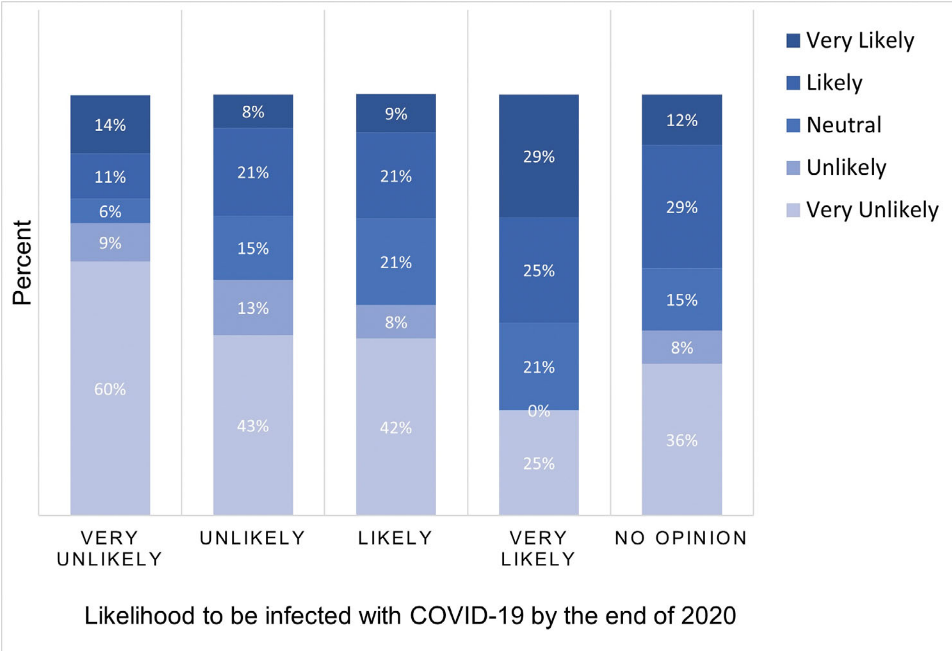

Figure 3 *Likelihood of respondents' preference for a nontraditional shelter such as government-contracted hotels by COVID-19 risk categories.*

the event of a hurricane if they were warned to do so. When asked about whether social distancing protocols and concerns of contracting COVID-19 made them less likely to evacuate, 58 percent of their respondents said no. In our study, approximately 35 percent of the respondents ($n = 567$) said they would consider evacuating if the government issued an evacuation order for their area in a Category 2 hurricane. The rate was 57 percent ($n = 567$) for a Category 3 hurricane and 80 percent ($n = 561$) for a Category 4 hurricane.

Shelter Preferences and COVID-19 Risk Perception

Before the pandemic started, less than 10 percent of the hurricane evacuees in Florida used public shelters according to a statewide behavioral study (Baker 2009). In the same report, the actual use of public shelters was around 5 percent for Hurricane Georges (1998) and Hurricane Charley (2004) in the Tampa Bay area. In our survey (Appendix A, Q6), approximately 4 percent of the evacuees for past hurricanes said they went to public shelters, 28 percent stayed in hotels or motels, and 48 percent stayed with family members or relatives. We also had a question about where the respondents planned to go if they decided to evacuate in 2020 (Appendix A, Q16). Less than 2 percent of people indicated they would go to a public shelter, 27 percent to a hotel or motel, and 47 percent to stay with family members or relatives. Therefore, intended public shelter use appeared to be lower during the pandemic than in the prepandemic situation. This could be explained by a recent survey in Florida that reported three-fourths of individuals viewed public shelter as more dangerous than enduring hurricane threats (Collins et al. 2021).

Approximately 55 percent of our survey respondents ($n = 558$) indicated that they would avoid public shelter even if it is a nontraditional shelter such as government-contracted hotels, whereas 30 percent said they would consider going to such shelters (Appendix A, Q18a). We found a statistically significant relationship between respondents' COVID-19 risk perception and their preference for a hotel shelter (Somers's d significant < 0.001). Greater fractions of the higher COVID-19 risk groups expressed the increasing likelihood to go to a hotel shelter (Figure 3). Approximately 55 percent of people belonging to the highest COVID-19 risk group ($n = 24$) indicated they would very likely or likely consider public shelter if it is government-contracted hotels. In contrast, only 25 percent of the people belonging to the lowest COVID-19 risk group ($n = 121$) said the same (Figure 3).

Research Limitations and Future Work

The overall response rate (7.4 percent) of our household survey was lower than the typical response rate of our previous hurricane evacuation surveys in Florida. The decline in response might have been affected by COVID-19, as people might have chosen to avoid unnecessary mailing activities due to the concern of contracting the virus in the middle of 2020 when they still had limited information about COVID-19 (Mulrooney and McGinn 2021). Additionally, our survey respondents tended to be wealthy, educated senior citizens (Appendix B). Future studies should focus on designing sampling strategies targeting underrepresented younger, low-income, less educated groups, which is a common challenge in most survey-based probability sampling (Korinek, Mistiaen, and Ravallion 2007; Nummela et al. 2011).

Our study area was less frequently or strongly affected by historical hurricanes, compared to southern or western Florida. Caution must be used when applying our results to a different geographic region. The direct comparison of hurricanes in the past and the hypothetical scenarios might have presented some challenges to the survey respondents as well as the interpretation of our results. For example, Matthew (2016) and Dorian (2019) took parallel tracks on Florida's east coast, whereas Irma (2017) landed from the Gulf side and moved northward over the land. Each hurricane is unique in terms of strength, path, speed of development, and so on, which are all important for people's risk perception and evacuation decisions. Future studies could incorporate experimental research to better control the confounding factors. Finally, for the analysis of factors influencing evacuation decisions, modeling techniques such as Bayesian networks or nonlinear models might be useful to identify hidden relationships because many of the influencing factors might be correlated and some might be nonlinearly related with the evacuation decision.

Conclusions

We studied relationships between people's hurricane and COVID-19 risk perception and their hurricane evacuation and shelter intention. Among the hypotheses tested, we found that (1) hurricane risk perception was positively related to evacuation intention. People who felt unsafe for a Category 2 hurricane were four times more likely to evacuate than their counterparts for an evacuation order issued for the Category 2 hurricane. The likelihood was three times greater for a Category 3 hurricane and one-and-a-half times greater for a Category 4 hurricane. (2) COVID-19 risk perception was not related to evacuation intention for a Category 2, 3, or 4 hurricane. For people who felt unsafe for such a hurricane, their chance of evacuation was about the same regardless of their COVID-19 risk perception. For a Category 1 hurricane, however, respondents in hurricane evacuation zone A/B indicated a decreased intention for evacuation during the COVID-19 period compared to the pre-COVID era. (3) COVID-19 risk perception appeared to reduce the intended use of public shelters. It also significantly influenced evacuees' preference for nontraditional shelters such as government-contracted hotels.

Our findings have several management implications for hurricane preparedness and response during the current or a similar pandemic to COVID-19. First, emergency management agencies should be prepared for a similar level of intended evacuation from their residents in hurricane evacuation zones if a Category 2, 3, or 4 hurricane occurs during a similar pandemic. They should make sure all evacuation routes are ready, including the coordination of the evacuation to avoid congestion on the route and dispatch of emergency response teams. Because the number of residents who would like to evacuate is similar to that in a prepandemic era, emergency management agencies might need to work with mass transit agencies to prepare even more buses and other public transit vehicles equipped with necessary sanitization supplies and allow for social distancing among people who rely on public transportation to evacuate. Second, emergency management agencies might need to provide different noncongregate sheltering options if a hurricane occurs during a similar pandemic. Our results suggest that evacuees with a higher perceived COVID-19 risk accounted for approximately 20 percent of the survey respondents and that the availability of hotel shelters was an important factor in their shelter decisions. Therefore, states and local governments should continue developing plans for using hotels or motels as hurricane shelters in preparation for future hurricanes that might occur during a similar pandemic. ■

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Appendix A: Survey Questions from Our Mail Questionnaire (Only Those Relevant to This Article Are Included Here)

Q3. If a hurricane of Category 2, 3, or 4 hits your area, would you think it is safe for you to stay in your home, considering possible damages from both wind and water?

		YES	NO	Don't Know
a.	Category 2	☐	☐	☐
b.	Category 3	☐	☐	☐
c.	Category 4	☐	☐	☐

Q4. What was the most recent hurricane that made threats to your area? (Check ONE)

- ☐ Dorian 2019
- ☐ Irma 2017
- ☐ Matthew 2016
- ☐ Other (Please Specify)__________________________
- ☐ Don't know

Q5. When this hurricane made threats to your area, did you leave your home to go someplace safer?

☐ Yes ☐ No (**SKIP TO Q9**)

Q6. Where did you go? (CHECK ALL THAT APPLY)

- ☐ Public Shelter
- ☐ Hotel or Motel
- ☐ Home-sharing housing (such as Airbnb or VRBO)

Q13. To what extent do you trust the information about emergencies (such as hurricane and COVID-19) from the following sources?

		Very Much	Somewhat	Not Much	Not at All	No Opinion
a.	Experts (e.g. Scientists and experts in research institutes)	☐	☐	☐	☐	☐
b.	Government officials (president, governor, mayor, department heads etc.)	☐	☐	☐	☐	☐
c.	Family and friends	☐	☐	☐	☐	☐
d.	Employers and co-workers	☐	☐	☐	☐	☐
e.	Other (Please Specify)____________	☐	☐	☐	☐	☐

Q15. If a hurricane threatens your area this year (2020) and the COVID-19 pandemic is still present, how likely would you evacuate if the government issues an evacuation order for your area?

	Very Likely	Likely	Unlikely	Very Unlikely	No Opinion
a. Category 1	☐	☐	☐	☐	☐
b. Category 2	☐	☐	☐	☐	☐
c. Category 3	☐	☐	☐	☐	☐
d. Category 4	☐	☐	☐	☐	☐
e. Category 5	☐	☐	☐	☐	☐

Q16. If you decide to evacuate this year (2020), where would you plan to go? (CHECK ONE)

☐ Public Shelter

☐ Hotel or Motel

☐ Home-sharing housing (such as Airbnb or VRBO)

☐ Stayed with families or relatives

☐ Stayed with friends

☐ Other (Please Specify)____________

☐ Don't' Know

Q18. Would you be more likely to go to a public shelter, if the following measures to contain the spread of COVID-19 are taken at this public shelter?

	Very Unlikely	Unlikely	Neutral	Likely	Very Likely
a. Smaller shelter such as government - contracted hotels	☐	☐	☐	☐	☐
b. The shelter provides people with spacious room (at least 60 square feet per person)	☐	☐	☐	☐	☐
c. The shelter deep cleans its space before people are admitted	☐	☐	☐	☐	☐
d. The shelter takes body temperatures before people are admitted	☐	☐	☐	☐	☐
e. The shel ter can provide COVID-19 tests	☐	☐	☐	☐	☐
f. The shelter requires people to wear a mask all the time except while eating or drinking	☐	☐	☐	☐	☐
g. The shelter provides hand sanitizers to use	☐	☐	☐	☐	☐
h. The shelter provides separate areas to isolate people with cold-like symptoms	☐	☐	☐	☐	☐
i. People on Google Maps and Yelp recommend this shelter	☐	☐	☐	☐	☐

Q19. What would be the major concerns for you not to evacuate if an evacuation order were issued in your area this year? (Check UP TO THREE)

☐ The storm may not be very bad as predicted
☐ Don't want to go to public shelters
☐ No families, relatives, or friends to shelter with
☐ Concerned about the traffic during evacuation
☐ Not sure where to take my pets
☐ Stay to protect my property
☐ Required to stay due to work or emergency respondent responsibility
☐ Concerned about special medical needs
☐ Concerned about the financial cost associated with evacuation
☐ No transportation options for evacuation
☐ Other (Please Specify)____________

Q20. Do you have any of the following existing health conditions? (Check ALL that apply).

☐ Cardiovascular disease
☐ Diabetes
☐ Chronic respiratory disease (including asthma)
☐ Hypertension
☐ Liver disease
☐ Kidney disease
☐ Cancer
☐ Immune Disorder
☐ Cardiovascular disease
☐ None of the above

Q22. Were you or are you currently sick with COVID-19?

☐ No
☐ Symptoms present, but not tested
☐ Test result pending
☐ Yes, confirmed with test **(SKIP to Q24)**

Q23. How likely do you think the chance for yourself to be sick with COVID-19 by the end of year 2020?

☐ Very Unlikely ☐ Unlikely ☐ Likely ☐ Very Likely ☐ No Opinion

Q25. Which year were you born? ____________________

Q26. What is your gender?

☐ Male ☐ Female ☐ Other

Q27. Do you have any children under the age of 18 living in the same household?

☐ YES
How many kids under 18? __________________

☐ No

Q28. Is any family member with special medical needs, disability or limited mobility living in the same household?

☐ Yes ☐ No

Q29. What type of housing do you live in?

☐ Single Family, site-built
☐ Mobile or manufactured home
☐ Multifamily
☐ Other (Please specify)____________________

Q30. How long have you lived at your current address?

☐ Less than 1 years
☐ 1-10 years
☐ More than 10 years

Q31. What is the highest grade you completed in school?

☐ Some high school
☐ High school graduate
☐ Some college
☐ Technical school
☐ College graduate
☐ Post-graduate school

Q32. What was your household income in 2019?

☐ Less than $25,000
☐ $25,000 to $49,999
☐ $50,000 to $99,999
☐ $100,000 and above
☐ Rather not to answer

Appendix B: Respondents' socioeconomic, housing, and health characteristics, as well as statistics for the population residing in the evacuation zones for Jacksonville and Tampa

	Jacksonville					Tampa				
	Sample ($n = 304$)			Population[a]		Sample ($n = 288$)			Population[a]	
	Valid cases	*n*	%	*n*	%	Valid cases	*n*	%	*n*	%
Evacuation zone	304					288				
A/B		193	63.5	148,942	39.7		155	53.8	429,619	42.8
C/D/E		111	36.5	226,221	60.3		133	46.2	574,037	57.2
Housing type	300					285				
Single-family		241	80.3	113,226	69.1		202	70.9	257,958	54.9
Mobile		8	2.7	7,460	4.6		15	5.3	41,461	8.8
Multifamily/condo		51	17.0	43,248	26.4		68	23.9	170,414	36.3
Length of residence	299					285				
< 1 year		12	4.0	68,019	18.5		18	6.3	171,873	17.5
≥ 1 year		287	96.0	300,237	81.5		267	93.7	811,264	82.5
Gender	294					280				
Male		134	45.6	182,291	48.6		123	43.9	488,977	48.7
Female		160	54.4	192,831	51.4		157	56.1	514,684	51.3
Median age (years)	293		62.0		39.5	276		63.0		43.1
Income level	295					281				
< $25,000		14	4.7	29,092	20.2		24	8.5	82,108	20.5
$25,000–49,999		41	13.9	33,336	23.1		45	16.0	95,384	23.8
$50,000–99,999		75	25.4	44,430	30.8		71	25.3	122,195	30.4
≥ $100,000		113	38.3	37,477	26.0		100	35.6	101,636	25.3
No answer		52	17.6				41	14.6		
Education attainment	296					281				
Some high school		5	1.7	17,913	4.3		4	1.4	45,170	3.9
High school graduate		23	7.8	234,756	56.3		26	9.3	656,378	56.8
Some college		53	17.9	81,880	19.6		48	17.1	209,548	18.1
Technical school		15	5.1	n/a	n/a		18	6.4	n/a	n/a
College graduate		110	37.2	54,303	13.0		106	37.7	156,730	13.6
Postcollege graduate		90	30.4	28,439	6.8		79	28.1	88,300	7.6
Child(ren) at home	296					285				
Yes		54	18.2		23.6		51	17.9		23.6
No		242	81.8		76.4		234	82.1		76.4
Special needs	298					283				
Yes		54	18.1		13.4		42	14.8		13.4
No		244	81.9		86.6		241	85.2		86.6
Underlying health	304					288				
Yes		111	36.5		N/A		77	26.7		N/A
No		193	63.5		N/A		211	73.3		N/A

[a]Data came from CENACS_2019 (https://www.fgdl.org/metadataexplorer/explorer.jsp). This data set includes demographic and housing variables from the 2015–2019 American Community Survey for the Census Block Groups for the State of Florida. The exceptions are the children at home (https://data.census.gov/cedsci/table?q=florida%20family&tid=ACSST5Y2019.S1101&hidePreview=true) and special needs (https://data.census.gov/cedsci/table?q=florida%20disability&tid=ACSST5Y2019.S1810&hidePreview=true) variables, for which data came from the state-level estimates (ACSST5Y2019).

Appendix C: Binary logistic regression

							95% CI for Exp(*B*)	
	B	***SE***	**Wald**	***df***	**Significance**	**Exp(*B*)**	**Lower**	**Upper**
HR_Cat3 (Safe to stay)	–3.874	0.375	106.986	1	0.000	0.021	0.010	0.043
COVID (Likely)	0.054	0.388	0.019	1	0.890	1.055	0.493	2.257
EvacZone (A/B)	0.051	0.339	0.022	1	0.881	1.052	0.541	2.045
Housing (multi)			0.601	2	0.740			
Housing (SF)	–0.324	0.418	0.601	1	0.438	0.723	0.319	1.641
Housing (mobile)	18.521	12608.382	0.000	1	0.999	110568354.001	0.000	
Residence (≥ 1 year)	0.537	0.699	0.589	1	0.443	1.710	0.434	6.736
Gender (male)	–0.127	0.333	0.145	1	0.704	0.881	0.459	1.691
Age (years)	–0.002	0.012	0.040	1	0.841	0.998	0.975	1.021
Income (< $25,000)			1.030	2	0.597			
Income (≥ $50,000)	0.444	0.753	0.348	1	0.555	1.559	0.356	6.817
Income ($25,000–50,000)	–0.013	0.828	0.000	1	0.988	0.987	0.195	4.999
Education (high)			1.005	2	0.605			
Education (low)	0.580	0.710	0.668	1	0.414	1.787	0.444	7.183
Education (middle)	0.295	0.394	0.562	1	0.453	1.343	0.621	2.905
Children (not present)	0.105	0.428	0.060	1	0.807	1.110	0.480	2.571
SpecNeeds (not present)	–0.056	0.460	0.015	1	0.903	0.945	0.384	2.328
TrustGov(not trust)	–0.067	0.336	0.040	1	0.842	0.935	0.484	1.806
Constant	1.943	1.258	2.385	1	0.122	6.983		

Note: Dependent variable = evacuation intention (evacuate or stay) for a Category 3 hurricane. All predictors except age are categorical variables. Model summary: –2 log likelihood = 257.910; Cox & Snell R^2 = 0.458; Nagelkerke R^2 = 0.612. The overall classification accuracy of the predicted dependent variable = 85.7%; percentage correct for stay = 92.9%; percentage correct for evacuate = 79.6%.