

**Individual Hurricane Preparedness During the COVID-19 Pandemic:
Insights for Risk Communication and Emergency Management Policies**

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Abstract

Climate change adaptation strategies should anticipate that the 2020 situation which resembles an above average hurricane season coinciding with a pandemic may occur more frequently in the future. This study draws lessons on how individual hurricane preparedness is influenced by a pandemic, which turns out to be a combination of perceptions of flood and pandemic risks that have opposite effects on preparedness behavior. We conducted three waves of surveys during 2019-2020 to monitor hurricane preparedness activities in flood-prone coastal areas in Florida, including a survey of 600 respondents in early June 2020 to obtain insights into households' risk perceptions and preparedness for this hurricane season under COVID-19. The results show that this hurricane season is dominated by concerns over COVID-19 which influences people's evacuation intentions. Whereas hotel costs were the main obstacle to evacuating during Hurricane Dorian in 2019, the main evacuation obstacle identified in the 2020 hurricane season is COVID-19. Our statistical analyses that investigates the factors influencing evacuation intentions consistently show that older individuals are less likely to evacuate voluntarily, because they are concerned about becoming infected by COVID-19. We discuss the implications of our findings for adaptation policies that aim to improve hurricane preparedness in situations of a pandemic, such as risk communication and emergency management policies.

Keywords: adaptation, COVID-19, evacuation, hurricane preparedness, pandemic, risk perception.

1. Introduction

It has been projected that climate change may increase the frequency and/or severity of hurricanes (IPCC 2014). Therefore, adaptation policies such as purchase of insurance, taking risk reduction measures, and evacuating from a storm and flood threat, should focus on improving individual preparedness for hurricanes to limit their destructive impacts. However, experience during the 2020 hurricane season shows that hurricane preparedness may be hampered by the occurrence of a pandemic. For instance, during the threat of Hurricane Laura in the US it was expected that evacuations could cause a surge in COVID-19 cases, whereas preparations for the pandemic led to transport disruptions and difficulties in providing adequate shelter accommodation. Moreover, individuals may be less likely to evacuate during a storm threat when they are concerned about COVID-19 infections. The reason is that many people evacuate to hotels or shelters that can be crowded, such that socially distancing is not possible.

The influence of pandemics on hurricane preparedness should be taken into account in the design of climate adaptation strategies, because pandemics are likely to occur more often in our globalized economy (Philips et al. 2020). Moreover, climate change may exacerbate the risks of certain infectious diseases in addition to increasing the frequency and severity of extreme weather (IPCC 2014). Hence natural disaster risk management strategies should anticipate that this year's situation which resembles a hurricane season with above average hurricane activity (NOAA 2020) coinciding with a pandemic may happen more frequently in the future. To our knowledge, this study is the first empirical analysis that draws lessons on how hurricane preparedness is influenced by a pandemic, which turns out to be the outcome of the combined effects of perceptions of flood and pandemic risks that have opposite effects on preparedness behavior.

We conducted a series of three surveys from 2019-2020 of coastal residents in Florida to monitor their individual hurricane preparedness behavior and risk perceptions. The results show that current flood risk perceptions are dominated by concerns over COVID-19. Moreover, COVID-19 is the main obstacle to evacuating during a storm threat. Older people who are also more vulnerable to becoming ill from the coronavirus (Meng et al. 2020) are less likely to evacuate due to concerns about COVID-19. This is problematic because older people are also more likely to experience adverse health impacts from hurricanes if they fail to evacuate. We draw several implications from these findings for risk communication and emergency management policies that should be part of a broader adaptation strategy to limit impacts from future hurricanes. Our policy implications are also highly timely, because they link to hurricane preparedness guidance with COVID-19 considerations that is being issued by various organizations and federal agencies, such as the American Red Cross (2020) and FEMA (2020), and state and local governments (NAIC/CIPR Research Library 2020).

2. Survey of coastal residents in Florida

This study is based on a repeated survey in which we monitored hurricane preparedness activities and risk perceptions of households in flood-prone areas of Florida using three waves of surveys during 2019-2020. The first survey, completed by 871 respondents, was conducted over the phone between 29 August and 2 September 2019 in real time during the threat of Hurricane Dorian. The second survey was conducted in February 2020 among 255 of the same respondents, to examine whether preparedness activities had changed after the near miss of potentially catastrophic Hurricane Dorian. The final survey was conducted in early June 2020 to obtain insights into preparedness for the 2020 hurricane season under COVID-19. This paper is primarily focused on

the last survey of 600 respondents, which was conducted online using a representative sample of households living in the same areas as the first survey.¹ Both surveys contained an identical set of questions on flood risk perceptions and hurricane preparedness activities. In addition, the final survey contained a set of questions about COVID-19 risks. Online Supplementary Information (OSI) 1 describes sample characteristics. OSI Table 1 defines the variables used in our statistical analyses.

3. Individual perceptions of flood and COVID-19 risks

A comparison of perceptions of COVID-19 and hurricane-related risks shows that perceptions of COVID-19 risks exceed those of flood risks. For example, more people are worried or strongly worried about COVID-19 risks (63%) than about flood risks (33%), as OSI Fig. 1 illustrates. Moreover, only 21% disagrees and 7% strongly disagrees with the statement “The probability of flooding is so low that I am not concerned about the consequences of a flood.” These percentages are 28% and 30% respectively for a similar statement about the consequences of being infected by the coronavirus. Individuals not only worry about the negative consequences of COVID-19, but also perceive high infection risks. For instance, 34% of respondents believe that it is likely or very likely they will become infected by COVID-19, and 39% expect to become very ill or extremely ill, once infected. More than half of the sample already experienced expenses for COVID-19, mainly due to a loss of income. The vast majority of respondents (81%) are worried about the current economic situation. Previous research has shown that feelings towards risks are likely to affect how people prepare for a disaster. Examples are worry about the consequences of a hazard

¹ See Botzen et al. (2020) for the results of surveys one and two (available on request).

or perceptions about whether or not the probability of experiencing a hazard is high enough to trigger concern (Kunreuther and Pauly 2018; Botzen et al. 2019). Taken together, our survey results indicate that the 2020 hurricane season is dominated by concerns about COVID-19, which can influence hurricane preparedness activities.

4. Hurricane preparedness

Results about wind and flood insurance purchases described in OSI 2 suggest that people cancelled insurance coverage in 2020, possibly due to the adverse economic situation. Many people who kept their insurance did an insurance checkup that resulted in a higher coverage. Overall, no clear pattern can be observed for changes in the implementation of risk reduction measures between our first and third survey, suggesting these have remained approximately stable (OSI 2).

With regards to evacuation, individuals are more likely to evacuate under a mandatory order than under a voluntary order. When being asked about intentions to evacuate to a safer place under a mandatory evacuation order, 62% of respondents answer that it is likely or extremely likely they would evacuate, while this figure is only 39% in case of a voluntary evacuation order (see OSI Table 2).

Descriptive statistics and regression analyses of factors influencing evacuation intentions indicate that concern about COVID-19 is the most important obstacle for evacuation during the 2020 hurricane season. Both surveys two and three contained a question about the obstacles for

evacuation during a hurricane threat. More respondents indicated at least one potential obstacle in survey three than in survey two (75% versus 56%). The inability to pay for hotel costs was the most frequently mentioned obstacle during Hurricane Dorian (by 26% of survey two respondents who reported an obstacle). However, as Fig. 1 illustrates, hotel costs dropped to the number four obstacle during the 2020 hurricane season. Instead, COVID-19 was mentioned most frequently, by almost half of the survey three respondents who expected to experience any obstacles.

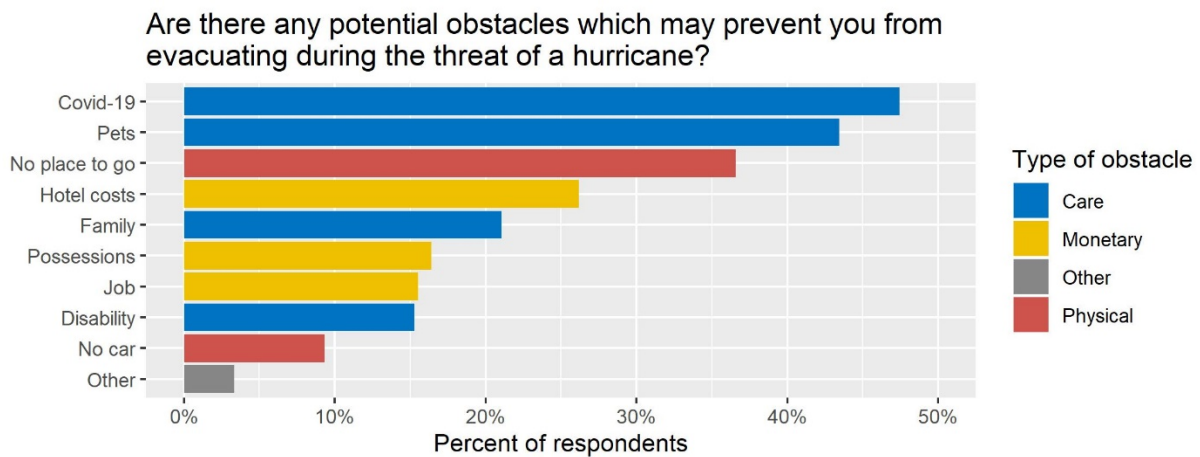


Fig. 1. Percent of respondents who answered obstacles for evacuation, by obstacle.

Note: Sample includes only respondents who reported at least one obstacle.

OSI Fig. 2 shows how individual perceptions of COVID-19 being an obstacle to evacuating varies across the 13 coastal counties. The top three counties with the highest average probability of viewing COVID-19 as an obstacle are Flagler, Martin, and Palm Beach. In these three counties, the average concern over the COVID-19 infection probability generally exceeds the neutral level. These findings give a first indication that individuals’ perceptions of COVID-19 risk can affect their evacuation behaviour. We conducted a probit model analysis to examine in more detail how

COVID-19 risk perceptions relate to people answering COVID-19 as an obstacle, while controlling for socio-demographic characteristics and flood risk perceptions. The results in OSI Table 3 show that reporting COVID-19 as an obstacle for evacuation is positively and significantly related to the degree of worry about COVID-19 risk and concern about the COVID-19 infection probability. In other words, high individual perceptions of COVID-19 risks are an important driver of viewing COVID-19 as an obstacle for evacuation.

We conduct a series of statistical analyses to examine how evacuation intentions under a voluntary order depend on socio-demographic characteristics and perceptions of hurricane and COVID-19 risks. An ordered probit model of the intentions to evacuate voluntarily with only socio-demographic characteristics as explanatory variables finds that older people are significantly less likely to evacuate (OSI Table 4). As a next step we add perceptions of hurricane and COVID-19 risks and length of residence as explanatory variables to the model. We find that the likelihood of voluntary evacuation significantly increases with worry about flooding, but significantly declines with concern about the COVID-19 infection probability and the length of residence (OSI Table 4). Moreover, the independent effect of age on intentions to evacuate voluntarily becomes insignificant, indicating that the negative significant effect of age in the first model is an indirect effect, perhaps driven by perceptions of flood and COVID-19 risks as well as length of residence. This result is examined in more detail using a mediation model (Table 1).

Table 1 displays the total effect of age on voluntary evacuation, divided into a direct and indirect effect via concern about the COVID-19 infection probability, worry about flooding, and length of residence. Overall, the total effect shows that older individuals have lower evacuation intentions.

Controlling for concern about the COVID-19 infection probability, worry about flooding, and length of residence leaves an insignificant direct effect of age. The indirect effect, which is the share of the relationship between age and voluntary evacuation which is attributable to perceptions of COVID-19 and flood risks and length of residence, is explained by the coefficient estimate - 0.007 (p-value < 0.01). Between 60% and 73% (depending on included control variables) of the relationship between age and voluntary evacuation is explained by concern about the COVID-19 infection probability, worry about flooding, and length of residence.² The two risk perception variables are statistically significant and explain a larger proportion of the relationship than the length of residence.

Table 1. Decomposition of the total effect of age on voluntary evacuation into direct and indirect effects via concern about the COVID-19 infection probability, worry about flooding and length of residence using the ordered probit model

	Without control variables	Including control variables
Total effect	-0.012*** (0.003)	-0.010*** (0.004)
Direct effect	-0.005 (0.003)	-0.003 (0.004)
Indirect effect	-0.007*** (0.001)	-0.007*** (0.002)
via concern about the COVID-19 infection probability	-0.001** (0.001)	-0.003** (0.001)
via worry about flooding	-0.004*** (0.001)	-0.003*** (0.001)
via length of residence	-0.001* (0.001)	-0.001 (0.001)
Mediation percentage	59.57	72.51
via concern about the COVID-19 infection probability	12.73	27.96
via worry about flooding	35.88	33.35
via length of residence	10.95	11.20
Observations	527	362
Notes:		
***Significant at 1%; **Significant at 5%; *Significant at 10%.		
Coefficient estimates are provided with standard errors in parentheses.		
Control variables are: female, education, income, perceived flood probability and perceived coronavirus infection probability.		

² Correlation analysis show that a higher age is associated with higher concern about COVID-19 and length of residence, but a lower worry about flooding.

5. Policy implications

The 2020 storm season which resembles above average hurricane activity coinciding with a pandemic, may be viewed as a learning experiment for climate adaptation strategies that aim to limit hurricane impacts when more severe hurricanes in the future occur simultaneously with other health emergencies, such as a pandemic. Indeed the results of our survey of 600 coastal residents in Florida show that hurricane preparedness is affected by the pandemic. This hurricane season is dominated by concerns over COVID-19, which is predominantly an obstacle for evacuation and may negatively impact insurance purchases that may have declined according to our repeated survey results. Moreover, older people, who are more concerned about COVID-19, state lower evacuation intentions. This should be taken into account by adaptation policies aimed at improving hurricane preparedness during a pandemic with a disease for which older people are more vulnerable. The majority of previous studies on evacuation did not observe a significant influence of age (Baker 1991; Sorensen 2000; Burnside et al. 2007; Meyer et al. 2018). Findings of a negative age effect by some (Huang et al. 2016) have been attributed to the length of residence (Mors et al. 2016). Our survey results show that evacuation behavior is different when a hurricane season coincides with a pandemic, because we observe a negative effect of age on evacuation intentions that is mainly caused by concerns over COVID-19 and worry about flooding, and to a lesser extent length of residence.

Adequate risk communication could be an important component of adaptation strategies to improve individual hurricane preparedness. For instance, our analyses of hurricane preparedness activities during Hurricane Dorian showed that risk awareness was an important driver of these activities (Botzen et al. 2020). Our third survey reveals that risk communication by state

governments, insurers, and insurance regulators reached a large number of respondents.³ Given the large influence of COVID-19 on this year's evacuation intentions, it is key to refocus risk communication activities in times when the hurricane season coincides with a pandemic towards how people can safely evacuate by minimizing health risks. Examples during the COVID-19 pandemic are: including COVID-19 mitigation measures in hurricane preparedness kits, such as hand sanitizer and mouth masks, abiding by social distancing rules during an evacuation, and planning ahead to identify safe evacuation locations. Moreover, governments and agencies can send more tailored communication messages to older people to alleviate their concern over COVID-19 or improve their perceptions of flood risks. Emergency management policies should focus on creating safe evacuation shelters where COVID-19 risks are minimized, which helps build trust that people are safe in these places. Moreover, we observe that experience of living in a hurricane-prone area reduces evacuation intentions, which may be due to experience of false alarms and near misses, such as Hurricane Dorian. Communication policies should stress that each storm is different, and the possibility of a direct hit by the next one should be taken seriously.

³ Approximately 50% consulted information from these agencies to prepare for the hurricane season.

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Online Supplementary Information (OSI)

OSI 1. Sample characteristics of the third survey

The average age of respondents in survey three is 48 years, with an average household income of \$74,000 per year before taxes, and 66% are female. Respondents reported their highest level of education as follows: some high school (2%), high school graduate (17%), some college (26%), college graduate (36%), and post graduate (18%). Compared with the sample of the first survey, respondents to the third survey are 14 years younger on average, which may be explained by the data collection method since older people are perhaps less likely to participate in online surveys than phone surveys.

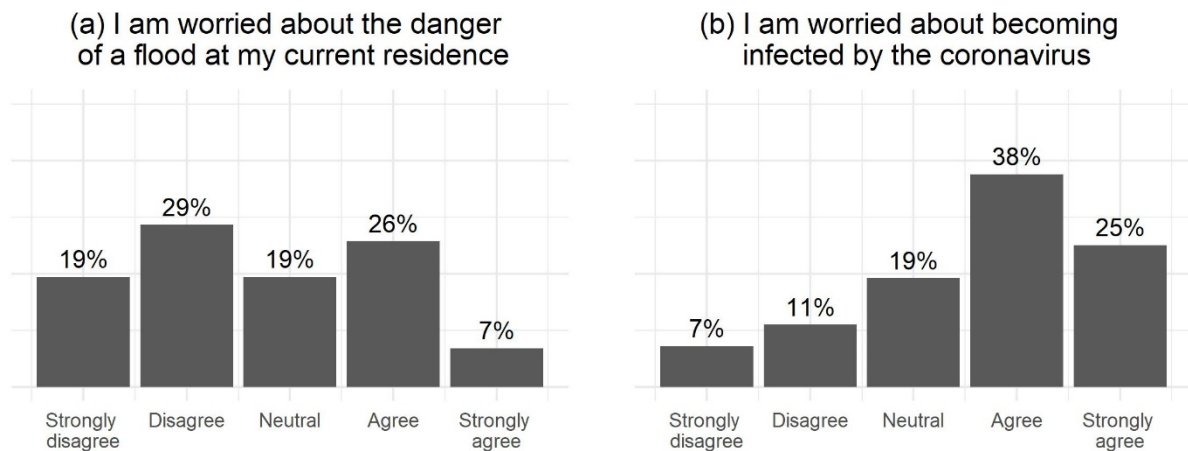
OSI 2. Wind and flood insurance purchases and the implementation of risk reduction measures

With regards to insurance purchases, 31% has flood insurance and 11% plans to buy it in the next year. Moreover, 46% has a policy that covers wind damages and 9% plans to buy wind coverage in the next year. Overall, we find that fewer individuals have wind and flood coverage than during Hurricane Dorian in 2019 when we observed that 43% have flood coverage and 75% have wind coverage. This could be an indication that people cancelled insurance coverage in 2020, possibly due to the adverse economic situation. Of those who still have flood (wind) insurance coverage, 47% (38%) changed their insurance status before the start of hurricane season. For both wind and flood insurance, most of these changes led to an increase in coverage amounts. This finding suggests that many people who kept their insurance did an insurance checkup that resulted in a higher coverage. The changes that we observed here are consistent with the insurance checkup

recommendation given by public awareness campaigns, for instance by the National Weather Service, that encourage people to insure hurricane damages and re-evaluate their coverage amounts before the start of the hurricane season.¹

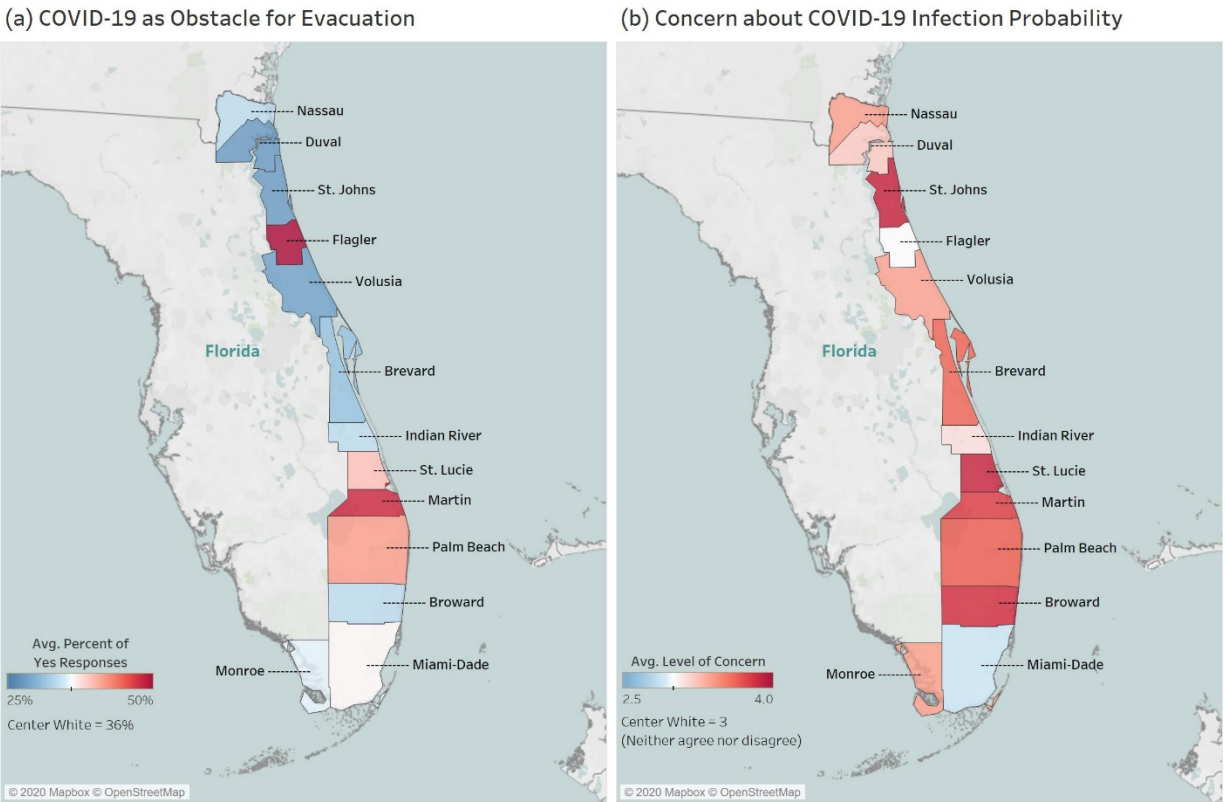
Answers to questions about the implementation of risk reduction measures show that many people (74%) have some form of window protection to limit wind damages. To minimize flood damages, the lowest proportion of people (23%) installed a pump and drainage system and the highest proportion (46%) elevated electricity installations above potential flood levels. Overall, no clear pattern can be observed in changes to the implementation of risk reduction measures between our first and third surveys, suggesting this has remained approximately stable.

OSI Figures



¹ See its website at <https://www.weather.gov/wrn/hurricane-preparedness>.

OSI Fig. 1. Responses to statements about worry of flooding (panel a) and COVID-19 (panel b).



OSI Fig. 2. Geographic maps of (a) COVID-19 as an obstacle for evacuation [1 = yes or 0 = no, center white = 36%] and (b) concern about the COVID-19 infection probability [1 = strongly agree to 5 = strongly disagree, center white = 3]

Note: Panel (a) maps whether COVID-19 is an obstacle for evacuation, with 1 = yes or 0 = no; the midpoint in white is the sample average percent of yes responses (36%). Panel (b) maps the level of people who disagree with the statement that they are not concerned about COVID-19 infection, with 1 = strongly agree to 5 = strongly disagree (larger numbers indicate higher concern); the white point is 3, which indicates a response to the neutral option neither agree nor disagree.

OSI Tables

OSI Table 1. Coding of variables used in our regression models

Variable	Coding
Worry about flooding	<i>"I am worried about the danger of a flood at my current residence."</i> 1 = strongly disagree; 5 = strongly agree
Perceived flood probability	<i>"What is your best estimate of how often a flood will occur at your home?"</i> categorical, 1 = less often than 1/1,000 years; 7 = more often than 1/10 years
Concern about flooding	<i>"The probability of flooding is so low that I am not concerned about the consequences of a flood."</i> 1 = strongly agree; 5 = strongly disagree (higher numbers indicate more concern)
Age	in years
Education	<i>"What is your highest completed level of education?"</i> 1 = some high school to 5 = post graduate
Income	<i>"Which of the following describes your total household income for 2018 before taxes?"</i> 1 = less than \$10,000 to 6 = \$125,000 or more
Home value	<i>"What is approximately the current market value of your home?"</i> 1 = less than \$100,000 to 8 = \$800,000 or more
Home owner	<i>"Do you rent or own your home?"</i> 1 = home owner, 0 = rent (or missing)
Length of residence	<i>"How long have you lived in your home (in years)?"</i>
Gender	<i>Was the respondent male or female?</i> female = 1, male = 0
Voluntary evacuation intention	<i>"Do you think you will evacuate to a safer place in the future if a voluntary evacuation were to be ordered for your county?"</i> 1 = not at all likely to 4 = extremely likely
Perceived coronavirus infection probability	<i>"How likely do you think it is that you will personally be infected by the coronavirus?"</i> 1 = very unlikely; 5 = very likely
Concern about the COVID-19 infection probability	<i>"The probability of being infected by the coronavirus is so low that I am not concerned about its consequences"</i> 1 = strongly agree; 5 = strongly disagree (higher numbers indicate more concern), missing = not sure
Expect to get ill from COVID-19	<i>"Suppose you became infected by the coronavirus. How ill do you expect to get from the virus?"</i> 1 = not ill at all to 5 = extremely ill, missing = not sure
Worry about COVID-19	<i>"I am worried about becoming infected by the coronavirus."</i> 1 = strongly disagree; 5 = strongly agree
Trust government response COVID-19	<i>"How much do you trust the ability of the government in terms of how it is dealing with the coronavirus pandemic?"</i> 0 = no trust at all to 10 = trust completely

OSI Table 2. How likely is it that you will evacuate to a safer place this hurricane season

if an evacuation order were to be ordered for your county?

	Voluntary order	Mandatory order
Not at all likely	37%	16%
Somewhat likely	25%	23%
Likely	24%	28%
Extremely likely	15%	34%

OSI Table 3. Binary probit model results of variables of influence on answering COVID-19 as an evacuation obstacle. A probit model is used to account for the binary nature of the dependent variable (1 = reported COVID-19 as obstacle for evacuation, 0 = otherwise).

	<i>Marginal effects</i>
Socio-demographics	
Age	0.001 (0.002)
Gender (1 = female)	-0.003 (0.055)
Education	0.031 (0.030)
Income	-0.051** (0.025)
Length of residence	-0.003 (0.003)
Home value	0.037** (0.017)
Flood risk perceptions	
Worry about flooding	0.045* (0.026)
Concern about flooding	-0.036 (0.024)
COVID-19 perceptions	
Trust government response COVID-19	0.002 (0.009)
Concern about COVID-19	0.087*** (0.024)
Worry about COVID-19	0.086*** (0.028)
Expect to get ill from COVID-19	0.004 (0.024)
Observations	398
Log likelihood	-241.639
Pseudo R ²	0.087

Notes: ***p < 0.01; **p < 0.05; *p < 0.1. Standard errors are shown in between parentheses below the marginal effects.

OSI Table 4. Ordered probit model of variables of influence on voluntary evacuation intentions. An ordered probit model is used to account for the ordinal nature of the dependent variable (1= not at all likely to 4 = extremely likely to evacuate).

	<i>Coefficients model 1</i>	<i>Coefficients model 2</i>
Socio-demographics		
Age	-0.010*** (0.003)	-0.003 (0.004)
Gender (1 = female)	-0.247** (0.102)	-0.196 (0.123)
Education	0.093* (0.053)	0.118* (0.068)
Income	-0.008 (0.038)	-0.004 (0.048)
Length of residence		-0.016** (0.007)
Flood risk perceptions		
Perceived flood probability		0.008 (0.039)
Worry about flooding		0.259*** (0.062)
COVID-19 perceptions		
Perceived coronavirus infection probability		0.092* (0.050)
Concern about COVID-19		-0.143*** (0.047)
Observations	519	362
Log likelihood	-682.4	-443.6
Pseudo R ²	0.017	0.081

Notes: ***p < 0.01; **p < 0.05; *p < 0.1. Standard errors are shown in between parentheses below the coefficients.