



Household hurricane evacuation during a dual-threat event: Hurricane Laura and COVID-19

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ABSTRACT

This study explores household-level evacuation decision-making in response to Hurricane Laura, in a context where hurricane risk reduction measures contradicted COVID-19 risk reduction measures. Data were collected using a mail-based survey approach from households along the coast of Texas and Louisiana to explore drivers of and barriers to evacuation, including COVID-19 measures such as negative affect, risk perceptions, protective actions, and exposure. Testing for direct and indirect effects among the drivers of and barriers to evacuation, we find that many of our COVID-19 measures did not have a direct effect on evacuation but did have indirect effects through other factors. We also found evidence of both direct and indirect relationships with regards to more conventional drivers of evacuation found in the literature. We close with a discussion of the limitations and implications of this study.

1. Introduction

The 2020 hurricane season presented several challenges for evacuation planning and decision-making among key stakeholders and households. Hurricane activity was above normal in the Atlantic, with 12 hurricanes striking the U.S. coastline in 2020, surpassing the previous record of nine set in 1916 (NOAA, 2020). Of these storms, four made landfall in Louisiana, including Hurricane Laura, which made landfall in Cameron, Louisiana, at around 1:00AM CT near the Louisiana-Texas border on August 27th as a Category 4 storm. While the hurricane was relatively well forecasted, the storm underwent rapid intensification the day before making landfall, likely complicating evacuation decisions for affected households (Mooney and Freedman, 2020; NOAA, 2020). Officials warned of “catastrophic, unsurvivable” storm surge associated with this storm in the day leading up to its landfall, and many counties and parishes that had issued voluntary evacuation orders changed to mandatory orders (NOAA, 2020). In the U.S., Hurricane Laura was responsible for 7 direct deaths and \$19 billion in losses (Pasch et al., 2021). In Lake Charles, one of the hardest hit cities by Laura, the storm produced 17ft storm surge and wind gusts up to 133 mph, devastating infrastructure and knocking out lifelines for some areas for weeks after the storm (Kasakove, 2021; Pasch et al., 2021).

At the same time, the novel coronavirus SARS-CoV2 (COVID-19) was challenging communities across the US and the world. By August 27, 2020, cases of COVID-19 had reached a daily average of 42,270 and the cases were highest in the South (Coronavirus in the

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U.S.: Latest Map and Case Count [WWW Document], 2020). After a period of widespread closures of non-essential businesses to slow the spread of COVID-19 infection initiated in March of 2020, by summer, states were in various stages of reopening (AJMC Staff, 2020). Phased reopening of businesses began in mid-May 2020 in Louisiana and in mid-April in Texas (Svitek, 2020; The Texas Newsroom, 2021). In June, the US reached 2 million COVID-19 cases and the White House COVID-19 Task Force held a Press Conference about rising cases in the U.S. South (AJMC Staff, 2020). By July 2020, science about how COVID-19 is transmitted had shown airborne transmission which led to mask mandates in Louisiana and Texas (Office of the Governor of Louisiana, 2020; The Texas Newsroom, 2021). By the time Laura made landfall in late August, states were managing evolving COVID-19 policies including phased reopening of businesses and mask mandates in addition to hurricane season disaster management.

There is a rich literature exploring how households decide whether and how to evacuate in response to a hurricane threat (Borowska-Stefańska et al., 2022; Dash and Gladwin, 2007; Dow and Cutter, 2000, 1998; Lindell et al., 2011; Wong et al., 2020; Wu et al., 2012; Yabe and Ukkusuri, 2020). Limited work has explored evacuation in the context of a dual threat event (Borowski et al., 2021; Botzen et al., 2022; Collins et al., 2022; Pei et al., 2020). This is critical to explore because the general guidance for hurricanes is to evacuate and shelter with others, which is antithetical to COVID-19 guidance (social distancing to the degree possible). Here, building on the Protective Action Decision Model (PADM) and a multi-stage model of evacuation proposed by Huang et al. (2017), we explore evacuation decision-making among households threatened by Hurricane Laura and COVID-19.

Using a mail-based survey approach, we collected data from households along the coast of Texas and Louisiana to explore drivers of and barriers to evacuation. To expand beyond existing evacuation literature, we also consider COVID-19 measures including negative affect, risk perceptions, protective actions, and exposure. We additionally tested for direct and indirect effects among the drivers of and barriers to evacuation considered. We find that many of our COVID-19 measures did not have a direct effect on evacuation but did have indirect effects on evacuation through other factors. In relation to more conventional drivers of evacuation found in the literature, we found evidence of both direct and indirect relationships with evacuation decisions. We close with a discussion of the limitations and implications of this study.

2. Hurricane evacuation literature

The PADM has long been used to study evacuation behaviors (Ahsan et al., 2016; Collins et al., 2021; Huang et al., 2017, 2012; Jon et al., 2018; Strahan et al., 2018; Strahan and Watson, 2019; Wu et al., 2012; Wu, 2020). This model provides a diagram that illustrates how factors of evacuation decisions influence one another (Lindell, 2018; Lindell and Perry, 2012, 2004). First, the model introduces several stimuli factors (social/environmental cues and warning messages) that trigger a decision maker's risk assessment stage. These stimuli factors can also be affected by one's social and environmental contexts. In the risk assessment stage, the pre-decisional process dictates the relevant risk information that a decision maker could use to assess the risk. Next, this relevant risk information will help a decision maker to assess the situation and develop their threat perception, stakeholder perception, and the perceived efficacy of protective actions. These perceptions then affect the decision maker's information search strategy and decisions on behavioral responses. The PADM also details how other personal characteristics, such as past experience, social and political factors, and demographic attributes could affect the risk assessment stage and how situational facilitators and impediments could also affect behavioral responses.

Building on the PADM, Huang et al. (2017) analyzed household survey data collected after Hurricane Katrina and Rita. Their study proposed a multistage model of hurricane evacuation decisions based on the PADM. Huang's model suggests external hazard information factors, environmental context, hazard experience, and evacuation impediments affect peoples' evacuation decisions through two mediators. These mediators are the two types of cognitive risk perceptions, including perceived storm characteristics and expected personal impacts. On the other hand, other demographic factors such as age, education, and income are poor predictors of evacuation behavior (Baker, 1991; Huang et al., 2017, 2016, 2012). The following sections review the existing literature that describes the relationships among these factors. Research hypotheses and questions are introduced based on the previous studies.

2.1. External hazard information factors

Unlike other types of hazards, such as earthquakes, flash floods, or tornadoes, hurricane forecast technology provides the public and emergency managers an extended forewarning period to make protective action decisions. During this forewarning period, two types of external hazard information generally have a substantial impact on people's hurricane evacuation decisions, according to PADM (Lindell, 2018). The first type of external hazard information is environmental and social cues that people receive by observing their surroundings. In the event of a hurricane, environmental cues refer to seeing storm conditions such as high wind, rain, or flooding, whereas social cues include seeing local businesses closing or people evacuating (Dow and Cutter, 1998; Horney et al., 2010; Huang et al., 2017, 2012; Lindell et al., 2005; Stein et al., 2010). In an early study, researchers found seeing friends or family member's evacuation actions was essential to convincing some study participants to evacuate during Hurricanes Bertha and Fran (Dow and Cutter, 1998). Other studies pointed out that environmental and social cues such as storm conditions, businesses closing, and peers evacuating were positively correlated with evacuation decisions during Hurricanes Lili, Katrina, Rita, and Ike (Huang et al., 2017, 2012; Lindell et al., 2005).

Another type of hazard information that could lead to evacuation is official warnings. Dow and Cutter (1998) found around a quarter of participants in their study reported official evacuation orders/advice were the most important reason for hurricane evacuation. Similar findings were also found in Hurricane Floyd evacuation studies (Dow and Cutter, 2000; Fu and Wilmot, 2004). During Hurricanes Rita, Katrina, and Ike, researchers also found that people tended to evacuate on the date the official evacuation warning

was issued (Wu et al., 2020).

Hypothesis 1. *Those scoring higher on official warning and cues are more likely to evacuate than those scoring lower on the measure.*

2.2. Environmental context, hurricane experience, and evacuation impediments

As noted earlier, environmental context is a critical factor that affects people's protective action decisions. During a hurricane event, whether people are in the mandatory evacuation zone or risk area is an essential factor that affects their evacuation decisions (Fu and Wilmot, 2004; Huang et al., 2012; Peacock et al., 1997; Zhang et al., 2004). While some studies have shown that people might not be able to locate themselves in the risk area (Horney et al., 2010), Dow and Cutter (2000) found that 64 percent of their respondents who lived in the evacuation zone during Hurricane Floyd complied with the evacuation order. Similarly, Stein et al. (2010) found that more than half of their survey respondents within the mandatory evacuation zone evacuated during Hurricane Rita.

The relationship between hurricane experience and evacuation decisions is not conclusive in the literature (Baker, 1991; Huang et al., 2016; Lazo et al., 2015). To illustrate, Huang, Lindell, and Prater's (2016) meta-analysis of Hurricane studies published 1991–2016 showed that two-thirds of studies reviewed found a nonsignificant relationship between experience and evacuation. As Demuth et al. (2016) notes, one reason for these mixed results is likely due to the way varied hurricane experience tends to be measured. For example, survey questions that only ask people to report whether they have experienced a hurricane (e.g., "Have you experienced a hurricane?") are generally poor predictors of hurricane evacuation decisions (Goodie et al., 2019; Peacock et al., 2005). This is because some people would report their "false" hurricane experience, thinking they have gone through a major hurricane but lack the experience that generally affects decision-making (Morrow and Gladwin, 2005). In general, people with hurricane experiences such as experiencing an evacuation, home damage, family injury, or personal life disruption are more likely to evacuate (Hasan et al., 2012; Horney et al., 2010; Huang et al., 2012; Lindell et al., 2005; Sharma and Patt, 2012). Finally, evacuation impediments are introduced as assessment variables in Lindell and Perry (2012). They are generally measured by asking about concerns regarding looting, home protection, evacuation expenses, and, in the context of COVID-19, protecting your family from COVID-19 infection. Studies suggest impediment factors could have a negative impact on evacuation decisions (Huang et al., 2017, 2012; Siebeneck et al., 2013).

Hypothesis 2. *Those in a mandatory evacuation zone are more likely to evacuate than those in a voluntary evacuation zone.*

Hypothesis 3. *Those scoring higher on hurricane experience are more likely to evacuate than those scoring lower on the measure.*

Hypothesis 4. *Those scoring higher on evacuation impediments are less likely to evacuate than those scoring lower on the measure.*

2.3. COVID-19 and hurricane evacuation

As mentioned earlier, the context for the 2020 hurricane season was unique. The COVID-19 pandemic started roughly in the spring of 2020 in the U.S. (Centers for Disease Control and Prevention, 2022). During Hurricane Laura, COVID-19 vaccinations were not yet available in the U.S., while infection rates were considered high for most of the country (Centers for Disease Control and Prevention, 2022). While limited, recent COVID-19 and hurricane evacuation studies have introduced variables such as COVID-19 protective actions (the level of engaging in activities such as masking, social distancing, or hand washing), COVID-19 exposure levels (encounters with individuals testing positive for COVID-19), COVID-19 risk perceptions (the likelihood of getting infected), and COVID-19 negative affect (feeling threatened, afraid, or stressed) into their study (Borowski et al., 2021; Botzen et al., 2022; Collins et al., 2022, 2021). These studies found that COVID-19 risk perception could influence people's hurricane evacuation decisions (Borowski et al., 2021; Botzen et al., 2022; Collins et al., 2022; Pei et al., 2020). For example, studies that focus on predominately Hispanic and senior neighborhoods in Florida found that COVID-19 protective action measures and COVID-19 exposure could affect people's hurricane evacuation decisions during the 2022 hurricane season (Collins et al., 2022, 2021). In addition, COVID-19 risk perceptions reduced coastal area residents' hurricane evacuation intentions in Florida (Botzen et al., 2022). While Borowski et al. (2021) did not specifically measure COVID-19 negative emotions, their study shows people feeling negative emotions regarding the evacuation are less likely to share a ride during a flood evacuation. Since COVID-19 related negative affect and risk perceptions are both perceived threat variables (affective risk perception and cognitive risk perception), a factor that captures both concepts should have an impact on evacuation decisions.

Hypothesis 5. *Those scoring higher on COVID-19 negative affect and risk perception are more likely to evacuate than those scoring lower on the measure.*

Hypothesis 6. *Those scoring higher on COVID-19 protective actions are more likely to evacuate than those scoring lower on the measure.*

Hypothesis 7. *Those who were recently exposed to COVID-19 are less likely to evacuate than those not recently exposed.*

2.4. Cognitive risk perceptions

In the context of hurricane hazards, cognitive risk perceptions include people's perceived storm characteristics and expected personal impacts. Hurricane storm characteristics are usually measured by asking people's perceptions regarding storm intensity and its threats to their families (Huang et al., 2012). Perceived personal impacts are measured by asking people to report their expectations

of storms damaging their property, injuring their family members, and disrupting their lives (Wu et al., 2012). Studies have found that people with stronger perceived storm characteristics and expected personal impacts are more likely to evacuate during Hurricanes Lili, Katrina, Rita, and Ike (Huang et al., 2012; Wu et al., 2020).

Hypothesis 8. *Those scoring higher on Perceived Storm Characteristics are more likely to evacuate than those scoring lower on the measure.*

Hypothesis 9. *Those scoring higher on Expected Personal Impacts are more likely to evacuate than those scoring lower on the measure.*

2.5. Mediation effects among factors affecting evacuation decisions

Previous studies have shown that hurricane risk perceptions are correlated with hazard information, location, hurricane experiences, evacuation impediments, and evacuation decisions (Aguirre, 1991, 2000; Baker, 2000; Huang et al., 2012; Lindell et al., 2005; Santella et al., 2011; Siebeneck et al., 2013; Zhang et al., 2004). Both PADM and the multistage model of hurricane evacuation suggest hurricane risk perceptions could also be mediators in evacuation decision models (Huang et al., 2017; Lindell, 2018), which is supported by research on other hazards such as earthquake adjustments (Arlakatti, Lindell, & Prater, 2007). However, limited research has been conducted to empirically examine the indirect effects in the PADM as it relates to hurricane evacuation. To illustrate, some hurricane studies do not perform mediation analysis to test these potential relationships (Huang et al., 2017), while others do not use procedures that formally test the significance of an indirect affect (see causal steps approach versus bootstrapping in Hayes, 2018a,b). Most hurricane evacuation studies, however, focus on one sequence of the model or solely test for direct effects, such as the relationship between risk perception and evacuation behaviors (second half of the model) (Peacock et al., 2005), or past experience and evacuation behaviors (Lazo et al., 2015; Lindell et al., 2005; Wu et al., 2020), and note whether the effect is significant and its direction.

Some evacuation factors, however, may also or instead indirectly effect hurricane evacuation behaviors. For example, Demuth et al. (2016) show that most dimensions of hurricane experience produce indirect effects (rather than direct effects), exerting influence on hurricane evacuation behaviors through intervening mechanisms such as cognitive and affective risk perception, and efficacy perceptions. Another study by Huang et al. (2012) suggests that hurricane experience and official warnings increases perceptions of expected personal impacts, which enhances evacuation behaviors. Research suggests official warnings have both direct effects and indirect effects on evacuation decisions (Baker, 1991; Gladwin et al., 2001; Huang et al., 2012). Demuth et al. (2016) note how ambiguities related to prior mixed findings (e.g., lack of consistency in significant direct effects of experience and hurricane evacuation) may be addressed by conducting mediation analysis, although much remains to be explored. Overall, it is important to understand how evacuation factors influence the decision to evacuate, in addition to whether they do.

To better assess and explain these intervening mechanisms, we use logic from the PADM which theorizes when people become aware of a risk, they draw upon information (prior experiences and other antecedent variables) to begin their risk assessment process, where they evaluate their chance of being affected by the hazard (mediator 1, perceived storm characteristic) and how harmful it will be (mediator 2, expected personal impacts). Studies also show that perceived storm characteristics have a positive influence on expected personal impacts (Huang et al., 2017, 2012). Therefore, a serial mediation relationship may be present. That is, factors such as hazard information and location are likely to positively influence perceived storm characteristics, which then should influence expected personal impacts and, in turn, people's evacuation decisions. Other variables such as hazard experience and/or impediments are likely to indirectly influence people's evacuation decisions through just one mediator, expected personal impacts. Since we seek to empirically identify the mediating paths for each of the evacuation predictors, the following research question is proposed.

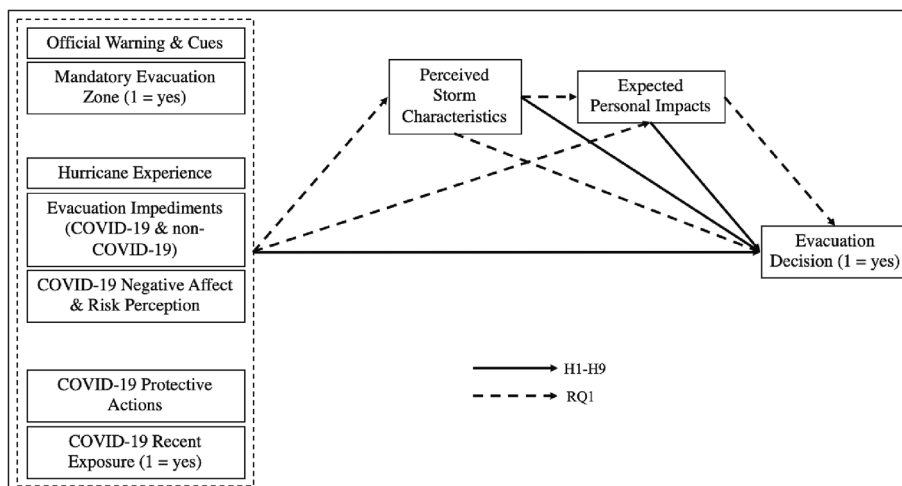


Fig. 1. Conceptual Model demonstrating the total (c), direct (c'), and indirect (a_1b_1) paths tested by which the Evacuation Factors influence the likelihood to evacuate.

Research Question 1: Does perceive storm characteristics and expected personal impacts mediate the relationships between hurricane/COVID-19 risk factors and evacuation decisions?

To sum up, hurricane risk factors include hazard information, location, hurricane experiences, and evacuation impediments. COVID-19 risk factors include COVID-19 negative affect/risk perception, protective action, and exposure. These factors could have various effects on the likelihood to evacuate, including one, some, or all of the following: 1) total effects (effect in regression model not including potential mediators as covariates), 2) direct effects (effect including potential mediators as covariates), 3) indirect effects via one intermediary variable (simple mediation path via perceived storm characteristic and/or expected personal impact), and/or 4) indirect effects via the two intermediary variables in serial (serial mediation path). Previous studies have identified the direct relationship between these factors and evacuation decisions. This study will explore the basic and serial mediation pathways among these variables (Fig. 1). The following sections describe the data collection, coding, and analytical methods used to test the research hypotheses and answer research questions.

3. Methodology

3.1. Data collection

Data for this study was collected via surveys mailed to households subject to either voluntary or mandatory evacuation for Hurricane Laura in Galveston and Jefferson counties in Texas and Calcasieu and Vermillion parishes in Louisiana. 2400 household addresses were identified using a disproportionate stratified sampling procedure via a randomly selected mailing list obtained from the *Marketing Systems Group*. Each household was sent as many as three survey packages and one reminder postcard (Dillman et al., 2014). Surveys were mailed in January, February, and March 2021 by the *University of North Texas Printing & Distribution Solution*. Of the 2400 households sampled, 629 surveys were undeliverable, 35 households refused, and a total of 304 households responded to the survey for a final response rate of 7.35%.

The summary statistics for respondents are included in Table 1. Generally, respondents' mean age is significantly older than the U. S. Census Bureau data for the four areas surveyed (United State Census Bureau, 2022). Likewise, income level and homeownership differ slightly from the US Census Bureau's 2020 data. Respondents' gender, race, and education groups are similar to the study area statistics (Wu et al., 2022).

3.2. Measures

Constructs included in the questionnaire are mostly based on established measures from previous studies and existing reports (Conway et al., 2020; Huang et al., 2012; National Institute of Environmental Health Science, 2018; Wu et al., 2012). Some measures (e.g., impediments) were modified or expanded upon using original items to ensure content validity. Most constructs are measured using 5-point Likert scales that compute the mean for analysis unless otherwise specified.

3.2.1. Official warning and cues

Receiving an official warning was measured with two items ($r_{xx'} = 0.82$, $r = 0.69$). Using a 1–5 (Not at all likely to Very great extent) Likert scale, respondents were asked, "To what extent do you consider the following issues in deciding whether or not to evacuate...? 1) Hearing local authorities issue official recommendations to evacuate" and, 2) Hearing an announcement of a hurricane 'watch' or 'warning.'" Environmental and social cues ($\alpha = 0.84$) were measured using three items following the same transition statement, including "1) Seeing storm conditions such as high wind, rain, or flooding, 2) Seeing area businesses closing, and 3) Seeing friends, relatives, neighbors, or coworkers evacuating". Based on results from factor analysis, reliability analysis, and efforts to reduce multicollinearity, the measures for receiving an official warning were combined with environmental and social cues to form a single

Table 1
Demographics Variable Difference (2020 Census vs. Household Survey).

State	Louisiana				Texas			
	Vermillion		Calcasieu		Jefferson		Galveston	
Data Type	Census	Survey	Census	Survey	Census	Survey	Census	Survey
Persons between 18 and 65*	76.87%	52.90%	77.65%	54.90%	78.41%	51.4%	78.62%	52.90%
Persons 65 years and over*	23.13%	47.10%	22.35%	45.10%	21.59%	48.6%	21.38%	47.10%
Female persons	51.70%	62.70%	51.10%	51.90%	48.90%	65.7%	50.90%	62.70%
White alone	81.50%	83.00%	70.10%	88.0%	59.10%	79.40%	80.30%	83.70%
Median household income**	\$52,219	25 K-49 K	\$52,866	50 K-79 K	\$50,840	50 K-79 K	\$74,633	25 K-49 K
Bachelor's degree or higher	16.20%	35.50%	21.90%	40.40%	19.30%	50.00%	32.10%	35.50%
Homeownership	74.40%	87.40%	68.50%	94.30%	61.50%	91.40%	67.50%	78.20%

Note: Reprinted from (Wu et al. 2022).

*18 years old and younger were excluded from the Census percentage calculation since the household survey can only collect data from 18 years and older respondents.

**Household income data were collected using a categorical variable in the survey.

combined measure, *Official Warning and Cues* ($\alpha = 0.86$).

3.2.2. Prior hurricane experience

Prior Hurricane Experience is measured using a four-item summative scale (checklist, 1 point each, 4 points maximum). The scale captures experience with hurricane evacuation, home damage, work disruption, and injury to oneself or family. Specifically, respondents were asked, "Prior to Hurricane Laura, have you ever... 1) Evacuated from a hurricane, 2) Experienced a hurricane that caused damage to your home, 3) Experienced a hurricane that caused a disruption that prevented you from going to school or workplace, and 4) Experienced a hurricane that caused injury to you or members of your immediate family".

3.2.3. Evacuation impediments

Evacuation Impediments is measured with four items that capture both COVID-19-related and non-COVID-19-related measures ($\alpha = 0.75$ with COVID-19 item, $\alpha = 0.77$ without). The scale also uses a 1–5 (Not at all likely to Very great extent) Likert scale and asks respondents the extent to which they considered the following factors in deciding whether or not to evacuate: "1) Concern about protecting your home from looters, 2) Concern about protecting your home from storm impacts, 3) Concern about evacuation expenses such as gas, food, and lodging, and 4) Concern about protecting your family from COVID-19 infection".

3.2.4. Mandatory evacuation zone

Living in a *Mandatory Evacuation Zone* was captured using a dummy variable (0 = no, voluntary; 1 = yes, mandatory) based on respondents' location during the time Hurricane Laura evacuation orders were issued. For each respondent, location data was validated with subjective data (asked respondents directly). 58% of the sample were in the mandatory evacuation zone, while 42% were in the voluntary zone.

3.2.5. COVID-19 negative affect and risk perception

COVID-19 Negative Affect (NA) and *Risk Perception* was captured using seven items ($\alpha = 0.90$) measured by a 1–5 Likert scale. The four risk perception items read, "During the hurricane response, how likely did you think it was that... 1) You would get infected with COVID-19 during the evacuation, 2) You would get infected with COVID-19 while staying at evacuation destination, 3) You would get infected with COVID-19 during your return home, and 4) You would have serious health effects from getting COVID-19, if infected". The three Negative Affect items read, "Please indicate how true the following statements are... 1) Thinking about the coronavirus (COVID-19) makes me feel threatened, 2) I am afraid of the coronavirus (COVID-19), and 3) I am stressed around other people because I worry I'll catch COVID-19".

3.2.6. COVID-19 protective actions

COVID-19 Protective Actions (PA) captures the number of protective behaviors respondents engaged in to lower their chance of getting infected with COVID-19 during Hurricane Laura. It is a summative scale based on the following five items (checklist, 1 point each for a maximum of 5 points): "1) Increased hand washing for at least 20 seconds with soap and water, 2) Increased hand sanitizer use, 3) Wear a face covering (such as a mask) when you were not able to maintain at least 6 feet between you and persons not part of your immediate family, 4) Maintained at least 6 feet between you and persons not part of your immediate family during evacuation, and 5) Brought items with you that could help protect you and others from COVID-19, such as hand sanitizer, cleaning materials, and two masks per person.

3.2.7. COVID-19 recent exposure

COVID-19 Recent Exposure is measured using a dummy variable (0 = no, 1 = yes) based on the following item: "Have you been told by a health care provider that you have or have had COVID-19 and were told to isolate or quarantine (stay at home)?"

3.2.8. Perceived storm characteristics

Perceived Storm Characteristics ($r_{xx'} = 0.66$, $r = 0.49$) is captured using two items. Using a 1–5 Likert scale, respondents were asked "As the storm was approaching, how likely did you think it was that... 1) The eye of the storm would track through your community, and 2) The storm would be a major (Category 4 or 5) hurricane when it struck".

3.2.9. Expected personal impacts

Expected Personal Impacts ($\alpha = 0.78$) is measured using five items that also use a 1–5 Likert scale. Respondents were asked, "As the storm was approaching, how likely did you think it was that... 1) Your home would be inundated by storm surge or inland flooding, 2) Your home would be severely damaged or destroyed by stormwind, 3) You and your family would be injured or killed if you stayed, 4) There would be disruption to your job (prevent you from working), and 5) There would be disruption to basic services (phone, electrical, etc.)".

3.2.10. Evacuation decision

Hurricane Laura Evacuation Decision was captured using a single binary variable (1 = yes, 0 = no) that asks whether respondents or anyone in their household evacuated from Hurricane Laura.

3.3. Analytical methods

A series of OLS regressions were performed for hypotheses with continuous variables as outcomes. Binary logistic regression analysis was performed for hypotheses 1–9 (binary outcome). To test simple and serial mediation, we use Preacher and Hayes's PROCESS macro (Hayes, 2022). PROCESS uses bootstrapping procedures to test for indirect effects (Hayes, 2018a). This method has an advantage over the causal steps approach due to its high power and reasonably controlled Type 1 error rate (Preacher and Hayes, 2008). 5,000 bootstrap resamples were used to calculate indirect effects; significance is determined by evaluating bias-corrected 95% confidence intervals (CIs) (Hayes, 2018b). The indirect effect is significant if the confidence intervals do not cross zero.

4. Results

4.1. Correlation results

We first provide the correlation results (Table 2), which do provide preliminary support for many of the hypothesized (direct) relationships. The associations show that *Official Warning and Cues* (0.41, $p < .01$; large effect size), *Mandatory Evacuation Zone* (0.50, $p < .01$), *Prior Hurricane Experience* (0.23, $p < .01$), *COVID-19 NA and Risk Perception* (0.12, $p < .05$), *COVID-19 PA* ($r = 0.26$, $p < .01$), and *Evacuation Impediments* ($r = 0.14$, $p < .05$) are positively correlated with the *Decision to Evacuate*. *Perceived Storm Characteristics* ($r = 0.21$, $p < .01$) and *Expected Personal Impacts* (0.41, $p < .01$) are also positively correlated with the *Decision to Evacuate*. Several other significant correlations are reported in Table 1. For example, all the predictors except *COVID-19 Recent Exposure* and *COVID-19 PA* have positive and significant associations with perceived storm characteristics, the first mediator. All the predictors including *COVID-19 Recent Exposure* (0.13, $p < .05$) and *COVID-19 PA* (0.25, $p < .01$) are positive and significantly associated with *Expected Personal Impacts*, the second mediator. *Perceived Storm Characteristics* is also positively associated with *Expected Personal Impacts* (0.48, $p < .01$).

Given the unexpected positive and significant correlation between Impediments and Evacuation Decision ($r = 0.14$; $p < .05$), we conducted further analysis to determine whether the bivariate association is spurious due to omitted variable bias. That is, if an omitted variable has an effect on Y (Evacuation Decision) and is correlated with X (Impediments), the analysis will mistakenly attribute the effects of the omitted variable to the X variable, hence creating omitted variable bias (Singer and Caves, 2017). The direction of the bias created by an omitted variable depends on the sign of the association between the omitted variable and the X variable, and the sign of the effect of the omitted variable on the Y variable; when both the association and effect are positive, the direction of the bias is positive (Singer, 2017). If another covariate meets this criterion, this means that Impediments, which should have been negatively associated with Evacuation Decision, will instead produce a positive effect on Evacuation Decision. As such, we next attempt to identify this potential omitted variable and any others that might create spurious results.

We created Table 1 and made note of all X variables producing both strong (positive) correlations with Impediments, and strong (positive) effects on Evacuation Decision (excluding our mediators, Expected Impacts and Storm Characteristics). A few variables became of particular interest. First, *Official Warning & Cues* is positively associated with Evacuation Decision ($r = 0.41$, $p < .01$) and Impediments ($r = 0.49$, $p < .01$), each with medium-large effect sizes. Partial correlation analysis showed that controlling for Official Warning & Cues, Impediments instead produces an expected negative, nonsignificant association with Evacuation Decision ($r = -.09$; $p = .14$).

Table 1 shows that *COVID-19 Protective Actions* is also positively associated with both Evacuation Decision ($r = 0.26$; $p < .01$) and Impediments ($r = 0.30$; $p < .01$), and that *COVID-19 NA & Risk Perception* is positively associated with Evacuation Decision ($r = 0.12$; $p < .05$) and Impediments ($r = 0.42$; $p < .01$). Testing for bias, partial correlation analysis showed that when controlling for either the former (COVID-19 Protective Actions, $r = 0.11$; $p = .06$) or the latter (COVID-19 NA & Risk Perception, $r = 0.09$; $p = .12$), the associations between Impediments and Evacuation Decision become nonsignificant and the signs remain positive. Controlling for all three

Table 2
Descriptive Statistics, Reliability, and Variable Intercorrelations.

Variable	M	SD	α	1	2	3	4	5	6	7	8	9	10
1. Evacuation Decision (1 = Yes)	0.54	0.50	–	–									
2. Perceived Storm Characteristics	3.39	1.04	0.66	0.21**	–								
3. Expected Personal Impacts	2.71	0.91	0.78	0.41**	0.48**	–							
4. Official Warning and Cues	3.37	1.08	0.86	0.41**	0.42**	0.51**	–						
5. Mandatory Evacuation Zone (1 = Yes)	0.58	0.49	–	0.50**	0.28**	0.39**	0.32**	–					
6. Hurricane Experience	2.52	0.83	–	0.23**	0.13*	0.26**	0.11	0.15*	–				
7. COVID-19 NA & Risk Perc.	2.49	1.14	0.90	0.12*	0.15*	0.33**	0.33**	-0.04	0.14*	–			
8. COVID-19 Protective Actions	3.37	1.85	–	0.26**	0.08	0.25**	0.36**	0.12*	0.15*	0.36**	–		
9. COVID-19 Recent Exposure (1 = Yes)	0.11	0.32	–	0.03	0.08	0.13*	0.13*	0.07	0.04	0.01	0.03	–	
10. Impediments (COVID-19 & non-COVID-19)	2.81	1.12	0.75	0.14*	0.28**	0.49**	0.49**	0.08	0.11	0.42**	0.30**	0.02	–

N = 272; $p < .01$ **, $p < .05$ * level; Coefficients for continuous / binary are point-biserial; coefficients for continuous / continuous are Pearson product moment; coefficients for binary / binary are Spearman. Perceived Storm Characteristics is a 2-item scale, where $r_{xx'} = 0.66$ (not alpha) and $r = 0.49$. $r_{xx'}$ = Spearman-Brown Coefficient and r = Correlation Coefficient for two-item scales.

simultaneously in higher-order partial correlation (Official Warning & Cues, both COVID-19 NA & Risk Perception and Protective Actions), however, the association between Impediments and Evacuation Decision produces the expected negative sign and is nonsignificant ($r = -0.08$; $p = .22$), suggesting Official Warning & Cues is the omitted variable driving the change in sign, rather than the COVID-19 variables. These results reflect the following logistic regression results and suggest that excluding Official Warning & Cues from the bivariate correlation analysis biased the association between Impediments and Evacuation Decision, incorrectly attributing the positive effects of Impediments on Evacuation Decision to the former that should instead be attributed to the omitted variable. In all other analyses, Impediments is negatively associated with Evacuation Decision, and is borderline significant in the direct effects regression results shown later ($\beta = 0.39$; $p = .054$).

We tested all other variables to ensure they were not being affected by omitted variable bias and found only one more discrepancy. Specifically, partial correlation analysis showed the association for COVID-19 NA & Risk Perception and Evacuation Decision is no longer significant when *also* controlling for Official Warning & Cues ($r = -0.04$; $p = .52$), a result that holds even if COVID-19 Protective Actions and Impediments (potential omitted variables) are included as second and third controls (strong bivariate correlates as seen in Table 1) in higher-order partial correlation analysis. This finding provides additional support for Official Warning & Cues driving bias and producing spurious associations if not accounted for, both for Impediments and Evacuation Decision and COVID-19 NA & Risk Perception and Evacuation Decision.

No other variables were significantly influenced by whether, or which variables were included as controls in partial correlation analysis (i.e., all other variables influenced Evacuation Decision independent of controls). Additionally, to further investigate how intercorrelations between predictors were impacting the model, we investigated potential issues of multicollinearity using the Variation Inflation Factor (VIF) test. As Hair, Ringle, and Sarstedt (2011) note, acceptable VIF's fall in between 1 and 5. The results show that VIF's do not exceed 1.72 for our variables suggesting that multicollinearity is unlikely to be present in regression analysis.

Taken together, the only issue found was that Official Source and Cues, Mandatory Evacuation, Hurricane Experience, and COVID-19 Protective Action all produce independent effects on evacuation (sign and significant do not change depending on control variables added). Impediments and COVID-19 NA & Risk Perception, however, do not produce independent effects. Both are influenced when Official Source and Cues is *not* entered as a control (creating spurious effects), and both are nonsignificant with the correct signs when Official Source and Cues is included as a control. While not producing significant direct effects, we later show that both instead solely influence evacuation indirectly via Expected Personal Impacts. Next, we standardized the regression coefficients and formally test the hypotheses.

4.2. OLS and binary logistic regression results

Here, we report the OLS regression results for the primary IVs and continuous mediators as outcomes (a_1 and a_2 paths). As shown in Table 3 Model 1 (a_1 path), the predictors explain 22% of the variance in perceived storm characteristics (Model 1: Adj. $R^2 = 0.22$, $F(7,272) = 10.6263$, $p < .001$). *Official Warning and Cues* is a positive and significant predictor of *Perceived Storm Characteristics* ($\beta = 0.38$, S.E. = 0.07, $p < .001$), where an increase in Official Warning and Cues is associated with an increase in *Perceived Storm Characteristics*. Moreover, *Mandatory Evacuation Zone* is positive and significant ($\beta = 0.16$, S.E. = 0.06, $p < .01$), indicating those located in a mandatory evacuation zone at the time of the order showed higher levels in *Perceived Storm Characteristics* as compared to those in a voluntary zone. The coefficients for *Hurricane Experience*, *COVID-19 NA and Risk Perception*, *COVID-19 PA*, *COVID-19 Exposure*, and *Evacuation Impediments* were each nonsignificant in Model 1.

Next, in Table 3 Model 2, we display the OLS regression results with the second mediator entered as the outcome (Expected Personal Impacts), controlling for *Perceived Storm Characteristics* (a_2 path). As shown, the model explains 49% of the variance in *Expected Personal Impacts* (Model 2: Adj. $R^2 = 0.49$, $F(8,272) = 31.6523$, $p < .001$), where a number of significant predictors contribute.

Table 3
Results for OLS (Model 1 & 2) Regression with Standardized Coefficients.

Predictor Variables	OLS: Perceived Storm Characteristics Model 1	OLS: Expected Personal Impacts Model 2
Official Warning and Cues	0.38(0.07)***	0.14(0.06)*
Mandatory Evacuation Zone (1 = yes)	0.16(0.06)**	0.23(0.05)***
Hurricane Experience	0.07(0.06)	0.13(0.05)**
COVID-19 NA & Risk Perc.	0.04(0.07)	0.12(0.05)*
COVID-19 Protective Actions	-0.12(0.06)	0.01(0.05)
COVID-19 Recent Exposure (1 = yes)	0.02(0.05)	0.06(0.04)
Impediments (COVID-19 & non-COVID-19)	0.11(0.06)	0.27(0.05)***
<i>Perceived Storm Characteristics (M1)</i>	—	0.24(0.05)***
<i>Expected Personal Impacts (M2)</i>	—	—
Constant	0.02(0.06)	-0.01(0.04)
F	10.6263***	31.6523***
ModelLL	—	—
Df	7	8
R^2	0.22	0.49
Obs	272	272

Standardized regression coefficients (Models 1 & 2) are reported. Standard errors are in parentheses. *** $p < .001$, ** $p < .01$, * $p < .05$.

Specifically, *Official Warning and Cues* ($\beta = 0.14$, S.E. = 0.06, $p < .05$), *Mandatory Evacuation Zone* ($\beta = 0.23$, S.E. = 0.05, $p < .001$), *Hurricane Experience* ($\beta = 0.13$, S.E. = 0.05, $p < .01$), *COVID-19 NA and Risk Perception* ($\beta = 0.12$, S.E. = 0.05, $p < .05$), *Evacuation Impediments* ($\beta = 0.27$, S.E. = 0.05, $p < .001$), and the first mediator, *Perceived Storm Characteristics* (d_{21} path) ($\beta = 0.24$, S.E. = 0.05, $p < .001$) each have positive and significant relationships with *Expected Personal Impacts*. For *Mandatory Evacuation Zone*, those living in the mandatory evacuation zone at the time of the order showed higher levels of *Expected Personal Impacts* as compared to those in a voluntary zone. *COVID-19 PA* and *COVID-19 Recent Exposure* are not significant in Model 2 either, being the only two variables that do not significantly influence either mediator.

We next attempt to predict the likelihood of evacuating Hurricane Laura (0 = did not evacuate, 1 = did evacuate) as a function of the predictors. As shown in Table 4, we run two separate binary logistic regression models: the first model includes all the primary IV's and does not control for the mediators, (c path, total effects: Model 3), while the second model includes all predictor variables and does control for the mediators (c' path, direct effects: Model 4). Both models were statistically significant (Model 3: McFadden $R^2 = 0.29$, $\chi^2(7,272) = 109.6007$, $p < .001$) (Model 4: McFadden $R^2 = 0.31$, $\chi^2(8,272) = 117.2918$, $p < .001$), suggesting each represents a significant improvement in fit relative to a null (no predictors) model. McFadden (1979) notes that ρ^2 (McFadden R^2) values tend to be considerably lower than those from the OLS R^2 index, and that ρ^2 values of 0.2 to 0.4 indicate excellent model fit. Model 3 explained 29% and Model 4 explained 31% of the variance in the dependent variable, which several predictor variables contributed to.

As shown in Table 3 (Models 3 and 4), the path from *Official Warning and Cues* to *Evacuation Decision* is positive and significant for both the total effects ($\beta = 0.80$, S.E. = 0.20, $p < .001$) and direct effects paths ($\beta = 0.74$, S.E. = 0.22, $p < .001$), indicating that a one standard deviation increase in *Official Warning and Cue* results, on average, in over three-fourths a standard deviation increase (0.80) in the log odds of evacuating, controlling for the other predictors; thus, Hypothesis 1 received support. In support of Hypothesis 2, the effect of *Mandatory Evacuation Zone* is also positive and significant for both the total effects ($\beta = 0.96$, S.E. = 0.16, $p < .001$) and direct effects paths ($\beta = 0.87$, S.E. = 0.17, $p < .001$), demonstrating that those who were in a mandatory evacuation zone saw, on average, nearly a full standard deviation increase (0.96) in the log odds of evacuating, as compared to those in the voluntary evacuation zone. Similarly, in support of Hypothesis 3 and Hypothesis 6, positive and significant total and direct effects are seen for prior experience (total effect: $\beta = 0.42$, S.E. = 0.16, $p < .01$; direct effect: $\beta = 0.34$, S.E. = 0.17, $p < .05$) and *COVID-19 PA* (total effect: $\beta = 0.35$, S.E. = 0.18, $p < .05$; direct effect $\beta = 0.37$, S.E. = 0.18, $p < .05$), indicating that a one standard deviation increase in prior hurricane experience and using protective measures for COVID-19 results, on average in just under and over a quarter standard deviation increases in the log odds of evacuating, respectively. *COVID-19 NA and Risk Perception* (Hypothesis 5), *COVID-19 Recent Exposure* (Hypothesis 7), and *Evacuation Impediments* (Hypothesis 4) were nonsignificant in either binary logistic regression model. Including the mediators as covariates (b_1 and b_2 paths), Model 4 shows that *Expected Personal Impacts* (b_2 paths) is positive and significant ($\beta = 0.64$, S.E. = 0.22, $p < .01$), indicating that a one standard deviation increase in *Expected Personal Impacts* results, on average, in nearly three-fourths (0.64) a standard deviation increase in the log odds of evacuating; this finding is in support of Hypothesis 9. However, *Perceived Storm Characteristics* (b_1 path) is not significant, rejecting Hypothesis 8; we conducted further testing and confirmed total effects were nonsignificant as well (same as Model 4 except with *Expected Personal Impacts* excluded). As mentioned in the OLS regression results, however, *Perceived Storm Characteristics* has a positive and significant effect on with *Expected Personal Impacts* ($\beta = .24$, $p < .001$), which has a positive effect on *Evacuation Decision*, suggesting a path in serial for numerous predictors. For *Official Warning and Cues* and *Mandatory Evacuation Zone*, for example, the drop in coefficient size from the total effect model (Model 3) to the direct effect model (Model 4) indicates preliminary support for mediation, especially given the significant findings for the a_1 , a_2 , b_1 and b_2 paths. However, formal significance testing for indirect effects will help identify the pathways.

Table 4
Results for Logistic (Models 3 & 4) Regression with Standardized Coefficients.

Predictor Variables	Evacuation Decision (Total Effects) Model 3	Evacuation Decision (Direct Effects) Model 4
Official Warning and Cues	0.80(0.20)***	0.74(0.22)***
Mandatory Evacuation Zone (1 = yes)	0.96(0.16)***	0.87(0.17)***
Hurricane Experience	0.42(0.16)**	0.34(0.17)*
COVID-19 NA & Risk Perc.	0.08(0.18)	0.03(0.19)
COVID-19 Protective Actions	0.35(0.18)*	0.37(0.18)*
COVID-19 Recent Exposure (1 = yes)	-0.10(0.15)	-0.15(0.16)
Impediments (COVID-19 & non-COVID-19)	-0.21(0.19)	-0.39(0.20)
Perceived Storm Characteristics (M1)	–	-0.20(0.18)
Expected Personal Impacts (M2)	–	0.64(0.22)**
Constant	0.10(0.15)	0.12(0.16)
F	–	–
ModelLL	109.6007***	117.2918***
Df	7	9
R ²	0.29 (McFadn.)	0.31 (McFadn.)
Obs	272	272

Standardized logistic regression coefficients (Models 3 & 4) are reported.

Standard errors are in parentheses. *** $p < .001$, ** $p < .01$, * $p < .05$.

4.3. Indirect effects

Next, to empirically identify the causal mechanisms underlying the PADM evacuation factors and the decision to evacuate during Hurricane Laura, we test three mediation paths (two simple paths, one serial path) for each predictor separately - each iteration controlled for the remaining predictors. The first path (simple mediation) tests each IV $\rightarrow$ *Storm Characteristics* $\rightarrow$ *Evacuation Decision*. The second path (simple mediation) tests each IV $\rightarrow$ *Expected Personal Impacts* $\rightarrow$ *Evacuation Decision*. The third path (serial mediation) tests each IV $\rightarrow$ *Storm Characteristics* $\rightarrow$ *Expected Personal Impacts* $\rightarrow$ *Evacuation Decision*. The results are shown in Table 5.

As shown in Table 5, there are several significant indirect effects to report. Specifically, the indirect effects of *Official Warning and Cues* (IE = 0.0900, 95%CI = 0.0080, 0.2173), *Mandatory Evacuation Zone* (IE = 0.1487, 95%CI = 0.0476, 0.3111), *Hurricane Experience* (IE = 0.0799, 95%CI = 0.0183, 0.1778), *COVID-19 Negative Affect and Risk Perception* (IE = 0.0782, 95%CI = 0.0057, 0.1927), and *Evacuation Impediments* (IE = 0.1708, 95%CI = 0.0562, 0.3416) via *Expected Personal Impacts* are each positive and significant. Those with higher levels among these predictors report higher levels in *Expected Personal Impacts*, who were in turn, more likely to have made the decision to evacuate. Moreover, following the Baron and Kenny (1986) approach, *COVID-19 Negative Affect*, *Risk Perception*, and *Evacuation Impediments* did not influence the likelihood to evacuate independent of their effects on *Expected Personal Impacts* (see total effects, Table 2 Model 3), suggesting the occurrence of *full mediation*. Thus, these variables solely produced indirect effects on the decision to evacuate. *Evacuation Impediments* interestingly produced a positive indirect effect on *Evacuation Decision* via *Expected Personal Impacts*. As shown in Table 4, its expected and natural sign (total and direct effects) on *Evacuation Decision* is negative independent of the mediator. In the discussion section, we explain how this can be interpreted as suppression effects, which is evidence for valid mediation but has a different interpretation. For the other predictors, *Official Warning and Cues*, *Mandatory Evacuation*, and *Hurricane Experience* did significantly influence the decision to evacuate independent of their effects on *Expected Personal Impacts*, suggesting *partial mediation*.

We also report two significant serial mediation paths. Specifically, the indirect effect of *Official Warning and Cues* via *Perceived Storm Characteristics* and in turn, *Expected Personal Impacts* is positive and significant (IE = 0.0510, 95%CI = 0.0136, 0.1227). Also, the indirect effect of *Mandatory Evacuation Zone* via *Perceived Storm Characteristics* and in turn, *Expected Personal Impacts* is positive and significant (IE = 0.0260, 95%CI = 0.0045, 0.0648). Respondents showing higher levels in *Official Warning and Cues* and respondents located in the mandatory evacuation zone are associated with increases in *Perceived Storm Characteristics* (as compared to those in voluntary evacuation zone for the latter), which in turn leads to increased perceptions in *Expected Personal Impacts*, and consequently are more likely to have made the decision to evacuate. There were no significant indirect effects to report for the simple mediation path via *Perceived Storm Characteristics* alone, since the 95% BC CI's for these paths all contained 0. In addition, were no significant indirect effects to report for *COVID-19 PA* and *COVID-19 Recent Exposure* via any of the mediation paths, indicating these variables likely work through different paths (other variables, or even another covariate) to predict evacuation. The results above are also visualized in Figs. 2-8 below.

Table 5
Mediation Results: Bootstrapping Indirect Effects.

Indirect Effects	β	Boot SE	LL 95% CI	UL 95% CI
Official Warning & Cues $\rightarrow$ Storm Char. $\rightarrow$ Evac. Decision	-0.0662	0.0686	-0.2118	0.0599
Official Warning & Cues $\rightarrow$ Exp. Personal Impact $\rightarrow$ Evac. Decision***	0.0900	0.0535	0.0080	0.2173
Official Warning & Cues $\rightarrow$ Storm Char. $\rightarrow$ Exp. Personal Impact $\rightarrow$ Evac. Decision***	0.0510	0.0276	0.0136	0.1227
Mandatory Evacuation Zone $\rightarrow$ Storm Char. $\rightarrow$ Evac. Decision	-0.0338	0.0406	-0.1332	0.0282
Mandatory Evacuation Zone $\rightarrow$ Exp. Personal Impact $\rightarrow$ Evac. Decision***	0.1487	0.0685	0.0476	0.3111
Mandatory Evacuation Zone $\rightarrow$ Storm Char. $\rightarrow$ Exp. Personal Impact $\rightarrow$ Evac. Decision***	0.0260	0.0159	0.0045	0.0648
Hurricane Experience $\rightarrow$ Storm Char. $\rightarrow$ Evac. Decision	-0.0135	0.0210	-0.0696	0.0157
Hurricane Experience $\rightarrow$ Exp. Personal Impact $\rightarrow$ Evac. Decision***	0.0799	0.0411	0.0183	0.1778
Hurricane Experience $\rightarrow$ Storm Char. $\rightarrow$ Exp. Personal Impact $\rightarrow$ Evac. Decision	0.0104	0.0108	-0.0066	0.0375
COVID-19 Neg. Affect & Risk Perc. $\rightarrow$ Storm Char. $\rightarrow$ Evac. Decision	-0.0072	0.0185	-0.0510	0.0265
COVID-19 Neg. Affect & Risk Perc. $\rightarrow$ Exp. Personal Impact $\rightarrow$ Evac. Decision***	0.0782	0.0488	0.0057	0.1927
COVID-19 Neg. Affect & Risk Perc. $\rightarrow$ Storm Char. $\rightarrow$ Exp. Personal Impact $\rightarrow$ Evac. Decision	0.0055	0.0109	-0.0162	0.0291
COVID-19 PA $\rightarrow$ Storm Char. $\rightarrow$ Evac. Decision	0.0239	0.0303	-0.0257	0.1105
COVID-19 PA $\rightarrow$ Exp. Personal Impact $\rightarrow$ Evac. Decision	0.0069	0.0385	-0.0638	0.0919
COVID-19 PA $\rightarrow$ Storm Char. $\rightarrow$ Exp. Personal Impact $\rightarrow$ Evac. Decision	-0.0184	0.0134	-0.0515	0.0008
COVID-19 Recent Exposure $\rightarrow$ Storm Char. $\rightarrow$ Evac. Decision	-0.0047	0.0167	-0.0430	0.0295
COVID-19 Recent Exposure $\rightarrow$ Exp. Personal Impact $\rightarrow$ Evac. Decision	0.0409	0.0384	-0.0245	0.1263
COVID-19 Recent Exposure $\rightarrow$ Storm Char. $\rightarrow$ Exp. Personal Impact $\rightarrow$ Evac. Decision	0.0036	0.0097	-0.0167	0.0232
Impediments (COVID-19 & non-COVID-19) $\rightarrow$ Storm Char. $\rightarrow$ Evac. Decision	-0.0246	0.0315	-0.1016	0.0242
Impediments (COVID-19 & non-COVID-19) $\rightarrow$ Exp. Personal Impact $\rightarrow$ Evac. Decision***	0.1708	0.0722	0.0562	0.3416
Impediments (COVID-19 & non-COVID-19) $\rightarrow$ Storm Char. $\rightarrow$ Exp. Personal Impact $\rightarrow$ Evac. Decision	0.0189	0.0145	-0.0020	0.0545

Note: N = 272. Standardized coefficients are reported. Bold coefficients indicate a significant indirect effect. Indirect effects calculated with 5,000 bootstrap resamples; bias-corrected bootstrapping confidence intervals used to determine significance of indirect effect (significant when the CIs do not contain zero); LL = lower limit; CI = confidence interval; UL = upper limit. Significant estimates are in bold.

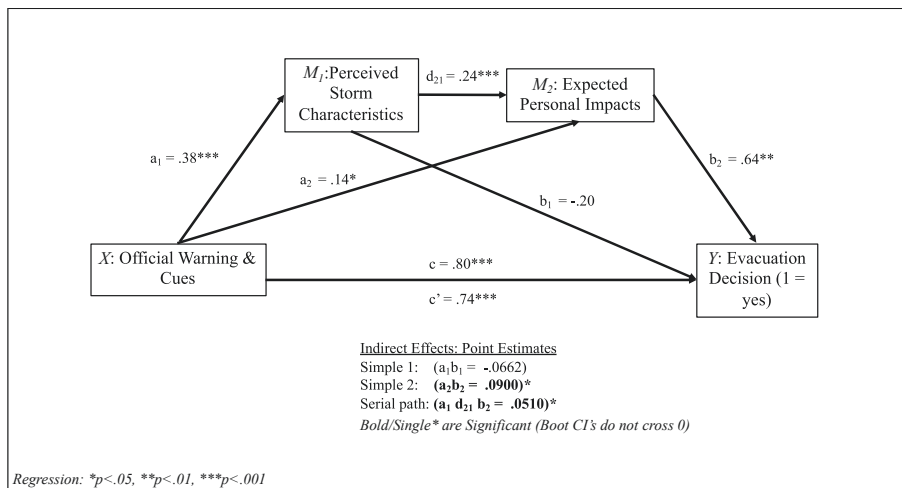


Fig. 2. Serial mediation model showing the total (c), direct (c'), and indirect (a_jb_j) paths by which Official Warning & Cues influence the likelihood of evacuation ($n = 272$). Statistical control variables are not represented in the model for simplicity.

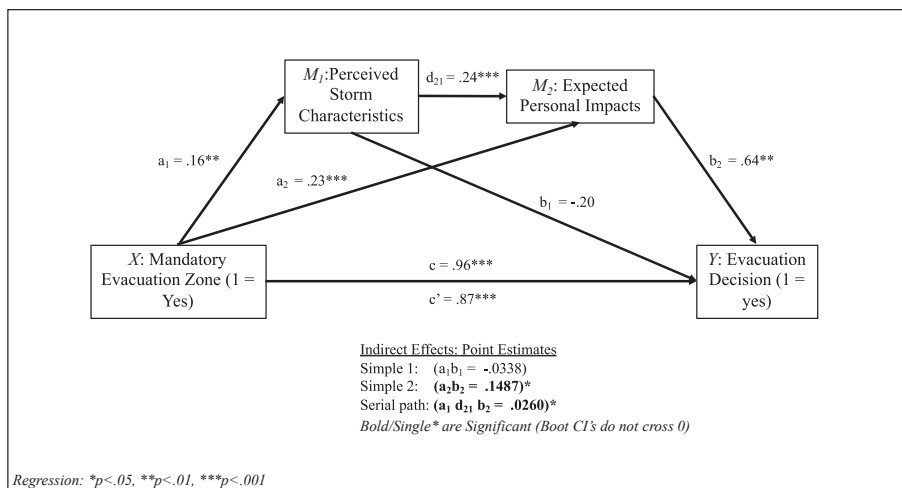


Fig. 3. Serial mediation model showing the total (c), direct (c'), and indirect (a_jb_j) paths by which Mandatory Evacuation Zone influences the likelihood of evacuation ($n = 272$). Statistical control variables are not represented in the model for simplicity.

5. Discussion

Given the fact that hazard adjustments for hurricanes and COVID-19 are different and contradictory (i.e. evacuation and sheltering for hurricanes v. social distancing and sheltering-in-place for COVID-19), it is important that we understand how the dual threat event of Category 4 Hurricane Laura and COVID-19 pandemic impacted household level decision making with regard to evacuations. While individual perceptions were positively and significantly correlated with evacuation decision, the regression analysis showed that *COVID-19 Negative Affect* and *Risk Perception* did not have a direct effect on the decision to evacuate during Hurricane Laura. However, both *COVID-19 Negative Affect* and *Risk Perception* were positively and significantly related to *Expected Personal Impacts* from the storm. Furthermore, the Mediation model (Table 3) shows that *COVID-19 Negative Affect* and *Risk Perception* have an indirect effect on *Evacuation Decision Making* through their significant effect on *Expected Personal Impacts* from the storm.

Those individuals who engaged in more *COVID-19 Protective Actions* were also more likely to respond that they had evacuated during Hurricane Laura. This may be a sign that individuals who engage in protective action behaviors for one hazard may be more likely to do so for other hazards. We included “concern about protecting your family from COVID-19” as one of four items that capture *Evacuation Impediments*. These combined COVID-19 and non-COVID-19 *Evacuation Impediments* had a positive direct effect on respondent’s *Expected Personal Impacts* and a positive indirect effect on *Evacuation Decision* through respondent’s *Expected Personal Impacts*. So, elements that, based on prior literature (Huang et al., 2017, 2012; Siebeneck et al., 2013), reduce evacuations, indirectly affected evacuation decisions through *Expected Personal Impact*, but interpreting the positive indirect effect in this instance can be

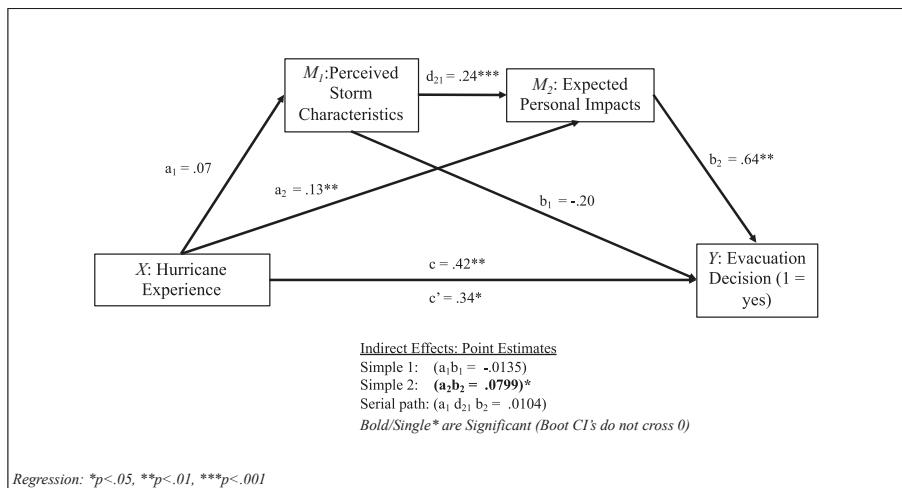


Fig. 4. Serial mediation model showing the total (c), direct (c'), and indirect (a_1b_1) paths by which Hurricane Experience influences the likelihood to evacuate ($n = 272$). Statistical control variables are not represented in the model for simplicity.

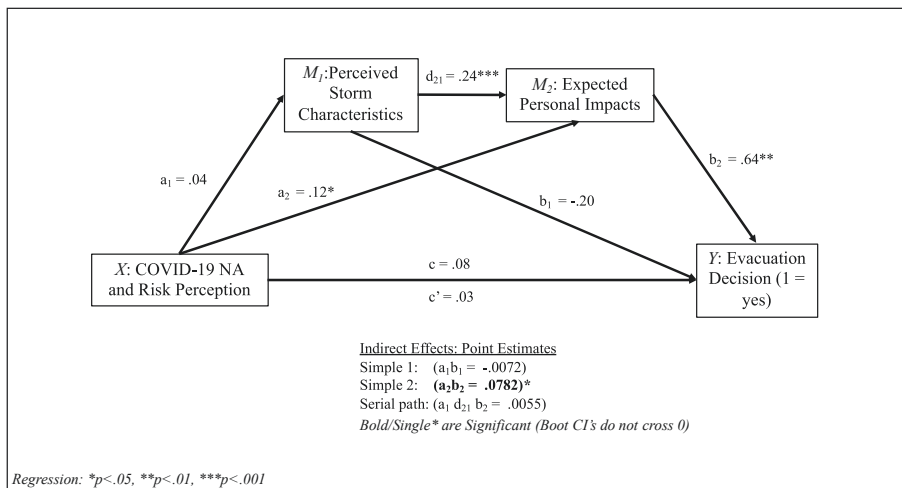


Fig. 5. Serial mediation model showing the total (c), direct (c'), and indirect (a_1b_1) paths by which COVID-19 NA & Risk Perception influences the likelihood to evacuate ($n = 272$). Statistical control variables are not represented in the model for simplicity.

challenging since the natural sign of Impediments on evacuation is negative (as shown while addressing omitted variable bias). However, this is because the positive indirect effect on Evacuation Decision via Expected Personal Impacts is likely due to suppression effects. Suppression effects occur when the direct and mediated effects of a X on a Y variable have opposite signs. Following Mackinnon et al., (2000), our findings may then be interpreted as the following: increasing perceptions of impediments would normally have a negative effect on evacuation, but because increasing impediments increases the expected impacts of the storm, which in turn increases the likelihood you evacuate, the potential effect of impediments is counteracted, or suppressed by expected impacts. In other words, Impediments would normally reduce evacuation due to concerns you have about looters, services, your home, and/or protecting your family from COVID-19, but the more concerns you have, the more likely a severe disruption to your services, job, or home from the storm is expected, and thus the more likely you are to evacuate. Increasing concerns imply an increasingly threatening storm. Finally, Recent exposure to COVID-19 had no statistically significant effect on the decision to evacuate, either directly or indirectly.

Other study findings focus on variables that are more commonly associated with the PADM and have been examined in other studies focused on hurricane evacuation (Huang et al, 2017). Analyzing multiple pathways, we were able to identify the causal mechanisms by which these predictors resulted in the decision to evacuate. A major component of the PADM is the effect of *Official Warnings and Cues* on individual protective action decision making. Likewise, a mandatory evacuation order has also been found to positively influence the decision to evacuate. Our model found statistically significant direct effects between both variables (*Official Warning and Cues* and *Mandatory Evacuation Zone*) and the variables *Perceived Storm Characteristics*, *Expected Personal Impacts*, and *Evacuation Decisions*. Both variables also indirectly affect evacuation decision making through *Perceived Expected Storm Impacts*, as

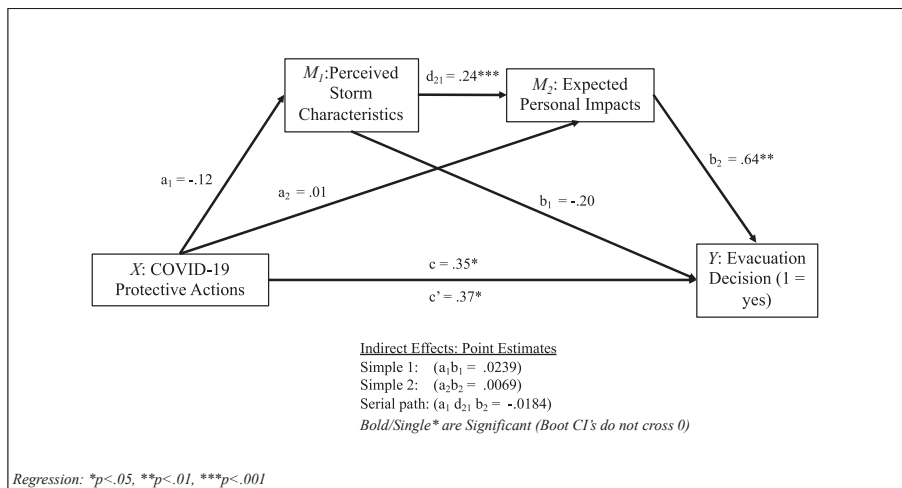


Fig. 6. Serial mediation model showing the total (c), direct (c'), and indirect ($a_1 b_1$) paths by which COVID-19 Protective Actions influences the likelihood to evacuate ($n = 272$). Statistical control variables are not represented in the model for simplicity.

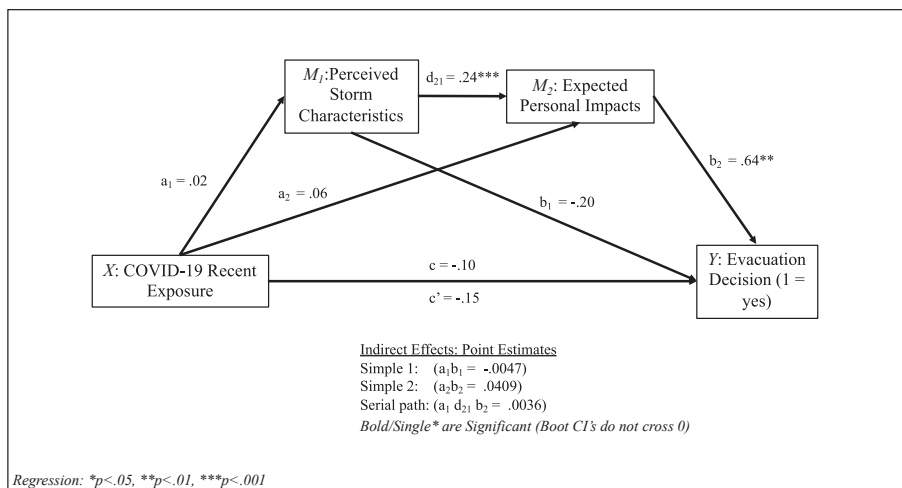


Fig. 7. Serial mediation model showing the total (c), direct (c'), and indirect ($a_1 b_1$) paths by which COVID-19 Recent Exposure influences the likelihood to evacuate ($n = 272$). Statistical control variables are not represented in the model for simplicity.

well as in serial via *Perceived Storm Characteristics* and in turn, *Expected Personal Impacts*. In this study, *Official Warnings and Cues* was measured through two dimensions that measured both official storm warnings and environmental and social cues such as seeing the storm, seeing businesses close, or seeing friends and other evacuating. These official and environmental cues have been consistently identified in prior literature as important tools for individuals to make the decision to evacuation in uncertain, hazardous situations (Dow and Cutter, 1998; Horney et al., 2010; Huang et al., 2017, 2012; Lindell et al., 2005; Stein et al., 2010), but in this study, we confirmed that these cues also influence individual perceptions of the storm itself and the potential impact the storm will have on individuals. In other words, individuals who experience official warnings and high levels of cues are more likely to evacuate because they see increases in their threat perceptions.

Only two variables, *Official Warning and Cues* and *Mandatory Evacuation Zone*, have a direct and significant effect on *Perceived Storm Characteristics*. This is consistent with previous literature (Huang et al., 2017, 2012), and there is no intuitive reason to expect that the COVID-19 related variables would influence an individual's perception of the storm itself. Likewise, *Perceived Storm Characteristics* only affect evacuation decision making as it relates to residence in a *Mandatory Evacuation Zone* and *Official Warnings and Cues*. For these individuals, *Perceived Storm Characteristics* act to increase *Expected Storm Impacts* enough to increase their protective action motivation. This is also consistent with other behavioral theories such as Protective Motivation Theory, such that *Perceived Storm Characteristics* matter less for personal protection unless you expect personal impacts from the storm - i.e. have a high threat appraisal (Hu et al., 2022; Prentice-Dunn et al., 2009).

Finally, individuals were asked about their prior hurricane experience including previous evacuations, prior damage to home or

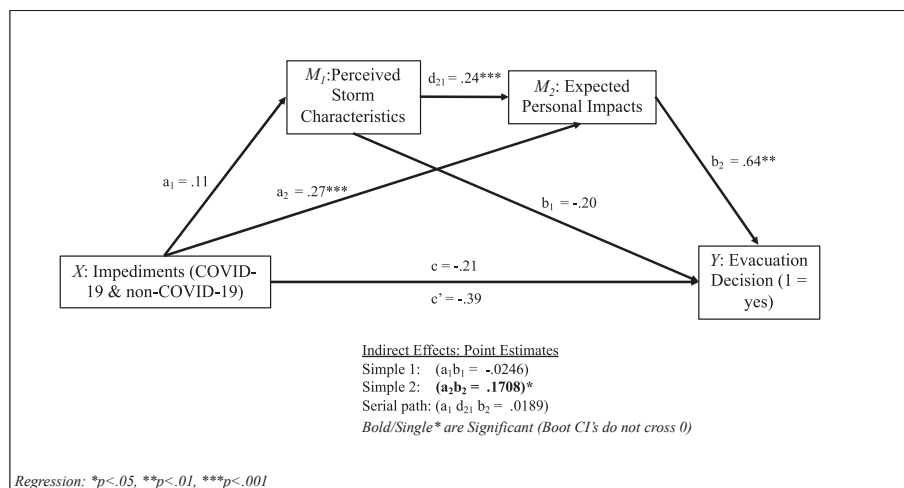


Fig. 8. Serial mediation model showing the total (c), direct (c'), and indirect ($a_2 b_2$) paths by which Impediments (COVID-19 & non-COVID-19) influences the likelihood to evacuate ($n = 272$). Statistical control variables are not represented in the model for simplicity.

injury to self or members of their family, and disruption to daily life caused by a hurricane. Prior experience with hurricanes had a significant direct effect on *Expected Personal Impacts* and *Evacuation Decisions*, such that individuals with more experience were more likely to expect impacts from Hurricane Laura, as well as more likely to have evacuated. These findings are consistent with previous literature on evacuations (Hasan et al., 2012; Horney et al., 2010; Huang et al., 2012; Lindell et al., 2005; Sharma and Patt, 2012). This study adds to our understanding of the effect of prior experience by showing the indirect effects that Prior Experience had on the decision to evacuate through *Expected Impacts*.

6. Conclusions

The 2020 hurricane season was challenging, both regarding the number and magnitude of hurricanes it produced and when considering the unique challenges presented by the COVID-19 pandemic. Households threatened by hurricanes had to weigh competing risks: do I reduce my hurricane risk and evacuate to a potentially communal setting, or do I stay in my home, shelter in place, and avoid human contact? To examine this, our study characterizes how individual perceptions of COVID-19 affected protective action decision making during Hurricane Laura. The research hypotheses and findings presented in this study were based on the abbreviated PADM model (Huang et al., 2017, 2012) and the original PADM model (Lindell and Perry, 2012). Our findings are somewhat different from the previous hurricane evacuation studies (e.g., Huang et al., 2017; Kulkarni et al., 2017; Lindell et al., 2005; Wu et al., 2012) that show wind or flood hazard risk factors typically have direct impacts on hurricane evacuations. Through mail-based surveys with affected households, we found that COVID-19 lacked direct effects but had indirect effects on evacuation decision-making, particularly relating to perceptions of potential hurricane impacts. Likewise, we found that many of the variables traditionally included in evacuation studies had both direct and indirect effects on evacuation decisions. Our findings shed light on how future PADM studies could hypothesize pandemic risk factors' effects on evacuation decisions and decision-making in a multi-hazard environment. Additionally, the findings shed light on the complicated relationship between variables in the PADM that affect individual decision-making, and how those relationships may be different in a dual-threat environment. This research provides initial insight into these relationships, but further research is needed on protective action decision making in other dual threat contexts in order to better inform preparedness and risk communication.

It is important to understand the relationships between individual perceptions of COVID-19 and protective action decision making regarding Hurricane Laura for a couple of reasons. First, it is likely that we will continue to see contagious respiratory diseases (i.e. the Flu virus, COVID-19 variants, or a future novel virus) that coincide with hurricane season or other hazards, both slow and fast onset, which require evacuation and sheltering. As we have shown here, this increases the complexity of household decision making, particularly as recommendations for managing multiple hazards conflict amid interpersonal, social, and institutional demands such as personalized family health risk factors, work and schooling expectations, and household resources within the context of a household's past disaster experience and political and cultural milieu. While it might be intuitive to think that individuals will not evacuate if they are concerned about potential pandemic infection, we found that individuals who are more concerned about COVID-19 had higher overall concern about the storm as well and were more likely to take protective action through evacuation. Given that, emergency managers should clearly communicate the risk trade-offs (i.e. higher risk of injury or death in Category 4 hurricane) and the protective measures they are implementing (i.e. provision of personal protective equipment, use of hotels as shelters), as well as the protective actions that individuals can implement (i.e. masking, screening symptoms) to increase their safety during evacuation and sheltering. Second, the use of path modeling to understand the direct and indirect effects of individual perceptions of one hazard on another hazard may be useful in the future as we see more complex and/or compounding disasters. This type of approach could lead to changes

in the way we try to encourage evacuation. For example, we found that official warnings and environmental and social cues shaped perceptions of storm characteristics and expected impacts, which in turn influenced the decision to evacuate. This suggests that the importance of timely, consistent, and quality information about hurricanes and their potential impact to persons and property cannot be understated. Further, engaging COVID-19 protective actions also encourages hurricane evacuation in our model. This suggests emergency managers could encourage evacuation by working with public health officials to help the public adopt health oriented protective actions, such as washing hands and wearing a mask when in public settings, when preparing for hurricane seasons during a pandemic respiratory illness.

There are several limitations of this study that can be addressed in future studies. First, we tested a select number of paths in our model based on our formulated hypotheses. However, it is possible for these variables to have different paths that serve as more informative, including indirect effects through other covariates. Our analysis was confined to the hypothesized relationships, although future research should explore all potential paths and interrelationships among variables. Second, our response rate was 7.35%. While this is lower than we wanted and likely partially attributable to the widespread damage and displaced residents in our sampling frame, this is in line with the averages of mail-based response rates (Dillman et al., 2014). While a low response rate indicates the possibility of nonresponse bias, demographics, except for age, were in line with Census Bureau data for the area. We suggest that future studies rely on alternative survey methods to acquire a better response rate. Second, future studies should consider the role of lead time and hazard type in evacuation decision-making in the context of dual threat events. At the time of this writing, COVID-19 is still a major threat in many areas of the U.S., while wildfires are affecting major parts of the American West. Future work should consider if these events that also have seasonal effects, require large-scale sheltering efforts, but typically have shorter warning periods lead to different evacuation decision-making processes. Additionally, when a respiratory disease has become a long-term effect (a regular type of evacuation impediment, such as concerns for traffic), future PADM studies should consider pandemic or respiratory disease-related items into evacuation considerations and assessments (e.g., facilitators and impediments). Third, future studies should test for simple and serial mediation among factors shaping evacuation decisions across a variety of hazards.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

- Arlikatti, Sudha, Lindell, Michael K., Prater, Carla S., 2007. Perceived Stakeholder Role Relationships and Adoption of Seismic Hazard Adjustments. *International Journal of Mass Emergencies and Disasters* 25 (3), 310–321.
- Aguirre, B.E., 1991. Evacuation in Cancun during Hurricane Gilbert. *International Journal of Mass Emergencies and Disasters* 9 (1), 31–45.
- Aguirre, B., 2000. Social science and severe weather warnings, in: Pielke, R.Jr., Pielke, R.Sr. (Eds.), *Storms*. Routledge, New York, NY, pp. 98–108.
- Ahsan, M.N., Takeuchi, K., Vink, K., Warner, J., 2016. Factors affecting the evacuation decisions of coastal households during Cyclone Aila in Bangladesh. *Environmental Hazards* 15 (1), 16–42.
- Baker, E.J., 1991. Hurricane Evacuation Behavior. *International Journal of Mass Emergencies & Disasters* 9 (2), 287–310.
- Baker, E., 2000. Hurricane Evacuation in the United States, in: Pielke, R.Jr., Pielke, R.Sr. (Eds.), *Storms*. Routledge, New York, NY, pp. 306–319.
- Baron, R., Kenny, D.A., 1986. Acute oromandibular dystonia reaction related to a single low dose sertraline. *Journal of Personality and Social Psychology* 51, 1173–1182.
- Borowska-Stefańska, M., Balážovičová, L., Goniewicz, K., Kowalski, M., Kurzyk, P., Masný, M., Wiśniewski, S., Žoncová, M., Khorram-Manesh, A., 2022. Emergency management of self-evacuation from flood hazard areas in Poland. *Transportation Research Part D: Transport and Environment* 107, 103307. <https://doi.org/10.1016/j.trd.2022.103307>.
- Borowski, E., Cedillo, V.L., Stathopoulos, A., 2021. Dueling emergencies: Flood evacuation resharing during the COVID-19 pandemic. *Transportation Research Interdisciplinary Perspectives* 10, 100352. <https://doi.org/10.1016/j.trip.2021.100352>.
- Botzen, W.J.W., Mol, J.M., Robinson, P.J., Zhang, J., Czajkowski, J., 2022. Individual hurricane evacuation intentions during the COVID-19 pandemic: insights for risk communication and emergency management policies. *Natural Hazards* 111, 507–522. <https://doi.org/10.1007/S11069-021-05064-2/TABLES/6>.
- Centers for Disease Control and Prevention, 2022. CDC Museum COVID-19 Timeline [WWW Document]. David J. Sencer CDC Museum Online Exhibitions.
- Collins, J., Polen, A., McSweeney, K., Colón-Burgos, D., Jernigan, L., 2021. Hurricane Risk Perceptions and Evacuation Decision-Making in the Age of COVID-19. *Bulletin of the American Meteorological Society* 102, E836–E848. <https://doi.org/10.1175/BAMS-D-20-0229.1>.
- Collins, J., Polen, A., Dunn, E., Maas, L., Ackerson, E., Valmond, J., Morales, E., Colón-Burgos, D., 2022. Hurricane Hazards, Evacuations, and Sheltering: Evacuation Decision-Making in the Pre-vaccine Era of the COVID-19 Pandemic in the PRVI Region. *Weather, Climate, and Society* 14 (2), 451–466.
- Conway, L.G., Woodard, S.R., Conway, L.G., 2020. Social Psychological Measurements of COVID-19: Coronavirus Perceived Threat, Government Response, Impacts, and Experiences Questionnaires.
- Coronavirus in the U.S.: Latest Map and Case Count [WWW Document], 2020. The New York Times. URL <https://www.nytimes.com/interactive/2020/us/coronavirus-us-cases.html> (accessed 8.30.20).
- Dash, N., Gladwin, H., 2007. Evacuation decision making and behavioral responses: Individual and household. *Natural Hazards Review* 8 (3), 69–77.
- Demuth, J.L., Morss, R.E., Lazo, J.K., Trumbo, C., 2016. The effects of past hurricane experiences on evacuation intentions through risk perception and efficacy beliefs: A mediation analysis. *Weather, Climate, and Society* 8, 327–344.
- Dillman, D.A., Smyth, J.D., Christian, L.M., 2014. *Internet, phone, mail, and mixed-mode surveys: the tailored design method*. John Wiley & Sons Inc, Hoboken, NJ.
- Dow, K., Cutter, S.L., 1998. Crying wolf: Repeat responses to hurricane evacuation orders. *Coastal Management* 26, 237–252. <https://doi.org/10.1080/08920759809362356>.

- Dow, K., Cutter, S., 2000. Public Orders and Personal Opinions: Household Strategies for Hurricane Risk Assessment. *Environmental Hazards* 2 (4), 143–155.
- Fu, H., Wilmot, C.G., 2004. Sequential logit dynamic travel demand model for Hurricane Evacuation. *Transportation Research Record* 1882 (1), 19–26.
- Gladwin, C.H., Gladwin, H., Peacock, W.G., 2001. Modeling the Hurricane Evacuation Decisions with Ethnographic Methods. *International Journal of Mass Emergencies and Disasters* 19, 117–143.
- Goodie, A.S., Sankar, A.R., Doshi, P., 2019. Experience, risk, warnings, and demographics: Predictors of evacuation decisions in Hurricanes Harvey and Irma. *International Journal of Disaster Risk Reduction* 41, 101320. <https://doi.org/10.1016/j.ijdr.2019.101320>.
- Hasan, S., Mesa-Arango, R., Ukkusuri, S., Murray-Tuite, P., 2012. Transferability of Hurricane Evacuation Choice Model: Joint Model Estimation Combining Multiple Data Sources. *Journal of Transportation Engineering* 138 (5), 548–556.
- Hayes, A.F., 2018a. *Introduction to Mediation, Moderation, and Conditional Process Analysis, Second Edition. A Regression-Based Approach*, the Guilford Press. Guilford Publications.
- Hayes, A.F., 2018b. Partial, conditional, and moderated moderated mediation: Quantification, inference, and interpretation. *Communication Monographs* 85 (1), 4–40.
- Hayes, A.F., 2022. *Introduction to mediation, moderation, and conditional process analysis : a regression-based approach*. The Guilford Press, New York, NY.
- Horney, J.A., MacDonald, P.D.M., Van Willigen, M., Berke, P.R., Kaufman, J.S., 2010. Individual actual or perceived property flood risk: Did it predict evacuation from Hurricane Isabel in North Carolina, 2003? *Risk Analysis* 30, 501–511.
- Hu, S., Yu, M., Que, T., Fan, G., Xing, H., 2022. Individual willingness to prepare for disasters in a geological hazard risk area: an empirical study based on the protection motivation theory. *Nat Hazards* 110, 2087–2111. <https://doi.org/10.1007/s11069-021-05026-8>.
- Huang, S., Lindell, M.K., Prater, C.S., Wu, H., Siebeneck, L.K., 2012. Household evacuation decision making in response to Hurricane Ike. *Natural Hazards Review* 13, 283–296. [https://doi.org/10.1061/\(ASCE\)NH.1527-6996.0000074](https://doi.org/10.1061/(ASCE)NH.1527-6996.0000074).
- Huang, S.-K., Lindell, M.K., Prater, C.S., 2016. Who leaves and who stays? A review and statistical meta-analysis of hurricane evacuation studies. *Environment and Behavior* 48 (8), 991–1029.
- Huang, S., Lindell, M.K., Prater, C.S., 2017. Multistage Model of Hurricane Evacuation Decision: Empirical Study of Hurricanes Katrina and Rita. *Natural Hazards Review* 18, 05016008. [https://doi.org/10.1061/\(ASCE\)NH.1527-6996.0000237](https://doi.org/10.1061/(ASCE)NH.1527-6996.0000237).
- Jon, I., Huang, S.K., Lindell, M.K., 2018. Perceptions and reactions to tornado warning polygons: Would a gradient polygon be useful? *International Journal of Disaster Risk Reduction* 30, 132–144. <https://doi.org/10.1016/j.ijdr.2018.01.035>.
- Kasakove, S., 2021. 3 Weeks After Hurricane Ida, Parts of Louisiana Remain Dark - The New York Times [WWW Document]. New York Times. URL <https://www.nytimes.com/2021/09/18/us/ida-louisiana-power-outages.html> (accessed 7.12.22).
- Kulkarni, P.A., Gu, H., Tsai, S., Passannante, M., Kim, S., Thomas, P.A., Tan, C.G., Davidow, A.L., 2017. Evacuations as a Result of Hurricane Sandy: Analysis of the 2014 New Jersey Behavioral Risk Factor Survey. *Disaster Medicine and Public Health Preparedness* 11, 720–728. <https://doi.org/10.1017/dmp.2017.21>.
- Lazo, J.K., Bostrom, A., Morss, R.E., Demuth, J.L., Lazrus, H., 2015. Factors Affecting Hurricane Evacuation Intentions. *Risk Analysis* 35 (10), 1837–1857.
- Lindell, M.K., 2018. Communicating Imminent Risk. In: Rodriguez, H., Donner, W., Trainor, J.E. (Eds.), *Handbook of Disaster Research*. Springer Nature, Cham, Switzerland, pp. 387–410.
- Lindell, M.K., Lu, J.-C., Prater, C.S., 2005. Household Decision Making and Evacuation in Response to Hurricane Lili. *Nat. Hazards Rev.* 6 (4), 171–179.
- Lindell, M.K., Kang, J.E., Prater, C.S., 2011. The logistics of household hurricane evacuation. *Natural Hazards* 58, 1093–1109. <https://doi.org/10.1007/s11069-011-9715-x>.
- Lindell, M.K., Perry, R.W., 2004. *Communicating environmental risk in multiethnic communities*. Sage, Thousand Oaks.
- Lindell, M.K., Perry, R.W., 2012. The protective action decision model: theoretical modifications and additional evidence. *Risk analysis : an official publication of the Society for Risk Analysis* 32, 616–632. <https://doi.org/10.1111/j.1539-6924.2011.01647.x>.
- McFadden, Daniel, 1979. Quantitative Methods for Analyzing Travel Behaviour on Individuals: Some Recent Developments. In: Hensher, D., Stopher, P. (Eds.), *Bahvioural Travel Modelling*. Routledge, London, UK, pp. 279–318.
- Mackinnon, D., Krull, J., Lockwood, C., 2000. Equivalence of the mediation, confounding and suppression effect. *Prevention Society* 1, 173.
- Mooney, C., Freedman, A., 2020. Hurricane Laura's rapid intensification is a sign of a warming climate, scientists say. *Washington Post*.
- Morrow, B.H., Gladwin, H., 2005. *Hurricane Ivan Behavioral Analysis*. Wilmington and Mobile Districts.
- National Institute of Environmental Health Science, 2018. NIH Disaster Research Response (DR2) [WWW Document].
- 2020 North Atlantic Hurricane Season Shatters Records | News | National Centers for Environmental Information (NCEI) [WWW Document]. URL <https://www.ncei.noaa.gov/news/2020-north-atlantic-hurricane-season-shatters-records> (accessed 7.12.22).
- Office of the Governor of Louisiana, 2020. Gov. Edwards Orders Statewide Mask Mandate, Closes Bars to On Premises Consumption as COVID-19 Continues to Spread Across Louisiana [WWW Document]. Office of the Governor Newsroom. URL <https://gov.louisiana.gov/index.cfm/newsroom/detail/2591> (accessed 8.15.22).
- Pasch, R.J., Berg, R., Roberts, D.P., Papin, P.P., 2021. National Hurricane Center Tropical Cyclone Report: Hurricane Laura.
- Peacock, W.G., Brody, S.D., Highfield, W., 2005. Hurricane risk perceptions among Florida's single family homeowners. *Landscape and Urban Planning* 73, 120–135. <https://doi.org/10.1016/j.landurbplan.2004.11.004>.
- Peacock, W., Morrow, B., Gladwin, H., 1997. Hurricane Andrew: Ethnicity, gender, and the sociology of disasters.
- Pei, S., Dahl, K.A., Yamana, T.K., Licker, R., Shaman, J., 2020. Compound Risks of Hurricane Evacuation Amid the COVID-19 Pandemic in the United States. *GeoHealth* 4. <https://doi.org/10.1029/2020GH000319>.
- Preacher, K., Hayes, A.F., 2008. Assessing mediation in communication research. In: Hayes, A.F., Slater, M.D., Snyder, L.B. (Eds.), *The Sage Sourcebook of Advanced Data Analysis Methods for Communication Research*. Sage Publications Ltd., London, UK, pp. 13–54.
- Prentice-Dunn, S., Mcmath, B.F., Cramer, R.J., 2009. Protection Motivation Theory and Stages of Change in Sun Protective Behavior. *J Health Psychol* 14, 297–305. <https://doi.org/10.1177/1359105308100214>.
- Santella, N., Steinberg, L.J., Aguirra, G.A., 2011. Empirical Estimation of the Conditional Probability of Natch Events Within the United States. *Risk Analysis* 31, 951–968. <https://doi.org/10.1111/j.1539-6924.2010.01561.x>.
- Sharma, U., Patt, A., 2012. Disaster warning response: The effects of different types of personal experience. *Natural Hazards* 60, 409–423. <https://doi.org/10.1007/S11069-011-0023-2/TABLES/4>.
- Siebeneck, L.K., Lindell, M.K., Prater, C.S., Wu, H.-C., Huang, S.-K., 2013. Evacuees' reentry concerns and experiences in the aftermath of Hurricane Ike. *Natural Hazards* 65 (3), 2267–2286.
- Singer, H., Caves, K., 2017. When Can an Omitted Variable Invalidate a Regression? *Applied Econometrics* 17, 1–9.
- Staff, A.J.M.C., 2020. A Timeline of COVID-19 Developments in 2020 [WWW Document]. accessed 12.22.20 American Journal of Managed Care. <https://www.ajmc.com/view/a-timeline-of-covid19-developments-in-2020>.
- Stein, R.M., Dueñas-Osorio, L., Subramanian, D., 2010. Who Evacuates When Hurricanes Approach? The Role of Risk, Information, and Location*. *Social Science Quarterly* 91, 816–834.
- Strahan, K., Watson, S.J., 2019. The protective action decision model: when householders choose their protective response to wildfire. *Journal of Risk Research* 22 (12), 1602–1623.
- Strahan, K.W., Whittaker, J., Handmer, J., 2019. Predicting self-evacuation in Australian bushfire. *Environmental Hazards* 18 (2), 146–172.
- Svitek, P., 2020. Gov. Greg Abbott isn't calling it a stay-at-home order. But he's telling Texans to stay at home. *The Texas Tribune*.
- The Texas Newsroom, 2021. How We Got Here: A Timeline of Gov. Houston Public Media, Greg Abbott's COVID Policies.
- United State Census Bureau, 2022. U.S. Census Bureau QuickFacts: Galveston County, Texas; United States [WWW Document].
- Wong, S.D., Pel, A.J., Shaheen, S.A., Chorus, C.G., 2020. Fleeing from Hurricane Irma: Empirical Analysis of Evacuation Behavior Using Discrete Choice Theory. *Transportation Research Part D: Transport and Environment* 79, 102227. <https://doi.org/10.1016/j.trd.2020.102227>.
- Wu, H.-C., 2020. Households disaster memory recollection after the 2013 Colorado Flood. *Natural Hazards* 102, 1175–1185. <https://doi.org/10.1007/s11069-020-03951-8>.

- Wu, H.-C., Clay, L., Greer, A., Murphy, H., 2022. Award 2051578 -Annual Project Report. National Science Foundation, Alexandria, VA.
- Wu, H.-C., Huang, S.-K., Lindell, M., 2020. Evacuation Planning, in: Lindell, M. (Ed.), *Handbook of Urban Disaster Resilience: Integrating Mitigation, Preparedness, and Recovery Planning*. Taylor & Francis, New York, NY.
- Wu, H., Lindell, M.K., Prater, C.S., 2012. Logistics of hurricane evacuation in Hurricanes Katrina and Rita. *Transportation Research Part F: Psychology and Behaviour* 15, 445–461. <https://doi.org/10.1016/j.trf.2012.03.005>.
- Yabe, T., Ukkusuri, S.V., 2020. Effects of income inequality on evacuation, reentry and segregation after disasters. *Transportation Research Part D: Transport and Environment* 82, 102260. <https://doi.org/10.1016/j.trd.2020.102260>.
- Zhang, Y., Prater, C.S., Lindell, M.K., 2004. Risk area accuracy and evacuation from Hurricane Bret. *Natural Hazards Review* 5 (3), 115–120.