Hurricane Risk Perceptions and Evacuation Decision-Making in the Age of COVID-19

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ABSTRACT: The COVID-19 pandemic increases the complexity of planning for hurricanes as social distancing is in direct conflict with human mobility and congregation. COVID-19 presents not only urgent challenges for this hurricane season due to the likeliness of continued or heightened COVID-19 threat, but also challenges with the next hurricane season with additional waves of the pandemic. There is severe urgency to understand the impact of COVID-19 risk perceptions and the extent people are willing to risk their lives by sheltering in place rather than evacuating during severe hurricanes. In June 2020, a survey (in both English and Spanish) of 40 questions was disseminated through regional planning councils, emergency management, and the media to Florida residents. A total of 7,072 people responded from over 50 counties. Most data obtained were ordinal or categorical in nature, encouraging usage of nonparametric analysis and chi-square tests. Almost half the respondents view themselves as vulnerable to COVID-19 due to preexisting health conditions, and 74.3% of individuals viewed the risk of being in a shelter during the COVID-19 pandemic as more dangerous than enduring hurricane hazards. Additionally, there was a significant number of individuals who would choose to not utilize a public shelter during COVID-19 when they would have previously. Officials can use the results of this study regarding how household evacuation plans change with social distancing to better inform strategies of shelter preparedness and COVID-19 risk mitigation to minimize risk to those in harm's way of storm surge and other hurricane effects during a mandatory evacuation order.

KEYWORDS: Atmosphere; Social Science; Emergency preparedness; Societal impacts

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The 2020 hurricane season was forecasted to be “an extremely active hurricane season” by numerous forecasting groups [e.g., Colorado State University (CSU), NOAA, and Tropical Storm Risk (TSR)]. Indeed, the 2020 Atlantic hurricane season was very active producing 30 named storms, 13 hurricanes, and 6 major (maximum sustained winds $101 \geq 96$ kt; category 3–4–5 on the Saffir–Simpson Hurricane Wind Scale) hurricanes. This is a result of sea surface temperatures averaged across the tropical Atlantic being considerably warmer than normal, and vertical wind shear much lower than average. It is expected that the cool neutral ENSO conditions observed during the first part of the hurricane season may transition to weak La Niña conditions. The CSU team anticipate “an above-normal probability for major hurricanes making landfall along the continental United States coastline and in the Caribbean” (Klotzbach et al. 2020). This expected activity is compounded by the fact that we are in a global pandemic. COVID-19 has caused 3.01 million mortalities worldwide as of 18 April 2021. It is the fifth pandemic to affect the world since the 1918 flu outbreak, known as Spanish flu. The February 1918 to April 1920 pandemic infected ~500 million and killed between 17 and 50 million, the 1957–58 flu infected in excess of 100 million and killed ~1.1 million, the 1968 flu killed 1 million, and the 2009 flu killed in excess of 201,000 (Barro et al. 2020; Kilbourne 2006; Simonsen et al. 2013). But, as we saw with Hurricane Laura (27 August 2020) making landfall as a category 4 (the strongest hurricane to hit Louisiana in over a century), this was the first time a mass evacuation was warranted during a pandemic since the 1918 influenza outbreak (Chandra et al. 2013).

While guidance from hurricane experts reminds residents that they should prepare the same for every season, regardless of how much activity is predicted, the 2020 season is different due to the COVID-19 outbreak and is causing some to rethink their evacuation plans. COVID-19 (declared as a pandemic by the World Health Organization on 11 March 2020) has resulted to date (25 August 2020) in 5.76 million cases and 178,000 deaths in the United States. The pandemic increases the complexity of planning for hurricanes as social distancing is in direct conflict with human mobility and congregation. This increased complexity is particularly problematic in Florida where the number of cases is 605,000 and number of deaths is over 10,000 at the time of writing (25 August 2020). In addition, evacuation options are more limited than other states due to the peninsular shape of Florida and because coastal residents comprise 76.5% of the total Floridian population (NOAA 2020). It is plausible that a large evacuation may trigger a sharp increase in COVID-19 cases and deaths, exacting a higher death toll than hurricanes alone. Given that social distancing is warranted, the capacity issues at public shelters may introduce competing priorities for evacuation decisions. As a result, people may risk sheltering in place to avoid COVID-19 exposure.

While research relating to hurricane evacuation behavior and risk perception has grown throughout the years (Baker 1979, 1991, 1995; Brinkley 2006; Buckle 2006; Collins et al. 2017, 2018; Dash and Gladwin 2007; Demuth et al. 2012; Dow and Cutter 1998, 2000; Dynes 2002; Eisenman et al. 2007; Elder et al. 2007; Gladwin et al. 2001; Haines et al. 2002; Miller 2007; Moore et al. 2004; Morss et al. 2016; Riad and Norris 1998; Senkbeil et al. 2019; Sherman-Morris et al. 2011; Whitehead et al. 2000), there is very little understanding of how COVID-19 will impact people’s evacuation decisions. Much of the population has had no prior experience dealing with pandemics and hurricane evacuations before this

season (2020). Despite this, research indicates what we should expect. One model of critical influence in this research is the Protective Action Decision Model (PADM), developed by Lindell and Perry (2004, 2012). This model dictates the steps and factors that can influence an individual's decision-making process during disasters. This includes a multistage process of absorbing information and cues from the environment and media communication, information searching, assessing the threat, and ultimately making an evacuation decision (Lindell and Perry 2004, 2012).

To establish the nature of disease outbreaks after natural disasters (in specific, hurricanes), Bissell (1983) conducted a study of five diseases and analyzed their spread over a period of 5 years after a disaster. Through his study, he found that four of the five diseases showed significant increases in infections. He concluded that unlike other natural disasters like earthquakes, hurricanes lend themselves to increasing the spread of disease by forcing large amounts of people into situations that are not necessarily designed to sustain that large of a gathering. Such close proximities to other people are especially conducive to the spread of disease via respiratory droplets. Likewise, Lemonick (2011) conducted a study of past natural disasters and their associated diseases. He found that increased risk for disease transmission was dependent on four factors, one of which is crowding, a frequent concern at shelters. Ivers and Ryan (2006) also explored weather-related and flood-related natural disasters and how these disasters can impact infectious disease spread. They concluded that the increased spread of a disease after a natural disaster is dependent on several factors, but they highlighted “endemicity of specific pathogens in the affected region before the disaster” and “the congregating of displaced individuals.” In another analysis of how tropical cyclones impact disease spread, Shultz et al. (2005) conducted a study on a wide variety of hurricanes and their associated disease outbreaks. They identified six factors that can play into infectious disease outbreaks: 1) disruption of public health services and the health-care infrastructure, 2) damage to water and sanitation networks, 3) changes in population density (especially in crowded shelters), 4) population displacement and migration, 5) increased environmental exposure due to damage to dwellings, and 6) ecologic changes. They note that infectious disease outbreaks after hurricanes are almost unheard of in first-world countries. However, COVID-19 has brought about unprecedented challenges to developed countries, in particular the United States.

In a study about the norovirus outbreak among Hurricane Katrina evacuees in a “mega-shelter,” where more than 1,000 evacuees were infected, Shukla et al. (2018) note how shelters create conditions that lead to the spread of infectious pathogens due to overcrowding, resource limitation, and reduced hygiene. The investigation highlights that even though intensive public health measures were promptly instituted, they did not definitively slow the progression of the outbreak of norovirus gastroenteritis, since there are additional difficulties in managing such outbreaks in crowded settings (Yee et al. 2007). Yee et al. (2007) and Murray et al. (2009) also determined that the illness spread through person-to-person transmission, as well as contact with contaminated surfaces and large aerosolized vomitus droplets. Similarly, a Hurricane Harvey mega-shelter in Harris County, Texas, which housed 3,365 residents at its peak, had an influenza A outbreak. In this outbreak, 20 people were infected with influenza, and attempts to combat the spread of the illness were challenged by the number of evacuees, lack of medical services, high mobility, and poor baseline health of some evacuees (Liu et al. 2019). Liu et al. (2019) noted that the rigorous approach of emphasized handwashing, enhanced inspection and cleaning, isolation of ill individuals, and on-site vaccinations helped to overcome the challenges that the densely populated shelter faced. Liu et al. (2019) note that influenza outbreaks in large evacuation shelters after a disaster pose a significant threat to populations already experiencing severe stressors.

Travers (2020) captured the underlying psychological variables that might explain differences in attitudes toward COVID-19. He found that Americans generally fall into one of

five “types” when it comes to their attitudes regarding COVID-19. Those were labeled as 1) sounding all alarms, 2) at risk, 3) under control, 4) open-ups, and 5) dismissers. Group 1, which was the largest group (29%), feel that the federal response has fallen short and worry about things getting worse, whereas group 5, the joint smallest group with group 4, think the concern has been blown way out of control. Group 1 are younger, more likely to live in urban areas, and more likely to be members of a minority group. Various studies support the conclusion that racial and ethnic minority populations are at greater risk during pandemics because they often have less capacity to implement preparedness strategies or tolerate its impact given disparities in underlying health status and social factors, such as socio-economic disadvantages, cultural, educational and linguistic barriers, and lack of access to health care (Hutchins et al. 2009).

The largest hurricane evacuation in U.S. history (Bousquet and Klas 2017) occurred in the recent 2017 season with Hurricane Irma making landfall in the state of Florida as a category 4 hurricane on 10 September 2017. Hurricane Irma had a death toll of 129 people and had a total cost of \$50 billion. Around 6 million Floridians evacuated their homes for Hurricane Irma and, in the Florida Keys, approximately 75% of the residents evacuated (Cangialosi et al. 2018). There were 77,000 people in 450 shelters (Amadeo 2020) and 54 out of 67 counties in Florida issued evacuation orders (Turner 2018). Should another high-intensity hurricane impact Florida during the intersection of the COVID-19 pandemic and the extremely active 2020 hurricane season, residents will be making complex decisions as they balance their need to evacuate against potential risks of COVID-19 infection.

Research questions

The purpose of this research is to understand public perceptions of compounding risks of COVID-19 and hurricane-induced storm surge and other hurricane impacts affecting evacuation decisions, ultimately examining the extent to which people risk their lives by sheltering in place rather than evacuating during severe hurricanes. The research questions addressed in the paper include “How will COVID-19 (and its associated health vulnerabilities) affect people’s risk perceptions and evacuation decisions?” and “Do people view public shelters as overtly risky and instead choose to shelter-in-place with a mandatory evacuation order due to concerns over COVID-19?” Prior research has not been conducted into an individual’s risk perception of natural hazards as they consider evacuating from a hurricane during a pandemic; COVID-19 poses a unique threat with shelter management considerations far beyond other cases of infectious diseases during hurricane evacuations. Officials also need to understand how evacuation plans change with COVID-19 encouraged social distancing, which is in direct conflict with the movement and congregation seen in hurricane evacuations.

Methodology

Data distribution and collection procedures. Memory decay can contribute to differing perceptions and recollections of past events, and this can be limiting in seasonal evacuation research (Stallings 2002). As well, there is the potential for perceptions and thoughts to become altered over time (Baker 1979; Baker 1991; Lindell et al. 2005). As such, it was critical that the survey be disseminated in a timely manner, at the beginning of the 2020 hurricane season, to properly capture thoughts and anticipated behaviors in real time.

The survey was provided through an anonymous online survey link hosted on Qualtrics and distributed to Florida residents over the age of 18. The network of distribution consisted of regional and community partnerships and their respective outreach programs including the emergency operations centers of west Florida, the University of South Florida’s College of Public Health, the Tampa Bay Regional Planning Council (TBRPC) and their expansive

statewide social media network, and numerous TV stations, particularly Spanish-speaking ones. The primary means of recruitment was through email and social media such as Facebook.

Survey design. A survey instrument, offered in both Spanish and English and containing 40 questions, was used to collect information regarding an individual's perceptions of risk with evacuation and public sheltering during the 2020 hurricane season. Due to the uniqueness of a pandemic occurring simultaneously with an active hurricane season, it was important to gather information relevant to aiding officials in the management of shelters and other close-quartered scenarios that could potentially occur due to a mass evacuation. Therefore, the survey instrument included questions on demographics, characteristics of their home (such as evacuation zone, year built, and structure), special needs shelter (SNS) demand, and preexisting health conditions. Furthermore, questions on the sources of information utilized during evacuation decision-making, as well as storm hazard perception, were presented. The survey also included a variety of Likert-scale questions that were aimed at assessing an individual's risk perception of sheltering in place versus going to a public shelter or other evacuation scenarios with comingling between people.

Many of the questions developed for this survey instrument were created in tandem with emergency managers from the Tampa Bay area to ensure the relevancy and practicality of the data being collected for planning and implementation purposes. Although many of the questions represented in this survey are from a practical background rather than a theoretical one, the PADM and other conceptual basis from Collins et al. (2017) and Collins et al. (2018) were utilized, especially in the section regarding sources of information and storm hazard threat perception.

Data analyses techniques. After data were cleaned from their original Qualtrics output, analysis was conducted using the software SPSS Statistics 26. Figures and maps were produced using ArcGIS Pro and EXCEL. Due to the overwhelming majority of our questions being either categorical or ordinal in nature, analytical techniques consisted of nonparametric testing including chi-square tests, McNemar's tests, and Spearman's rho. Any free-response boxes, such as "other" hazards, health conditions, were cleaned and categorized for analytical purposes.

Results

The survey had a total of 7,072 respondents (7,018 who completed the English version and 54 Spanish survey respondents) who completed the survey from the dates of 5 June 2020 to 5 August 2020 for a total of 2 months, with a majority of participants responding within 2 weeks. On 5 June, there were 1,248 new COVID-19 cases reported in Florida; by 5 August, 7,635 new cases were reported that day. In the end of June and into July, a huge spike in COVID-19 cases occurred as many restrictions had been lifted. Within the state of Florida, on 1 July, over 9,000 new cases were reported, with a total of 166,303 positive confirmed cases of Florida residents and over 15,000 related hospitalizations (Florida Department of Health 2020).

Sample size and characteristics. Respondents ranged from 18 to 96 years of age. The majority of people fell in the 55–74 age range (51.4%), with younger adults (18–34) representing only 10% of the sample, and 69% of respondents identified as female. The majority of respondents (75.6%) self-identified as white; the other significant populations represented were Latinx with 2.6%, African Americans with 1.9%, and those who identified as multiple ethnicities with 1.7%. Among the respondents, 17.1% stated that they had someone residing in their household with a disability, and 6.4% identified that English was their second language.

Many respondents had a college degree (68.2%), with 10.6% of those respondents having associate's degrees, 45.8% with bachelor's, 35.1% with master's, and 8.6% with doctorate degrees. Three percent of respondents had a high school education, 5.5% had less than a high school education, and 23.3% had completed some college without obtaining a degree.

The majority (54.8%) of respondents were employed full-time; 2.8% of respondents said they were temporarily unemployed due to COVID-19, with 0.7% saying they were permanently unemployed due to COVID-19. Of interest to note is that 32% of respondents stated they were retired. The majority of the sample (48%) stated an annual household income of above \$80,000 a year; on the other end, 3.7% stated they made under \$20,000 a year.

The participants were primarily concentrated in west-central Florida, specifically from Pinellas (48.1%) and Manatee (24.5%) Counties; however, there were respondents representing 52 counties in Florida (Fig. 1). Among the respondents, 26% lived in evacuation zone A, 35.2% resided outside of a hurricane evacuation zone, 81.5% were homeowners, 57.2% lived in block construction home structures, and only 19.5% lived in a home constructed under improved Florida building codes between 2005 and 2020. Of special concern during evacuations are those who live in mobile or manufactured homes, which represents the housing type that 5.9% of our respondents occupied.

COVID-19 and health. When asked “Do you consider yourself vulnerable to COVID-19 due to existing health risks?”, 45.1% of respondents answered yes, 51.2% answered no, and 3.6% answered that they did not know. There were differences in responses found to be statistically significant by age [$\chi^2(14) = 695.229, p < 0.001$], with those in older age brackets more frequently identifying as vulnerable.

Although this could be skewed due to the relatively high age of our sample (mean age of 56 years old, and over half being in the 55–74 age range, with 32% of respondents being retirees), it does show that almost half the sample feel they are vulnerable to COVID-19 due to preexisting health conditions such as asthma, diabetes, oxygen dependency, or immunocompromised.

Fig. 1. Survey respondents by county in Florida. Many respondents are concentrated in the greater Tampa Bay region, primarily Manatee and Pinellas Counties.

Most (94.5%) respondents stated that they would be able to provide masks for each family member if they needed to go to a shelter.

Access to a shelter. Almost all (98.9%) of the respondents answered that they would have access to reliable transportation to evacuate to a shelter or elsewhere if they needed to; 96.9% would use a personal vehicle to evacuate or get to a shelter location. This could be due to the high annual household income of our sample permitting individuals to have greater access to personal vehicles and other transportation options due to their financial security. Considering that 17.1% of the respondents identified that they had someone with special needs in their household, and 45.1% considered themselves vulnerable to COVID-19 due to existing health risks SNSs are a topic of interest this season, especially when planning to ensure social distancing. Of note, 7.1% of respondents considered themselves needing access to an SNS, while only 1.2% reported applying to determine eligibility for special needs shelters.

Utilization of social networks for alternative sheltering. We asked respondents to also rank their thoughts on alternative evacuation plans for going to a shelter. Two questions addressed this, one specifically for finding alternative shelter by staying with family and friends *in* the county during a hurricane and the other addressing staying with family and friends *outside* of the county. Respondents strongly agreed (50.3%) or probably agreed (25.3%) that they could find an alternative place to go outside of their county of residence; a total of 59.6% of respondents believed they could find an alternative place to go within their county of residence. This does suggest hope that many people could evacuate to somewhere out of the mandatory evacuation zones that is not as close quartered as a traditional governmental shelter.

A weak relationship was found where those with higher completed education had an increased likelihood of being able to access family and friends to stay with within the county [$X^2(9) = 15.477, p = 0.079$]. There was a strong relationship between those with higher education being able to access their social networks outside of their county for alternative shelter options [$X^2(9) = 44.291, p < 0.001$]. There was also a relationship between what age respondents were and their responses. Younger respondents were more likely to be able to find alternative shelter options within and outside of the county [$X^2(21) = 190.282, p < 0.001$ and $X^2(21) = 294.029, p < 0.001$, respectively]. Those who were older were more likely to choose to evacuate to a hurricane shelter during COVID-19 if mandatory [$X^2(21) = 50.426, p < 0.001$]. This is supported by the fact that those in older age brackets were also more likely to agree with the statement that the risks of being in a shelter during the upcoming season outweighed the risks of enduring a hurricane by sheltering-in-place [$X^2(21) = 137.372, p < 0.001$] and that they would rather shelter-in-place than risk being exposed in a shelter [$X^2(21) = 45.095, p = 0.002$].

Public shelter perceptions. We asked respondents to rate, on a scale from 0 to 3 (with 3 representing “definitely true” and 0 representing “definitely false”) their likelihood to take certain protective actions and their perceptions of personal safety during the 2020 hurricane season due to COVID-19 (see Table 1). Some conclusions of note include that the majority of participants disagreed with the statement that they would have evacuated to a shelter pre-COVID (77.8%). This number, when asking the participants to account for the situation with COVID-19, increases by 7.7% (for a total of 85.5%).

This matches previously conducted research, which found that very few U.S. residents would choose to evacuate to a shelter, regardless of the pandemic (Perry and Lindell 2007). However, a McNemar’s test was used to determine if the decision to go to public shelters was affected in any way by COVID-19. The results of this test showed statistical significance between an individual’s decision to use a public shelter before and during the COVID-19 pandemic ($p < 0.001$). This reflects that, although evacuees rarely decide to use a public

Table 1. Likert-scale question responses; these questions, listed in the left column, deal specifically with perceptions regarding sheltering decisions and the risk of COVID-19 contraction.

Question	Definitely true (3) %	Probably true (2) %	Probably false (1)	Definitely false (0) %
Prior to COVID-19, if I needed to evacuate to a shelter during the 2020 hurricane season, I would most likely have gone to a shelter.	6.5	15.7	33.8	44.0
Considering the current situation with COVID-19, I would still go to a shelter if I needed to during a hurricane evacuation order in 2020.	3.8	10.6	29.6	55.9
If I was ordered to leave my house during a hurricane evacuation, I think the risks of being in a shelter during COVID-19 times would be worse than sheltering-in-place and enduring the risks of a hurricane (e.g., storm surge, strong winds, etc.).	37.5	36.8	18.6	7.1
If my only option was to evacuate to a shelter in my county, I would rather shelter-in-place than risk being exposed to the potentially large group inside a shelter.	55.3	31.4	9.2	4.1
I think if I went to a shelter, there would be adequate safeguards in place such as being able to social distance at least 6 ft. in place to keep me safe from COVID-19.	4.7	26.6	46.1	22.6
If I had to make alternative evacuation plans other than evacuating to a shelter in 2020, I could find friends or family to give me shelter IN my COUNTY.	35.1	24.5	16.8	23.7
If I had to make alternative evacuation plans other than evacuating to a shelter in 2020, I could find friends or family to give me shelter OUTSIDE of my COUNTY.	50.3	25.3	11.5	13.0

shelter, this usage has potential to decrease when the decision is coupled with COVID-19 threats. Respondents to the Spanish survey were more likely to utilize a public shelter before COVID-19, with over half agreeing that they would most likely have gone to a shelter during an evacuation (51.3%).

The majority of respondents also felt that they were at greater risk of being in a shelter during COVID-19 times than enduring a hurricane in their homes (74.3%). Over half (55.3%) strongly agreed with the statement that they would rather shelter-in-place than risk being exposed to a potentially large group inside a shelter, and 31.4% of respondents generally agreed, resulting in a total of 86.7% agreement with this statement.

Results were more distributed on the perception of readiness of emergency management for a sheltering situation: when given the statement, “I think if I went to a shelter, there would be adequate safeguards in place such as being able to social distance at least 6 ft. to keep me safe from COVID-19,” 26.6% felt that statement was probably true, while 46.1% indicated they felt it was probably false. This indicates that there may be negative shelter perceptions in certain areas regarding local government management of COVID-19.

Hazards’ effects on perceptions. When asked about any additional concerns a respondent had regarding their property’s location, 10 common categories of hazards or concerns emerged (Fig. 2). Concerns about water hazards in location of residence were identified the most, with 87.7% of those who responded to this question identifying water hazards (including coastal, inland, and flooding). These concerns about the location of residence had a relationship with shelter

Fig. 2. Responses to the question “Are there any additional concerns for your home or its location (e.g., near a river, floods during heavy rainfall, near a hazardous site)?” were grouped into these categories for analysis.

usage before the COVID-19 pandemic [$X^2(27) = 55.595$, $p = 0.001$], with those that listed hazardous debris and state roads as a concern in their living area being more likely to go to a shelter before COVID-19. In addition, the category of concern near one's residence did influence the individual's likelihood to choose sheltering-in-place compared to being exposed to large groups inside of a shelter [$X^2(27) = 43.042$, $p = 0.026$]. These results indicate that those who have concerns about hazardous debris, building integrity, trees and wind are the most likely to shelter-in-place, compared to those that have water-based hazards concerns or other common concerns.

Evacuation zones also affected shelter perceptions. Those from high-risk evacuation zones were less likely to choose to shelter-in-place instead of going to a public shelter [$X^2(18) = 121.390$, $p = 0.001$]; however, these respondents were also less likely to use a public shelter both before and now with the COVID-19 pandemic [$X^2(18) = 63.089$, $p = 0.001$ and $X^2(18) = 34.491$, $p = 0.011$, respectively]. They also viewed the risks of being in a shelter during the COVID-19 pandemic as more dangerous than sheltering-in-place with hurricane hazards [$X^2(18) = 38.943$, $p = 0.003$ (Fig. 3)].

Discussion

One of the most vulnerable populations in terms of evacuating for weather-related disasters is older people, and based on the statistical analyses, the older population is especially vulnerable during this hurricane season. On top of the decreasing physical and cognitive abilities that are a characteristic of aging, around 80% of adults aged 65 years and older have a chronic health condition that makes evacuating more complicated than for younger populations (Aldrich and Benson 2008). These preexisting conditions can also make older people more susceptible to other illnesses and viruses, so hurricanes pose an even bigger threat to their health because they increase the spread of pathogenic diseases (Maness 2019).

As seen by the results, older people view themselves as more vulnerable, which posits the need for more direct action in emergency situations. For example, in a hurricane evacuation situation, older evacuees could potentially choose to shelter-in-place rather than go to a designated hurricane shelter if they view it as unsafe due to COVID-19. This potentially leaves them at more risk to harm. The elderly, especially those residing in nursing homes, are especially health vulnerable as they are at an increased risk of morbidity, mortality, and hospitalization from evacuations (Brown et al. 2012). Special consideration should be given to those elderly in nursing homes, as evacuation becomes even more difficult for nursing home residents who may not have strong social connections to aid them in evacuating.

Without a perceived risk to their well-being, people are less likely to take appropriate action to prepare for or respond to a potential hazard (Manuell and Cukor 2011). During this hurricane season (2020), the perceived risk could be affected regarding both the hurricane, which can be influenced by factors such as prior evacuation experience (Dow and Cutter 1998) and COVID-19 (such as asymptomatic

"If my only option was to evacuate to a shelter in my county, I would rather shelter-in-place than risk being exposed to the potentially large group inside a shelter."

Fig. 3. Variations in the answer for the question "If my only option was to evacuate to a shelter in my county, I would rather shelter-in-place than risk being exposed to the potentially large group inside a shelter."

carriers and those who do not take public health measures as guided by the CDC). Older individuals and those with less formal education were more likely to believe the threat of COVID-19 in shelters is more dangerous than the threat of a hurricane and are more likely to shelter-in-place in the case of an evacuation. Furthermore, younger individuals were less likely to view themselves as vulnerable to COVID-19. Due to these results, there should be extra attention and concern to clarify appropriate protective action decisions and convey the seriousness of public health measures. A lack of preparedness was also seen regarding special needs shelters, where 7.1% of respondents considered themselves needing access to an SNS, while only 1.2% reported applying to determine eligibility for an SNS.

This research showed that a resident's evacuation zone does impact their perceptions of risk for going to shelters, both before the pandemic and now with COVID-19. Residents from high-risk evacuation zones were found to be less likely to evacuate to a shelter, even before COVID-19, but at the same time they are less likely to shelter-in-place. Therefore, these residents may have alternate evacuation plans. Residents are hesitant to evacuate to a shelter because of conditions that may put them at risk of getting infected with COVID-19, like large groups. Upon examination of the geographical distribution of the COVID-19 cases across Florida, it was observed that many of the counties that are COVID-19 hot spots are also coastal counties that are vulnerable to hurricane hazards such as storm surge. This arises a concern that those with a greater propensity to adhere to a mandatory evacuation, if they were to evacuate, will have a great chance of carrying the virus to shelters and possibly infecting other vulnerable communities.

Limitations. Some limitations to this study should be noted. One significant limitation to the research is that the sample gained through this convenience-style survey is non-representative of the entire population of Florida (Table 2). The sample represented in this research is generally older, is more educated, and has higher annual household incomes. This can affect results such as the perceived health vulnerability (due to the increased percentage of elderly in the sample), the sample's access to materials and disposable income that could help in an evacuation (such as a vehicle), and their overall sense of safety (which can be influenced by their level of education or financial security). Other potential limitations to the methodology include self-selection bias and access issues to those who do not use social media or subscribe to the emailing lists used by the regional partners, who are thus not represented in this sample.

Conclusions

Public hurricane shelters tend to be utilized by the most vulnerable, those who lack the economic means for other evacuation options, and populations that may also have high COVID-19 health risk factors. This research has presented novel results regarding the intended 2020

Table 2. Study sample demographics in comparison to the U.S. Census Bureau (2019) population estimates for the state of Florida. As seen here, our sample was generally more educated, had a higher median income, had a higher percentage of those of over the age of 65, and had more people identify that they had a disability.

Demographics	Study sample population	Florida population estimates
Identify as white	75.6%	77.3%
Over the age of 65	32.4%	20.9%
Those with a disability	17.1%	8.6%
High school graduate or higher	94.5%	88.0%
Bachelor's degree or higher	68.2%	29.2%
In labor force/employed	59.8%	58.3%
Median household income	\$70,000–\$79,999	\$53,267

hurricane season behaviors of different groups within our population. Of particular note is that almost half the respondents view themselves as vulnerable to COVID-19 due to preexisting health conditions, and 74.3% of individuals viewed the risk of being in a shelter during the COVID-19 pandemic as more dangerous than enduring hurricane hazards. Additionally, there was a statistically significant number of individuals who would have used a public shelter in the past that would not use one when that decision is coupled with the COVID-19 pandemic.

Of special concern are the elderly. Results show they are more likely to consider themselves vulnerable to COVID-19 and thus seem hesitant to rely on public sheltering despite them also being the most likely group to utilize shelters. This sheltering aversion is so strong that those in older age brackets were more likely to view public sheltering as more of a risk during a hurricane than the actual storm hazards themselves. A hurricane evacuation, which is based on congregation and movement, is in direct conflict with messaging regarding the COVID-19 pandemic. As such, considerations for all groups must be accounted for in the planning and execution of protective actions taken this hurricane season (2020) and future hurricane seasons while a pandemic is a major health hazard.

There is an acute urgency to understand the impact of COVID-19 risk perceptions and the extent to which people risk their lives by sheltering in place rather than evacuating during threatening tropical cyclones. Prior research suggests that without good planning there is an increased risk of compounding impacts originating from natural hazard events during the COVID-19 pandemic (Quigley et al. 2020). Officials can use the results of this study to better inform planners of how to prepare the shelters and mitigate health risks from COVID-19. One method of targeted planning that could be employed is communication campaigns strengthening the public perception of the safety within shelters, as over half of respondents felt that there would not be adequate safeguards to keep them safe in a public shelter against COVID-19, indicating a lack of trust in the local government management of the pandemic. Another method that may be of interest to emergency managers would be to target those living in high-risk evacuation zones since they were less likely to utilize public sheltering and viewed the risks of a public shelter as being more dangerous than the risks of the storm itself.

Officials can use the materials presented here to better understand how evacuation plans have changed with social distancing, possibly leaving people in harm's way of storm surge and other hurricane effects if they do not comply with a mandatory evacuation order. We need to be prepared and anticipate future challenges with the next hurricane season if the pandemic is still a major health issue.

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Data availability statement. Data summaries related to this project are available on <http://hennarot.forest.usf.edu/main/depts/geosci/research/weathercenter/REU.html>.

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