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Evacuation Decision-Making Post-COVID-19 Vaccine Availability: Implications of Compound Hazards in Puerto Rico and the US Virgin Islands

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Abstract

Objective: The threat of novel pathogens and natural hazards is increasing as global temperatures warm, leading to more frequent and severe occurrences of infectious disease outbreaks and major hurricanes. The COVID-19 pandemic amplified the need to examine how risk perceptions related to hurricane evacuations shift when vaccines become available. This study explores individuals' expected evacuation plans during the early stages of COVID-19 vaccine availability.

Methods: In March 2021, an online survey was disseminated in Puerto Rico and the US Virgin Islands.

Results: An overwhelming majority (72.6%) of respondents said that their vaccination status would not affect their hurricane evacuation intentions. The unvaccinated were significantly more likely to consider evacuating during a hurricane than the vaccinated. Even with vaccines available, respondents suggested they were less likely to evacuate to a shelter during the 2021 season than prior to the COVID-19 pandemic. Respondents generally believed that the risk of contracting COVID-19 at a shelter was greater than the risk of sheltering-in-place during a hurricane.

Conclusions: Government officials need to develop and communicate clear information regarding evacuation orders for municipalities that may be more impacted than others based on the trajectory of the storm, social determinants of health, and other factors like living in a flood zone.

Puerto Rico (PR) and the US Virgin Islands (USVI) are vulnerable to a suite of natural hazards including earthquakes, tsunamis, wildfires, extreme heat events, and drought. However, tropical cyclones pose a particular threat to both PR and the USVI (PRVI).[1] In November 2019, a novel coronavirus emerged in Wuhan, China, and by March 2020, the World Health Organization (WHO) officially declared COVID-19 a global pandemic.[2] The pandemic profoundly affected hurricane evacuation decisions, as mass-sheltering facilities often conflict with disease control strategies.[3,4]

Prior to the development and distribution of the COVID-19 vaccine, Shultz et al. noted an elevated risk of contracting COVID-19 during hurricane mitigation activities.[5] The authors suggest that 2 of the primary mitigation strategies—evacuating and utilizing public shelters—were associated with higher COVID-19 risks. These increased risks likely influence people's perceptions of public shelters. As Collins et al.[6,7] observed, most individuals who would have considered evacuating to a shelter before the pandemic were now reconsidering that option. This shift reflects a potential decrease in the use of public shelters, especially when the decision is coupled with concerns about COVID-19. The authors found that many individuals had a negative perception of public shelters, with approximately half of respondents expressing little confidence in the shelters' ability to implement effective measures to prevent the spread of COVID-19. Most respondents indicated that they would "definitely" shelter-in-place to minimize exposure to large groups in a shelter, and about three-quarters believed the risks of being in a shelter were greater than staying at home during a hurricane.[8]

Since these studies, the COVID-19 vaccine became widely available to the public, with the first vaccinations administered in PRVI in December 2020. The purpose of this study is to explore whether the availability of COVID-19 vaccines influences the expected hurricane evacuation plans of PRVI residents. Specifically, this study aims to better understand how compound factors, such as the availability of the vaccine, influence evacuation decisions, particularly during the early stages of vaccine distribution in a global pandemic.

Background

Tropical Cyclones in the PRVI Region

The PRVI region is particularly vulnerable to tropical cyclones, as more than 15% of yearly Atlantic hurricanes affect the Caribbean Antilles, which includes PRVI.[9] According to the National Hurricane Center (NHC),[10] this region averages 1.1-1.9 named tropical cyclones per year. These storms often bring high winds, storm surge, intense rains, flooding, and landslides to these small, isolated islands. Such life-threatening conditions frequently result in disaster-induced displacement or evacuation orders for residents.

From March 2020 to May 2021, no hurricanes passed within 60 nautical miles of PRVI. However, prior to the pandemic, the islands were directly impacted by Hurricanes Irma and Maria in 2017, and by Hurricane Dorian in 2019. Hurricane Irma passed just north of PRVI in 2017 as a Category 5 storm. Shortly after, Hurricane Maria made direct landfall over USVI on September 19, 2017 and over PR on September 20, 2017 as a high-end Category 4 storm. Due to weak and outdated utility systems, compounded by the effects of Irma weeks before, Maria severely damaged the islands' critical infrastructure. This led to cascading failures in energy, transportation, communications, water supply, and wastewater treatment systems, which persisted for weeks to months after the storm.[11] Both hurricanes prompted significant evacuations, with shelters housing 10 692 people in PR and 558 people in USVI.[8,12] The aftermath of these storms also caused major disruptions to essential health services, as both health care and public health infrastructure were heavily damaged.[13] Kishore et al.[14] estimate that mortality rates following the storms were 62% higher than the year before, with nearly one-third of the deaths attributed to delayed or interrupted health care. Hurricane Dorian, a low-end Category 1 storm as it passed between PR and the USVI, was the most recent hurricane experienced by our respondents prior to survey distribution. Although many feared Dorian would be the first major test of the public infrastructure since Hurricanes Irma and Maria, it turned out to be relatively mild, producing more rain than wind and causing little damage compared to previous storms.[15]

Vulnerability and Hurricane Evacuation Decision-Making

The vulnerability and preparedness of individuals in response to a natural hazard varies across socioeconomic demographics. Factors such as access to resources, limited representation, social capital, cultural beliefs, physical limitations, and the built environment all contribute to social vulnerability.[16,17] Researchers have also found that income, prior experiences, perceived susceptibility and severity, age, the presence of a chronic conditions, and social inequities are significant predictors of preparedness for hurricane evacuations.[18–23] Goldberg et al.[24] discovered that prior hurricane experiences strongly influence future evacuation intentions. Positive experiences tend to promote similar responses to future storms, while financial losses from past evacuations can increase evacuation intentions. Emotional impacts, however, can have mixed effects, as they influence fear, anxiety, and an individual's sense of self-efficacy.[25]

Huang, Lindell, and Prater[26] suggest that official warnings are strong predictors of hurricane evacuations. Similarly, Lazo et al.[27] found that evacuation orders from public officials have a greater impact on evacuation intentions than hurricane watches and warnings issued by forecasters. However, repeated false alarm evacuations can erode public trust, diminishing the credibility of official advisories.[28] In addition, many individuals rely on their social networks for information and decision-making. In minority communities, the strength of social connections positively influenced evacuation decisions during Hurricane Katrina by affecting access to critical resources such as transportation, money, and shelter.[29]

COVID-19 in the PRVI Region

At the time of the survey (March 2021–May 2021), the region was heavily affected by COVID-19, with more than 100 000 infections and 2000 COVID-related deaths (Table 1). While confirmed COVID-19 cases remained relatively steady during the survey period in the USVI, PR saw a surge in April 2021 (Table 1). This increase was followed by a rise in COVID-related hospitalizations and deaths in PR in April and May 2021. Overall, infection rates and COVID-19 related deaths in PR were higher than those in the USVI.[30] During the study period, approximately 20%-50% of PR's population has received at least 1 dose of the COVID-19 vaccine, while 12%-36% were fully vaccinated. The USVI had a slightly higher vaccination rate in March and April but lagged PR's rates in May 2021 (Table 1).

Disease Transmission and Hurricane Evacuation Decision-Making

The compounded risks of COVID-19 and hurricanes present new challenges for decision-making during hurricane evacuations.[5,31–36] Wu et al.[35] suggest that cognitive risk perceptions of both hurricanes

Table 1. COVID-19 and vaccination statistics in PRVI. Population estimates obtained from the United States Census Bureau[59,60] and COVID cases, positivity rates, deaths, and vaccination data obtained from Dong et al.[30]

Total population estimates			
Date	PR	USVI	Total
July 2021	3 263 584	87 146	3 350 730
Cumulative (monthly) confirmed COVID–19 cases			
Date	PR	USVI	Total
March 2021	107 470 (6 886)	2907 (261)	110 377 (7147)
April 2021	131 956 (24 486)	3125 (218)	135 081 (24 704)
May 2021	138 757 (6 801)	3442 (317)	142 199 (7118)
Cumulative (monthly) COVID–19 deaths			
Date	PR	USVI	Total
March 2021	2118 (82)	26 (1)	2144 (83)
April 2021	2310 (192)	27 (1)	2337 (193)
May 2021	2505 (195)	27 (0)	2532 (195)
Number of persons at least partially vaccinated (percent of population)			
Date	PR	USVI	Total
March 2021	692 863 (21.2%)	24 315 (27.9%)	717 178 (21.4%)
April 2021	1 173 182 (35.9%)	33 281 (38.2%)	1 206 463 (36.0%)
May 2021	1 621 909 (49.7%)	37 755 (43.3%)	1 659 664 (49.5%)
Number of persons fully vaccinated (percent of population)			
Date	PR	USVI	Total
March 2021	393 521 (12.1%)	13 575 (15.6%)	407 096 (12.1%)
April 2021	760 772 (23.3%)	25 989 (29.8%)	786 761 (23.5%)
May 2021	1 183 285 (36.3%)	31 243 (35.9%)	1 214 528 (36.2%)

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and COVID-19 significantly influenced evacuation decisions during Hurricane Laura in 2021. These decisions are often shaped by the conflicting needs to socially distance to prevent disease spread while also congregating in safe locations during a hurricane. This tension may exacerbate preexisting vulnerabilities and complicate the traditional emergency management frameworks designed for singular disasters.[3,5,33,37–41] Tang, Luo, and Walton[41] found that social distancing measures imposed for COVID-19 hindered preparedness, response, and recovery efforts during hurricanes. Emergency managers must rapidly assess both the hydrological and wind threats from an incoming storm while also addressing residents' health needs in shelters.[42,43] Efforts to support the sick and prevent disease spread often strain resources, limiting the capacity of emergency managers to respond to additional crises.[44] Whytlaw et al.[3] emphasize that vulnerabilities from preexisting health conditions and socioeconomic disparities are major concerns for emergency planners. Without adequate preparation, these multi-hazard events can be far more damaging than if each hazard were managed in isolation.[45]

Studies conducted since the pandemic have revealed a negative perception of public shelters, with many people expressing greater reluctance to risk contracting COVID-19 in a shelter than to endure a hurricane at home.[6–8,46] Alam et al.[47] observed similar behaviors in Bangladesh ahead of Cyclone Amphan in 2020, where residents were less likely to evacuate to shelters due to fears of contracting COVID-19. Botzen et al.[48] note that older individuals, in particular, are more hesitant to evacuate due to their heightened vulnerability to the virus. The fear of contracting COVID-19 in evacuation shelters is supported by evidence; Pei et al.[39] found a higher infection rate in shelters during the early stages of the pandemic.

Hurricane Evacuation Decision-Making in PRVI

The populations of PRVI differ from those studied in much of the existing literature on evacuation decision-making, which predominately focuses on the contiguous United States. Since evacuation decisions involve both logistical and mental preparation,[49] individuals from varying circumstances are likely to respond differently to risk information. Thus, it is essential to account for these differences when developing communication strategies for natural hazard preparedness.[50] Senkbeil et al.[51] found that risk perceptions of hurricane hazards can vary between inland and coastal residents, with inland populations typically more concerned with wind, tornadoes, falling trees, and inland flooding, while coastal residents are more focused on storm surge and other coastal risks. However, this pattern may not apply to PRVI residents, as mass evacuations from coastal areas to safer inland locations are not feasible on smaller islands and are limited on larger islands.[52,53] Emergency managers must also consider the potential for residents fleeing the island entirely, rather than evacuating inland.[54] Although data on the number of residents who fled PRVI in preparation for Hurricane Maria is scarce, it is estimated that more than 300 000 Puerto Ricans left for the US mainland in the storm's aftermath, resulting in a net emigration of over 123 000 individuals.[54,55]

Few studies have been conducted in PRVI, and most of the available data were collected prior to the widespread availability of COVID-19 vaccines. Collins et al.[8] found that, in the pre-vaccine era, half of the participants felt vulnerable to the disease, and nearly three-quarters believed the risks of contracting COVID-19 in public shelters outweighed those of enduring a hurricane without evacuating. Additionally, Puerto Ricans who were more concerned about evacuation costs and the potential for spreading COVID-19 within their community were less likely to evacuate, even when evacuation orders were issued. In contrast, those with prior hurricane evacuation experience and greater concerns about infecting friends and family (as opposed to society at large) were more likely to evacuate despite the threat of COVID-19.[56]

Research Questions

With the availability of vaccines, PRVI residents may currently have different perspectives on their level of risk during the hurricane season. The purpose of this research is to determine whether vaccine availability and status influence an individual's risk perceptions and evacuation intentions for a hurricane. In particular, the study explores (1) whether vaccination status affects hurricane evacuation plans; (2) whether an individual's evacuation plans are influenced by their perceptions of others' vaccination status; and (3) whether there are spatial patterns in evacuation intentions for residents of PRVI.

Methods

Survey Design

The survey instrument used in this study was adapted from the pre-vaccine survey developed by Collins et al.[8] Updates to the original instrument were made following consultations with the research team, local public health and emergency management professionals, and the National Weather Service in PRVI. The revised survey focused on gathering valuable information to support practitioners involved in hurricane response and COVID-19 pandemic management in PRVI. A draft of the updated instrument was circulated to experts in emergency management, public health, geosciences, and communications for feedback.

The survey was pilot tested with bilingual participants (Spanish and English) to assess the equivalence of the translated versions and reach a consensus on alternative phrasing. Overall, the questions were well-received in terms of perceived clarity, translation accuracy, question structure, and technological combability, with only minor revisions needed. The survey relied on self-reported data regarding vaccination status and expected evacuation plans. Findings from Tjaden et al.[57] suggest that self-reported vaccination status aligns well with actual records. After final revisions, the 50-question instrument was submitted to the Ponce Health Sciences Human Research Protection Program and was exempted by the Institutional Review Board (IRB).

Sampling Strategy and Distribution

The targeted sampling population was all adult residents of PRVI, with participants aged 21 and older in PR and 18 and older in the USVI, as required by the IRB (Figure 1). The survey was distributed online through Qualtrics using convenience sampling between March 2021 and May 2021. Following methods outlined by Norris,[58] the sample was obtained through an extensive network of personal and professional connections, who shared the survey link within their networks.

The Puerto Rico Public Health Trust (PRPHT) played a key role in disseminating the survey link to community leaders, community-based organizations, public health and emergency management professionals, local news outlets, and via social media to reach a broad and diverse range of respondents. After assessing the geographic distribution of responses, the PRPHT team used targeted Facebook ads to increase participation from underrepresented municipalities. Respondents were not compensated for their participation.

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Figure 1. Townships and islands in PRVI.

Sample Demographics

In total, 547 respondents participated in the survey, representing 71 municipalities in PR and the 3 primary islands of USVI—St. Croix, St. John, and St. Thomas (Figure 2). The overall survey completion rate was 71.7% (n = 392); however, the number of responses varied by question. Only responses from participants who provided their location were analyzed, with 82.2% (n = 506) from PR and 17.8% from the USVI. Most respondents were from St. Croix and St. Thomas in the USVI, and from Mayagüez, Ponce, Caguas, and San Juan in PR (Figure 2). The majority (76.9%, n = 506) completed the survey in Spanish, and 64.2% of these respondents considered English their second language.

The median birth year of respondents was 1974 (1975 for PR and 1970 for USVI), aligning with the median age reported in the 2020 census for both territories.[59] The oldest respondent was born in 1926, and the youngest in 2000. The sample was predominately female (71.8%, n = 476), which is higher than the 52.1% female population across the islands.[59,60] There was a slightly higher percentage of female respondents in the USVI (77.3%) compared to PR (70.6%), though the difference was not significant ($Z = 1.46$, $P = 0.144$).

Most respondents identified as Hispanic or Latinx (68.8%, n = 384), with the remaining participants identifying across other racial and ethnic categories. However, a notable territorial difference was observed: 85.6% (n = 298) of respondents from PR identified as Hispanic or Latinx, while 56.6% (n = 76) of respondents from the USVI identified as Black or African American. These proportions, while consistent with the 2020 Census data, were significantly different ($P < 0.01$) than the population statistics: 98.8% of PR residents identify as Hispanic or Latinx, and 71.4% of USVI residents identify as Black or African American.[59,60]

Approximately three-quarters (77.0%, n = 366) of the sample earned a bachelor's degree, and 65.8% had completed a post-graduate degree, both of which are disproportionately higher ($Z = 20.78$, $P < 0.001$) than the overall population of the islands.[59,60] Respondents from PR (72.8%) were significantly more likely ($Z = 5.34$, $P < 0.001$) to hold an advanced degree than respondents from the USVI (40.5%). The average household size of respondents was 2.89 (SD = 1.36), with no significant difference ($t = 0.352$, $P = 0.73$) between PR and the USVI. Additionally, 40.8% (n = 319) of respondents had at least 1 child under 18, and 33.1% (n = 363) reported having at least 1 household member aged 65 or older. Respondents from the USVI (53.1%, n = 64) were significantly more likely ($Z = -2.26$, $P = 0.024$) to have a child in the household than respondents from PR (37.6%, n = 255).

Over half of the sample (56.1%, n = 285) reported being employed full-time, with a median household income range of $30k-$39k per year. Respondents from the USVI had a significantly higher ($X^2(1) = 14.97$, $P < 0.001$) median income ($60k-$69k)

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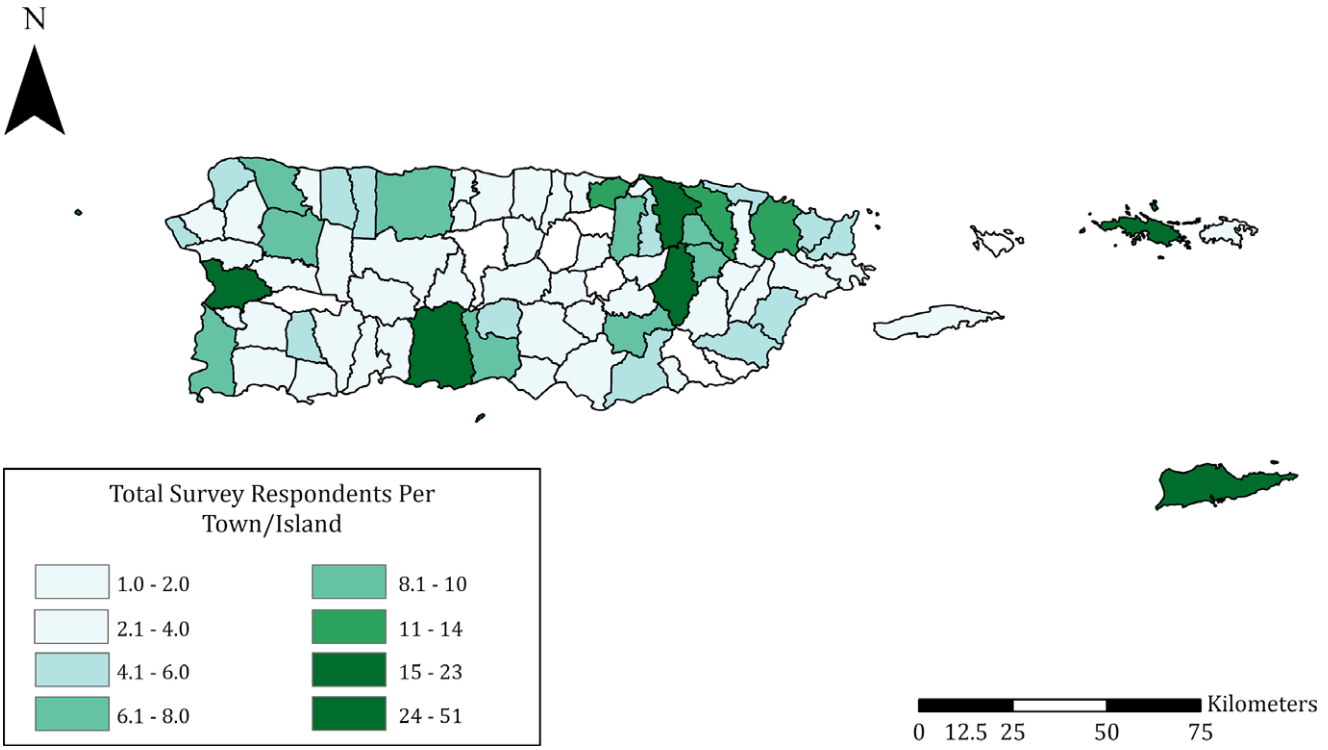

Figure 2. Location of survey respondents per municipality and island. The total number of respondents per municipality (PR) and island (USVI) is shown.

compared to those from PR ($30k-$39k). While both median incomes exceed the overall population statistics ($21 967 for PR and $40 408 for the USVI), this finding reflects a broader trend that USVI residents tend to have higher incomes than their counterparts.[59,60] While some demographic characteristics closely match those of the island populations, limitations in the sampling procedure may have influenced the results, which are further discussed in the Limitations section.

Statistical Analyses

Descriptive statistics were generated for the overall sample and by territory (PR vs. USVI). These statistics included sociodemographic variables, vaccination status, COVID-19 vulnerability, risk perception, the impact of hurricanes, and hurricane evacuation plans. Given the nonparametric nature of most responses, McNemar's change tests and chi-square goodness of fit tests were used to assess whether there were significant associations between categorical variables within each question. Chi-square tests of independence were applied to examine whether demographic variables (e.g., island resident, sex, age) influenced survey responses.

Since hurricane hazards are often geographically distributed,[51] Getis-Ord hot spot analyses[61–64] were used to assess spatial variability in some responses. The results from these analyses identify areas where responses are significantly clustered.

Results and Discussion

Vaccination Status

At the time of the survey, 57.3% (n = 495) of respondents reported being fully vaccinated against COVID-19 (i.e., 2 doses of the Moderna or Pfizer vaccine, or a single dose of the Johnson & Johnson vaccine), while 21.7% had received only the first dose of a 2-dose series. A small proportion of respondents had yet to receive a dose of the vaccine, with some waiting for the vaccine to be available longer (7.1%) and others indicating no intention to receive the vaccine (8.5%) (Table 2). Respondents from PR were significantly ($X^2(1) = 45.31$, $P < 0.001$) more likely to be at least partially vaccinated than those from USVI (Table 2). Additionally, a significantly ($X^2(1) = 46.95$, $P < 0.001$) higher percentage of USVI respondents were waiting to receive the vaccine (17.0%) or had no intention on receiving it (21.6%) compared to respondents from PR (8.5% and 7.1%, respectively). These findings align with population statistics, as PR residents were significantly ($X^2(1) = 10.51$, $P = 0.001$) more likely to be at least partially vaccinated and significantly ($X^2(1) = 9250$, $P < 0.001$) more likely to be fully vaccinated against COVID-19 than residents of the USVI (Table 1). These results suggest that USVI residents exhibited more vaccine hesitancy, indicating a need for greater efforts to reduce vaccine hesitancy and refusal on the islands.

It should be noted that vaccination status may influence an individual's perception of their vulnerability to COVID-19 transmission[65] and could impact the results of the survey. To reduce potential biases, we analyzed the responses of vaccinated versus non-vaccinated individuals. Additionally, we compared the vaccination rates of our

Table 2. Vaccination sample statistics, total, and percentage, for the PRVI populations

	Sample population and percentage vaccinated				
	Fully	Partially	No/want to	No/waiting	No/won't
PR	243 (59.95%)	98 (24.1%)	22 (5.4%)	27 (6.7%)	16 (3.9%)
USVI	40 (45.5%)	9 (10.2%)	5 (5.7%)	15 (17.0%)	19 (21.6%)
Total	283 (57.3%)	107 (21.7%)	27 (5.5%)	42 (8.5%)	35 (7.1%)

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sample with those of the PRVI population (Tables 1 and 2). Although a larger percentage of respondents in each territory reported being at least partially vaccinated compared to their respective population statistics, the differences were not significant for either PR ($X^2(1) = 0.08$, $P = 0.78$) or the USVI ($X^2(1) = 1.05$, $P = 0.31$). This suggests that our results are consistent with population-level vaccination trends.

Hot spot analyses were conducted to examine the spatial distribution of respondents' vaccination status (Figure 3). The results reveal significant clustering of fully vaccinated individuals in south-central PR (Coamo, Salinas, and Aibonito), and a significant ($P \leq 0.05$) clustering of non-vaccinated individuals in eastern PR (Loíza, Río Grande, and Ceiba) (Figure 3). Analyzing the spatial distribution of vaccinated versus unvaccinated individuals can assist emergency managers in addressing both community needs and concerns related to natural hazards, as well as vulnerability to COVID-19.[4]

Vaccination Status and Demographics

Vaccination rates across different demographic groups were examined. Although there were slight variations in the vaccination rates between sexes (Table 3), no significant differences were found in full vaccination rates between men and women ($X^2(1) = 1.76$, $P = 0.19$), nor in partial vaccination rates ($X^2(1) = 0.50$, $P = 0.48$). Additionally, no significant differences in vaccination rates were observed between men and women in either PR or the USVI ($X^2(1)$, $P > 0.05$). These findings suggest that sex was not a determining factor in receiving the COVID-19 vaccination in PRVI.

Most respondents self-identified as Hispanic or Latinx (n = 231), and the majority of them were at least partially vaccinated against COVID-19 (83.1%) (Table 3). Hispanics/Latinx individuals in PR had a considerably higher vaccination rate (82.7%) compared to those in the USVI (33.3%). However, due to the lack of self-identified Hispanic/Latinx respondents in the USVI, a statistical comparison between the 2 territories was not possible. Respondents who identified as non-Hispanic White were significantly ($X^2(1) = 17.32$, $P < 0.001$) more likely to be fully vaccinated compared to other racial/ethnic groups. In contrast, respondents identifying as Black or African American had the lowest vaccination rate (34.0%, n = 47) and the highest rate of non-vaccination, with 57.4% reporting they had never received a dose of the COVID-19 vaccine (Table 3).

While non-Hispanic White respondents in both PR and the USVI were more likely to report full vaccination compared to Black or African American respondents, the difference was not significant in PR ($X^2(1) = 1.91$, $P = 0.17$) but was significant in the USVI ($X^2(1) = 15.82$, $P < 0.001$). This suggests a greater racial disparity in vaccination rates in the USVI than in PR. These patterns align with findings by Kriss et al.,[66] which showed that non-Hispanic White adults in the US had the highest COVID-19 vaccination rates by the end of April 2021. However, in our study, the vaccination rate among Hispanic/Latinx respondents was considerably higher than the percentage reported by Kriss et al.[66] The higher vaccination rates among Hispanics/Latinx respondents in PR may be attributed to the island's leadership in vaccination rates, as PR had the highest vaccination rates among US states and territories by October 2021.[67] This is likely due to PR's political culture and general acceptance of vaccines. Although demographic data were not analyzed spatially due to the limited number of responses, the results from the hot spot analysis (Figure 3) align with demographic data from PR, where Loíza had one of the lowest vaccination rates on the island. This was largely attributed to the predominantly Black and lower-income population in that municipality.[67]

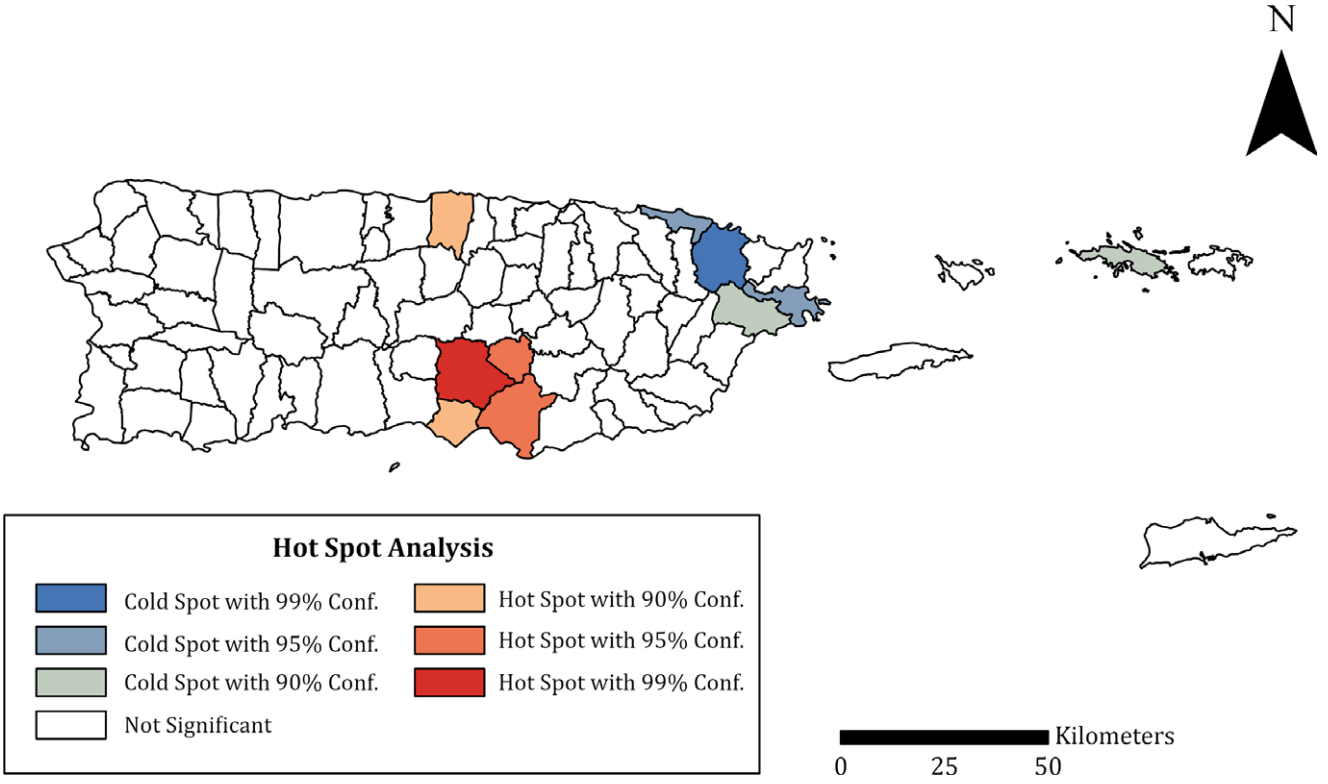

Figure 3. Getis-Ord Gi* hot spot analysis assessing the spatiality of vaccination status. Areas denoted in red represent significant ($P \leq 0.10$) clustering of respondents who were vaccinated against COVID-19, while areas in blue represent significant ($P \leq 0.10$) clustering of respondents who were unvaccinated.

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Table 3. Vaccination rates and demographics for PRVI. Percentages for each demographic are in parentheses

Vaccination status and gender					
Total					
Vaccination		Male			Female
Fully		67 (52.8%)			201 (58.8%)
Partially		101 (79.5%)			263 (76.9%)
Total responses		127			342
PR					
Vaccination		Male			Female
Fully		61 (56.0%)			167 (60.9%)
Partially		48 (86.2%)			107 (80.7%)
Total responses		109			274
USVI					
Vaccination		Male			Female
Fully		6 (34.0%)			34 (50.0%)
Partially		7 (42.0%)			42 (61.8%)
Total responses		18			68
Vaccination status and race/ethnicity					
Total count					
Vaccination	Non-Hispanic White	Black	Hispanic	Multiple	Other
Fully	37 (72.5%)	16 (31.4%)	133 (57.6%)	20 (57.1%)	3 (60.0%)
Partially	44 (86.3%)	22 (43.1%)	192 (83.1%)	29 (82.9%)	3 (60.0%)
Total responses	51	51	231	35	5
PR					
Vaccination	Non-Hispanic White	Black	Hispanic	Multiple	Other
Fully	19 (65.5%)	4 (40.0%)	131 (58.2%)	17 (53.1%)	1 (50.0%)
Partially	25 (86.2%)	8 (80.0%)	186 (82.7%)	26 (81.3%)	1 (50.0%)
Total responses	29	10	225	32	2
USVI					
Vaccination	Non-Hispanic White	Black	Hispanic	Multiple	Other
Fully	18(81.8%)	12 (29.3%)	2 (33.3%)	3 (100%)	2 (66.7%)
Partially	18 (81.8%)	12 (29.3%)	2 (33.3%)	3 (100%)	2 (66.7%)
Total responses	22	41	6	3	3
Vaccination status and income					
Total count					
Vaccination	< $20k	$20k-$49k	$50k-$99k		> $100k
Fully	30 (44.1%)	68 (55.7%)	59 (65.6%)		19 (63.3%)
Partially	53 (77.9%)	94 (77.0%)	70 (77.8%)		23 (76.7%)
Total responses	68	122	90		30
PR					
Vaccination	< $20k	$20k-$49k	$50k-$99k		> $100k
Fully	30 (44.1%)	60 (59.4%)	41 (75.9%)		13 (65.0%)
Partially	53 (77.9%)	84 (83.2%)	49 (90.7%)		17 (85.0%)
Total responses	68	101	54		20

(*Continued*)

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Table 3. (*Continued*)

Vaccination status and income					
Total count					
Vaccination	< $20k	$20k-$49k	$50k-$99k	> $100k	
USVI					
Vaccination	< $20k	$20k-$49k	$50k-$99k	> $100k	
Fully	0 (N/A)	8 (38.1%)	18 (50.0%)	6 (60.0%)	
Partially	0 (N/A)	10 (47.6%)	21 (58.3%)	6 (60.0%)	
Total responses	0	21	36	10	
Vaccination status and politics					
Total count					
Vaccination	Very cons.	Cons.	Mod.	Lib.	Very lib.
Fully	22 (57.9%)	38 (56.7%)	62 (57.9%)	45 (62.5%)	14 (53.8%)
Partially	29 (76.3%)	52 (77.6%)	82 (76.6%)	63 (87.5%)	18 (69.2%)
Total responses	38	67	107	72	26
PR					
Vaccination	Very cons.	Cons.	Mod.	Lib.	Very lib.
Fully	20 (62.5)	35 (58.3%)	53 (62.4%)	30 (57.7%)	12 (60.0%)
Partially	26 (81.2%)	48 (80.0%)	71 (83.5%)	47 (90.4%)	16 (80.0%)
Total responses	32	60	85	52	20
USVI					
Vaccination	Very cons.	Cons.	Mod.	Lib.	Very lib.
Fully	2 (33.3%)	3 (42.9%)	9 (40.9%)	15 (75.0%)	2 (33.3%)
Partially	3 (50.0%)	4 (57.1%)	11 (50.0%)	16 (80.0%)	2 (33.3%)
Total responses	6	7	22	20	6

Respondents from wealthier households (≥ $50k/yr) were significantly ($X^2(1) = 5.82$, $P = 0.016$) more likely to be fully vaccinated than those from lower-income households (< $50k/yr) (Table 3). However, these patterns were not consistent across the 2 territories. In PR, wealthier households were significantly more likely to be vaccinated than lower-income households ($X^2(1) = 8.16$, $P = 0.004$), while no such association was found in the USVI ($X^2(1) = 0.91$, $P = 0.34$). The lack of significance in the USVI may be due to the higher median income and the lower proportion of individuals earning less than $20k annually. This suggests that income may not have been as significant a factor influencing vaccination status in the USVI. These findings are consistent with those of López-Cepero et al.,[68] who reported that lower-income individuals in PR were more likely to express no intention of receiving the COVID-19 vaccine by February 2021.

There was no significant variation in vaccination rates based on political ideology ($X^2(1) = 0.68$, $P = 0.41$) (Table 3). These results were consistent across both PR and the USVI ($X^2(1)$, $P > 0.10$), but differ from studies conducted in the mainland US, where conservative voters generally had lower COVID-19 vaccination rates compared to liberal voters.[69] This discrepancy may stem from the overrepresentation of PR respondents in the survey and the unique political landscape of the island. Traditional US party affiliations (e.g., Democrats and Republican) do not directly apply to PR's local politics, where parties are largely defined by their stance on PR's statehood. As a result, while conservatism on the US mainland is often linked with the Republican Party, the opposition to COVID-19 vaccines among Republicans[69] may not correlate with conservative views in PRVI. The absence of strong partisan divides regarding the COVID-19 vaccine in PRVI may help explain the higher vaccination rates there compared to the US mainland.[67] While convenience sampling may introduce some bias, the vaccination patterns observed across different demographics are consistent with other studies conducted in PRVI.

Hurricane Evacuation Plans

Survey participants were asked what their evacuation plans were for the 2021 hurricane season in the event of a severe hurricane. The majority of respondents (67.9%, n = 501) indicated they would stay home, while 21.8% planned to evacuate to a shelter, hotel, the home of a friend or family member, or even leave the island. Additionally, 7.8% selected both staying home and evacuating. The strong preference for sheltering in place may be influenced by concerns about COVID-19, as Page-Tan and Fraser[70] suggest that while evacuation-related mobility did not immediately lead to a surge in COVID-19 cases, individuals who sheltered in place experienced a decreased risk of spreading the virus.

Only 5.0% (n = 501) of respondents indicated they would consider going to a public shelter if a severe hurricane were to hit during the 2021 season. There was no significant ($X^2(1) = 5.52$, $P = 0.36$) difference in the evacuation plans between respondents from PR and

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the USVI. The reluctance to evacuate to public shelters may stem from dissatisfaction with such facilities, combined with a preference to endure the storm at home with family and friends rather than in a shelter with strangers. During the peak of the pandemic, family members may have also felt uncomfortable leaving behind individuals who preferred to shelter in place. These findings align with prior research, which found that in the absence of vaccines, many people preferred to face hurricane risks at home or in nontraditional shelters, rather than in public shelters where the risk of COVID-19 transmission was heightened.[6–8,46]

After the survey concluded, Hurricane Fiona made landfall in southwestern PR on September 18, 2022, as a Category 1 storm.[71] While Fiona was not classified as a major hurricane, it caused significant damage, with over 30 inches of rain leading to severe flooding, landslides, and rockslides.[72] The storm also severely impacted PR's aging and inefficient food, energy, and water infrastructure systems. A week later, approximately 746 144 homes and businesses were still without power, and 778 320 people lacked access to potable water, as recovery efforts from Hurricane Maria in 2017 remained incomplete.[72–74] Although Hurricane Fiona provides important context for understanding post-vaccine evacuation behaviors, it is crucial to note that evacuation rates were lower than during Hurricane Maria, even with the availability of COVID-19 vaccines. For instance, only 2198 people sought shelter across 132 sites in PR, and over 1000 individuals required rescue.[75] These lower numbers reflect the broader trend in our survey, where fewer respondents expressed a willingness to evacuate to a shelter compared to pre-pandemic times. However, we caution against overinterpreting these findings, as Fiona was a relatively weak storm, and COVID-19 vaccines had been available for an additional year following the survey.

Respondents living in flood zones who would be advised or required to evacuate during a hurricane were significantly ($X^2(7) = 522.1$, $P < 0.001$) more likely to indicate they would evacuate (39.4%, n = 94) compared to those who did not live in a flood zone (9.7%, n = 308). These findings align with previous research showing that official warnings and evacuation orders are strong predictors of hurricane evacuation behavior.[26,27] Additionally, respondents who had previously been advised or ordered to evacuate by officials were significantly more likely to report they would evacuate during the 2021 hurricane season (53.2%, n = 47) compared to those with no prior evacuation experience ($X^2(3) = 38.4$, $P < 0.001$). Despite the compounded risks of COVID-19, these results are consistent with Goldberg et al.,[24] who found that past hurricane experiences influence future evacuation intentions.

When comparing evacuation plans across different demographics groups, women were significantly ($X^2(4) = 11.41$, $P < 0.02$) more likely to consider evacuating during the 2021 hurricane season (26.4%, n = 333) compared to men (12.2%, n = 123). However, no significant (X^2, $P > 0.10$) relationships were found between evacuation intentions and respondents' race/ethnicity, income, political ideology, or age.

COVID-19 and Hurricane Evacuation Plans

The remaining analyses focus on how COVID-19 and vaccine availability influenced respondents' evacuation plans for the 2021 hurricane season in PRVI. When asked whether they would have evacuated to a shelter before the COVID-19 pandemic, responses were not evenly distributed across the categories ($P < 0.001$). Most respondents (34.2%, n = 473) stated they "definitely" would not have evacuated to a shelter, while 30.4% said they "probably" would have (Table 4). There was no significant difference ($X^2(4) = 2.33$, $P = 0.51$) between responses from PR and USVI residents.

Respondents were then asked to consider the current COVID-19 situation and whether they would evacuate to a shelter if needed during the 2021 hurricane season (Question 33). Of the 474 responses, 37.6% said they "definitely" would not evacuate to a shelter, 24.7% said they "probably" would not, 24.9% said they "probably" would, and 7.2% said they "definitely" would (Table 4). A significantly greater percentage ($X^2(1) = 3.84$, $P < 0.05$) of respondents indicated they "probably" or "definitely" would not go to a shelter due to COVID-19 concerns, compared to those who would. There was no significant

Table 4. Respondents' perception of COVID-19 vulnerability during a hurricane evacuation. Results reflect responses to Questions 32-35 of the survey

Question 32. Prior to COVID–19, if I needed to evacuate to a disaster shelter during hurricane season, I would most likely have done so.			**Question 34.** I think the risks of being in a disaster shelter during the COVID–19 pandemic would be worse than staying at home and enduring the risks of a hurricane.		
Response	Total	Percent	Response	Total	Percent
Definitely True	69	14.6	Definitely True	207	43.7
Probably True	144	30.4	Probably True	160	33.8
Probably False	98	20.7	Probably False	72	15.2
Definitely False	162	34.2	Definitely False	35	7.4
Total	473		Total	474	
Question 33. Considering the current situation with COVID–19, I would still go to a shelter if I needed to during a hurricane evacuation advisory in 2021.			**Question 35.** I think if I went to a disaster shelter during a hurricane, the authorities will have adequate safeguards in place to prevent the spread of COVID–19 in the facility, such as being able to social distance at least 6 ft. in place.		
Response	Total	Percent	Response	Total	Percent
Definitely True	36	7.6	Definitely True	69	14.5
Probably True	125	26.4	Probably True	191	40.2
Probably False	124	26.2	Probably False	127	26.7
Definitely False	189	39.9	Definitely False	88	18.5
Total	474		Total	475	

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difference ($X^2(3) = 5.13$, $P = 0.16$) between responses from PR and USVI residents. However, there was a significant decrease (McNemar Change Test, $P < 0.001$) in the proportion of respondents who "definitely" or "probably" would have evacuated to a shelter prior to COVID-19 (45.0%, n = 473) compared to those considering shelter evacuation in 2021 (34.0%, n = 474) (Table 4). This suggests that, despite the availability of vaccines, the threat of COVID-19 continued to influence evacuation decisions regarding public shelters. These findings contrast with those of Yusuf et al.[36] and Diaz et al.,[31] conducted in the Hampton Roads area of the US mainland, which indicated fewer concerns regarding COVID-19's impact on evacuation decisions. In contrast, our results suggest that PRVI residents were more likely to shelter-in-place, prioritizing COVID-19 risks over the dangers posed by a severe hurricane.

The general distrust or dissatisfaction with public shelters highlights the need for emergency management professionals to reassess their approach to sheltering and develop tailored communication strategies for their communities.[56] This should include a reevaluation of shelter organization, ensuring that pre-staged resources are available on-site, and crafting clear messaging that emphasizes the importance of shelters as low-cost, safe options during disasters. Additionally, it is critical to establish protective measures for at-risk populations to prevent disease outbreaks. Since the majority (55.4%, n =496) of respondents reported that their trust in public shelters has remained the same since the pandemic, efforts should focus on messaging campaigns that reassure the public about the safety measures implemented in shelters to mitigate COVID-19 risks.

Improving existing shelters involves considering the needs of vulnerable populations. Shelters should offer space and services for individuals with underlying medical conditions, mental health support, and free transportation to and from the shelter. Other considerations include accommodations for pets, a stronger security presence, and a clear reporting process for incidents that may occur during sheltering.[3,22,27,37]

We then explored whether the decrease in the potential use of disaster shelters was related to respondents' self-reported vulnerability to COVID-19. However, there was no significant association ($P = 0.80$) between self-identified COVID-19 vulnerability and the likelihood of using a disaster shelter prior to the pandemic, nor between COVID-19 vulnerability and the intention to evacuate during a severe hurricane in 2021 ($P = 0.84$). Instead, the reduced willingness to use shelters appears to stem from the public's perception of the risk of contracting COVID-19 in a shelter. While more than half (55%, n = 475) of respondents believed that the safeguards in disaster shelters would be sufficient to prevent COVID-19 spread, nearly half (43.7%, n = 475) felt that the risks of sheltering during the pandemic outweighed those of a hurricane (Table 4).

Respondents who considered themselves vulnerable to COVID-19 were particularly skeptical of sheltering, as they were significantly more likely ($X^2(6) = 19.67$, $P = 0.003$) to view going to a disaster shelter as riskier than sheltering at home due to the potential spread of COVID-19. These findings align with earlier studies conducted before vaccine availability,[6–8] suggesting that, despite the availability of vaccines, many respondents still perceived an inevitable risk of transmission within shelters. However, over half of respondents also believed that adequate safeguards were in place to mitigate this risk.

The skepticism toward public shelters may be further explained by uncertainty over the vaccination status of other evacuees. Those who considered themselves vulnerable to COVID-19 were significantly more likely ($X^2(4) = 13.37$, $P = 0.01$) to report having an alternative evacuation plan if more people on their island were vaccinated. This preference for staying home, even when an evacuation order is issued, aligns with research by Meng et al.,[56] which found that individuals who took social distancing seriously were more likely to shelter-in-place.

This preference to shelter-in-place could also be influenced by the frequency of hurricanes in the PRVI region. Many residents have significant experience with storms, and this familiarity with hurricane risks may affect their perceptions. According to Joshipura et al.,[76] 84% of survey participants in PR believed they were well-prepared for future hurricanes based on their past experiences. Additionally, a large percentage (66.1%, n = 489) of respondents owned a generator, indicating a high level of self-sufficiency and contributing to a preference for sheltering at home. This suggests that, despite the availability of vaccines, the perceived novelty of COVID-19 risks may still be outweighed by the more familiar and frequent risks posed by hurricanes.

Geographically, there was a significant ($P \leq 0.01$) clustering of respondents in southwest PR (Guayama and Arroyo) who indicated they would "definitely" evacuate to a shelter during the 2021 hurricane season (Figure 4). This trend may be linked to the recovery challenges these areas faced following Hurricane Maria. While Guayama and Arroyo experienced less storm surge than towns like Humacao, Naguabo, and Ceiba,[77] they fall within the Ponce region, which was one of the slowest to recover from the 2017 hurricane.[78] The long-lasting impacts of Hurricane Maria likely influence future evacuation decisions in these areas, as residents in heavily impacted regions may perceive sheltering-in-place as riskier than evacuating. These findings are consistent with Demuth et al.,[25] who suggest that residents in areas disproportionately affected by previous hurricanes may be more inclined to view the risks of sheltering at home as comparable to, or greater than, those posed by a hurricane itself.

There was a significant ($X^2(9) = 380.2$, $P < 0.001$) association between residents' vaccination status and their evacuation plans. Respondents who were fully (19.9%, n = 276) or partially (22.1%, n = 104) vaccinated were less likely to consider evacuating for a storm compared to those who were unvaccinated (29.4%, n = 102). This finding contradicts a prior survey question (Question 9: "Would your vaccination status affect your hurricane evacuation decision?"), in which a large majority (72.6%, n = 496) of respondents indicated that their vaccination status would not influence their decision to evacuate during the 2021 hurricane season. Notably, unvaccinated respondents were significantly ($X^2(2) = 10.10$, $P = 0.006$) more likely (80.8%, n = 104) to report that their vaccination status would not affect their evacuation plans, compared to the fully (73.8%, n = 282) and partially vaccinated (61.7%, n = 107).

Among respondents who said their vaccination status would affect their evacuation plans, 19.6% (n = 136) specifically mentioned they would reconsider going to a shelter if their vaccination status were different. The higher rate of vaccinated respondents' reluctance to evacuate to a shelter may reflect behavioral differences between vaccinated and unvaccinated individuals. Fisman, Amoako, and Tuite[79] suggest that unvaccinated individuals were less likely to alter their typical behaviors, while vaccinated individuals were generally more cautious about contracting the virus. This finding is consistent with Yusuf,[80] who surveyed vulnerable and medically fragile populations in the US during the early stages of vaccine distribution. Yusuf[80] found that even vaccinated individuals expressed concerns about contracting COVID-19 and called for separate shelters for vaccinated and unvaccinated evacuees. Such concerns present

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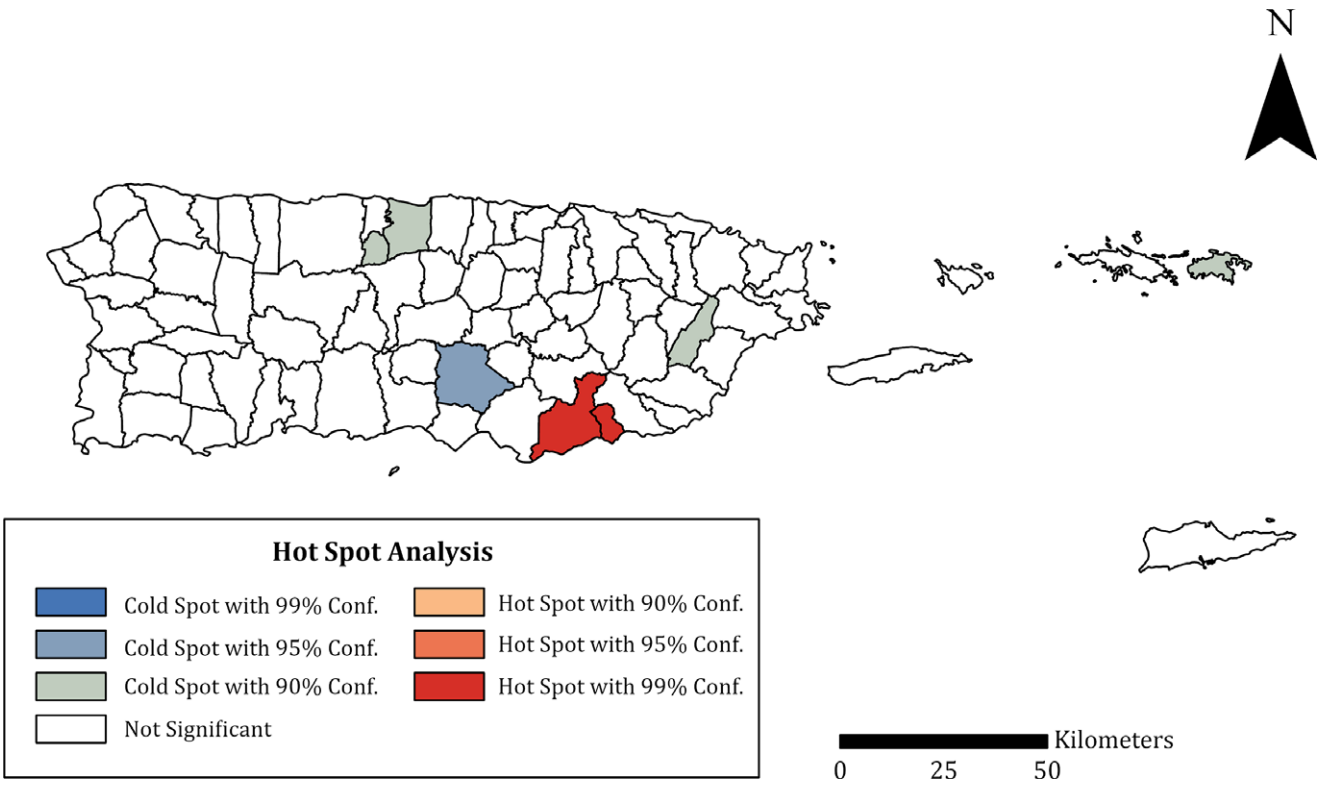

Figure 4. Hot spot analyses assessing respondents' willingness to evacuate to a shelter during the 2021 hurricane season during the COVID-19 pandemic.

significant challenges for shelter operations, as shelter staff, regardless of their vaccination status, often felt vulnerable to COVID-19 and reluctant to work in shelters. It is recommended that public officials focus on building trust, particularly among vaccinated individuals, to reduce the risk of disease transmission in shelters, and consider measures to separate evacuees by vaccination status to minimize the likelihood of contagion.

Further demographic analyses revealed no significant (X^2, $P >$ 0.10) differences between respondents' vaccination status and their hurricane evacuation plans based on gender, race/ethnicity, political ideology, or age. However, there were significant differences in evacuation plans based on vaccination status for respondents with household incomes below \$20k ($X^2(4) = 9.3$, $P = 0.05$) and above \$100k ($X^2(4) = 10.9$, $P = 0.027$). Interestingly, unvaccinated respondents from households earning less than \$20k were more likely to indicate they would evacuate (60.0%, n = 15) compared to those from households with incomes over \$100k (0.0%, n = 10). These finding challenges conventional wisdom, which typically associates higher income with a greater likelihood of evacuation, with disadvantaged minority populations generally being less likely to evacuate than wealthier individuals (e.g., Deng et al.,[81] Yusuf et al.[36]). This discrepancy may be attributed to the geographic isolation effect in PRVI and the disproportionate impacts of recent hurricanes, such as Irma and Maria, on lower-income communities.[78]

Conclusions

Respondents to this survey overwhelmingly (62.3%) indicated that, given the state of COVID-19 during the survey period (March 2021 to May 2021), they would not evacuate to a disaster shelter in response to a severe hurricane. These results are consistent with pre-vaccine research conducted in both PRVI and the US mainland. The preference to shelter-in-place may reflect the experiences of the sample population, as PRVI residents are regularly affected by tropical storms and often feel well-prepared to remain at home during a storm. There was a significant decrease in the number of respondents who, prior to COVID-19, would have considered evacuating to a shelter but no longer see it as an option, even with vaccines available.

Interestingly, respondents with lower incomes (household income under \$20k) and those who were unvaccinated were significantly more likely to consider evacuating for a severe hurricane than those with higher incomes (household income above \$100k) and vaccinated individuals. This finding suggests a lack of confidence in public shelters, especially as individual wealth increases, underscoring the importance of public health measures to prevent the spread of COVID-19, as well as a stronger preference for sheltering-in-place in PRVI. However, despite the USVI having a higher median household income, there was no significant difference between USVI and PR residents in terms of their likelihood to consider evacuating to a shelter.

According to our results, a key determinant in whether an individual will use a hurricane shelter during the COVID-19 era is their perception of local vaccination rates. While most respondents believed that shelters had adequate safeguards in place to prevent COVID-19 transmission, the majority (77.5%) felt that the risks of being in a disaster shelter during the pandemic were greater than the risks posed by a hurricane. This perception was particularly pronounced among individuals who considered themselves vulnerable to COVID-19. When comparing the risks of a hurricane to those of COVID-19 in a shelter, our results suggest

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that the uncertainty regarding the vaccination status of others in a shelter, coupled with the novelty of COVID-19, made the risks of sheltering with others seem greater than enduring a hurricane at home.

The spatial analysis in this study was limited due to a relatively low response rate outside the large municipalities of PR and the 2 most populous islands in the USVI (St. Croix and St. Thomas). However, some significant spatial patterns emerged. In PR, a notable cluster of respondents who were less likely to be vaccinated was found in the island's eastern region, which corresponds to some of the island's poorest neighborhoods. Conversely, a cluster of fully vaccinated respondents was concentrated in the south-central region of PR, centered around Coamo. This area also showed a significant clustering of individuals who were least likely to evacuate for a severe hurricane, reinforcing our previous finding that vaccinated individuals are less likely to evacuate compared to unvaccinated individuals. An interesting trend also emerged in southwestern PR, particularly in Guayama and Arroyo, where respondents were more likely to consider evacuating during a hurricane. This could be related to the region's slower recovery following the devastation of Hurricane Maria in 2017, suggesting that past storm experiences may influence current evacuation intentions.

Implications for Practice

Public health emergency planners coordinating mass care efforts can draw valuable lessons from the challenges highlighted by this study to improve future shelter planning. Effective communication strategies are critical, particularly for communities at higher risk due to inequities in social determinants of health, such as limited access to medical services, medications, and safe housing. Access to medical services is especially crucial post-storm, as Kishore et al.[14] highlighted the significant increase in mortality rates in PR months after Hurricane Maria. Public messaging should emphasize the benefits of hurricane shelters, including access to medical care, safe drinking water, electricity, adequate space, and structural integrity to withstand hurricane-force winds.

Shelter planning and preparedness measures should include provisions for essential medical needs, such as a generator to power life-saving equipment, stockpiling commonly used medications and oxygen, and providing transportation for individuals with limited access to reliable transport. Additionally, personnel certified to respond to public health and medical emergencies should be stationed at shelters.[82,83]

As highlighted in the literature since the onset of the pandemic, government planning to protect public health and well-being during hurricanes and the ongoing COVID-19 crisis has become more complex.[3,39,56] Officials must develop and communicate clear, concise information about evacuation orders, taking into account variables such as the projected hurricane trajectory, social determinants of health, and housing vulnerabilities, such as living in flood zones or in structures that cannot withstand high winds.

Based on the findings of this survey, comprehensive guidelines and strategies are needed at the community level across all phases of disaster planning—mitigation, preparedness, response, and recovery. These plans should support decision-making on whether specific population segments should evacuate to public shelters or shelter-in-place during future hurricanes. Households should also develop emergency preparedness plans that account for public health risks, including the care of individuals with disabilities, medical dependencies, or chronic illnesses who may be more vulnerable to health complications. A key part of these plans should include criteria for determining when household members should evacuate to a general population shelter or a special medical needs shelter.

Climate Change and Hurricane Risk

Although there is limited evidence suggesting that the overall frequency of tropical cyclones is changing,[84] there is stronger evidence indicating an increase in the proportion of category 4 and 5 storms.[85–87] Additionally, it is highly likely that, in a warming world, both average and maximum rainfall rates, as well as peak wind speeds from tropical cyclones, will increase.[88] With the ongoing climate change, the North Atlantic Ocean is expected to experience longer hurricane seasons,[88] while storms may also move at slower forward speeds.[89] As tropical cyclones become more intense and potentially more deadly, evacuation orders may become more frequent and affect larger areas.

However, as demonstrated by the COVID-19 pandemic, the perceived risks of evacuating during a hurricane are not limited to the storm's physical characteristics. External factors, such as disease prevalence, play an important role in shaping evacuation decisions. A warming climate could lead to the spread of more vector-borne and communicable diseases,[90–92] which would compound the risks associated with hurricanes. This study contributes to a better understanding of how citizens make evacuation decisions when faced with the threat of both a tropical cyclone and the risk of contracting an infectious disease—particularly at the early stages of vaccine availability.

Limitations

One limitation to acknowledge is that the findings may not be fully generalizable to the entire PRVI population due to a sample that does not adequately represent it, as evidenced by a comparison with census data. For example, the sample, was disproportionately composed of women, individuals with higher educational attainment, and those with greater annual incomes compared to territorial averages.[59,60] Due to the pandemic guidelines and risk of contracting COVID-19, researchers opted against in-person interviews to minimize exposure, instead distributing the survey online. This sampling approach is susceptible to selection bias, as individuals from lower socioeconomic backgrounds are less likely to have the necessary technology or resources to access the survey. However, in the interest of minimizing risk for both surveyors and respondents, the decision was made to avoid in-person survey distribution and community workshops.

Data availability statement. Publicly available census data for PRVI were accessed from the United States Census Bureau at https://data.census.gov. Due to its proprietary nature, the raw dataset is not available, but the survey instrument is available at https://doi.org/10.17603/DS2-7CZQ-EN54.

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Competing interests. The authors declare no competing interests.

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