



# Dueling emergencies: Flood evacuation ridesharing during the COVID-19 pandemic

Elisa Borowski, Victor Limontitla Cedillo, Amanda Stathopoulos\*

Department of Civil and Environmental Engineering, Northwestern University, Technological Institute, 2145 Sheridan Road, Evanston, IL 60208, USA



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## ABSTRACT

Volunteered sharing of resources is often observed in response to disaster events. During evacuations the sharing of resources and vehicles is a crucial mechanism for expanding critical capacity and enabling inclusive disaster response. This paper examines the complexity of rideshare decision-making in the wake of simultaneous emergencies. Specifically, the need for physical distancing measures during the coronavirus (COVID-19) pandemic complicates face-to-face resource sharing between strangers. The ability of on-demand ridesharing to provide emergency transportation to individuals without access to alternatives calls for an understanding of how evacuees weigh risks of contagion against benefits of spontaneous resource sharing. In this research, we examine both sociodemographic and situational factors that contribute to a willingness to share flood evacuation rides with strangers during the COVID-19 pandemic. We hypothesize that the willingness to share is significantly correlated with traditional emergency resource sharing motivations and current COVID-19 risk factors. To test these hypotheses, we distributed an online survey during the pandemic surge in July 2020 to 600 individuals in three midwestern and three southern states in the United States with high risk of flooding. We estimate a random parameter multinomial logit model to determine the willingness to share a ride as a driver or passenger. Our findings show that willingness to share evacuation rides is associated with individual sociodemographics (such as being female, under 36 years old, Black, or republican-identifying) and the social environment (such as households with children, social network proximity, and neighborly sharing attitudes). Moreover, our findings suggest higher levels of income, COVID-19 threat perception, evacuation fear, and household preparedness all correspond with a lower willingness to share rides. We discuss the broader implications of emergency on-demand mobility during concurrent disasters to formulate strategies for transportation agencies and on-demand ridehailing providers.

## 1. Introduction

In the Midland area of central Michigan on May 19th and 20th of 2020, the Edenville Dam and downstream Sanford Dam failed consecutively, forcing the evacuation of over 11,000 people. Parts of the city of Midland, the village of Sanford, Edenville Township, and Dow Chemical were evacuated. At the time of evacuation, the COVID-19 pandemic stay-at-home order would continue to be in place for another two weeks. Evacuation shelters were set up at several high schools where masks were required and with beds spaced six feet apart. Amidst an ongoing global pandemic with the threat of concurrent climate disruptions, this study examines resource sharing behavior in response to flood evacuation orders during an era of physical distancing.

Resilience describes a community's ability to prepare for, respond to, and recover quickly from disruptive events. Throughout the COVID-19 pandemic, the U.S. has experienced numerous climate disruptions, including tornadoes, earthquakes, floods, wildfires, and hurricanes. Although resilience research often focuses solely on a single disruption event, the COVID-19 pandemic has shown that multiple hazards can and do occur together. This study seeks to fill a gap in current resilience research by examining the agility expressed by individuals while navigating a transportation emergency (i.e., a flood evacuation scenario) during a simultaneous health emergency (i.e., the COVID-19 pandemic).

When deciding how to prepare for or respond to multiple concurrent hazards, individuals must prioritize between a multitude of perceived risks that may interact with and influence one another in unexpected

\* Corresponding author.

E-mail addresses: [elisaborowski2022@u.northwestern.edu](mailto:elisaborowski2022@u.northwestern.edu) (E. Borowski), [victorlimontitla2021@u.northwestern.edu](mailto:victorlimontitla2021@u.northwestern.edu) (V.L. Cedillo), [a-stathopoulos@northwestern.edu](mailto:a-stathopoulos@northwestern.edu) (A. Stathopoulos).

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ways. When an evacuation scenario is encountered during the COVID-19 pandemic, many additional hazards must be considered. For example, the impacts of the ongoing pandemic may cause evacuees to experience heightened physical, economic, and psychological vulnerabilities. Lasting stresses caused by the pandemic may limit adaptive capacity, which refers to the excess resources available for disaster response (often materialized by volunteerism and resource sharing between individuals and neighboring states). Furthermore, physical distancing guidelines present challenges to volunteer response, evacuation sheltering, and the movement of resources. All of these complications are expected to influence the decision of what evacuation resources to share, how, and with whom. At the same time, the consequences of this complex decision-making process must be considered, especially the impacts absorbed by highly vulnerable populations.

Pandemic context aside, spontaneous resource sharing behavior has a long history of occurring in response to single disaster events. Recently, research in the field of transportation has begun to examine the role of shared ridehailing during evacuations. The car-less population in the U.S. consists largely of people who are elderly, low income, of a racial minority, or with disabilities (Renne et al., 2011), and as such, car-less and accessible evacuation planning is essential and a matter of social equity. Furthermore, car-less households range from 2.1% to 5.2% of the population in the focus states of this research (U.S. Census Bureau, 2018). Considering this sizable share, disaster response planning needs to incorporate mobility alternatives for car-less individuals. In light of existing evidence for spontaneous resource sharing during disasters, one viable alternative is the implementation of on-demand shared evacuation rides. *Ridesharing* is defined as “the formal or informal sharing of rides between drivers and passengers with similar origin–destination pairings” (Shaheen and Cohen, 2020; Shared and Digital Mobility Committee, 2018). Findings from prior research on the demand and supply of evacuation ridesharing have been promising. Our earlier efforts show that demand for shared evacuation rides may reflect a need for navigational assistance, a sense of urgency, or the intersectional vulnerability of evacuees (Borowski and Stathopoulos, 2020). Additionally, over half of surveyed California wildfire evacuees were willing to supply an evacuation ride to a stranger (Wong and Shaheen, 2019). While acknowledging the encouragement of these early findings, the decision of whether or not to offer a shared evacuation ride during a viral pandemic introduces a new set of challenges that must be explored.

Research on the role of ridesharing in evacuations is still in its infancy. The following section will summarize previous scholarship examining factors that influence the willingness to share rides and resources in response to wildfires, hurricanes, and general emergencies. However, the willingness to share evacuation resources has been understudied for floods, in general, and is for the most part nonexistent for pandemics. Our study begins to fill this gap in the understanding of the willingness to share resources face-to-face during a viral pandemic and the relationship of this willingness to disaster resilience. Drawing on a web-based survey administered during the pandemic surge in July 2020 to 600 individuals, we begin to uncover this relationship using discrete choice modeling. Specifically, we identify several sociodemographic and situational factors that influence willingness to share flood evacuation rides during the COVID-19 pandemic.

## 2. Theoretical background

### 2.1. Motivations to share

#### 2.1.1. Emergency ridesharing factors

Sharing behavior during emergencies has been widely observed, but research on the willingness to share evacuation rides remains comparatively sparse. Existing research in this area shows that willingness to share joint evacuation rides is correlated with *sociodemograph-*

*ics* like being elderly, unmarried, and socially well-connected (Ahmed et al., 2020). Willingness to supply shared evacuation rides is associated with *sociodemographics* like being young, single, and male (Li et al., 2018), *personal history* like volunteer experience and residence in the local county, *situational factors* like sheltering with friends, and *external factors* like a mandatory evacuation order, high police presence, and elevated danger along the evacuation route (Wong et al., 2020a). Wong et al. (2020a) also highlight the main barriers to evacuation ridesharing as being related to *sociodemographics* like being under the age of 35 (counter to findings in China by Li et al., 2018), lower income, having children, or being a homeowner, *personal history* like experience with evacuations and wildfires, and *external factors* such as a high presence of first responders.

This small but growing body of literature exemplifies how a wide range of sociodemographic, personal, situational, and external factors can interact in complex ways to influence one's willingness to share evacuation rides with a stranger. We expect to uncover further complications when examining evacuation ridesharing during a pandemic, wherein additional concerns have the potential to impact decision outcomes, including whether to evacuate, by what mode, and to where. Guidelines for evacuation sheltering during the pandemic have encouraged sheltering-in-place when possible, followed by sheltering in hotels or dormitories as a second-best solution (American Red Cross, 2020; Centers for Disease Control and Prevention, May, 2020). This prioritization of evacuation decision-making reflects the uniqueness of the multi-hazard scenario. We anticipate the concurrent viral pandemic will reflect many of the influential decision-making factors found in existing studies on emergency ridesharing while introducing new factors related to conflicting risk perceptions that attempt to balance the need to evacuate while avoiding potential exposure to a virus. Our interests lie in examining this multitude of factors along the dimensions of social identity, vulnerability, risk perception, and access to resources.

#### 2.1.2. Social identity theory

Spontaneous sharing with strangers during disasters, also known as *emergent volunteerism*, has been attributed to the phenomenon of shared social identity (Ntontis, 2018; Ntontis et al., 2018; Van Bavel et al., 2020). During disaster events, diverse individuals often experience similar difficulties and goals, creating a sense of community, which can bring about collective action. As such, one might expect that in an evacuation overlapping with a global pandemic, individuals would identify with others facing similar risks, resulting in the emergence of a collective shared social identity. In turn, they might be more likely to volunteer assistance during this multi-hazard disaster, potentially offering shared rides for emergency relocation. In reality, however, the following two significant socio-political movements came to a head during the pandemic period, further driving social divisions and likely influencing the propensity for spontaneous sharing among strangers.

First, political polarization over the COVID-19 pandemic emerged in the U.S. This polarization has been expressed through beliefs and behaviors tailored to reflect cultural identities and group belonging (Van Bavel et al., 2020). These politically motivated beliefs and behaviors are related to perceptions of risk and justifications regarding protective measures that influence the decision of whether to engage in physical distancing and whether to wear a facial covering in public (Allcott et al., 2020).

Second, racial injustice in the U.S. has garnered mass public attention following numerous acts of police brutality against the Black community. This has raised to the forefront of the collective consciousness the social inequities present in the distribution of impacts caused by the pandemic. Black and Latinx Americans have experienced higher rates of hospitalization, death, and unemployment from COVID-19 (Artiga et al., 2020; California Department of Public Health, 2020; Cowan, 2020; Larsen et al., 2020; Oppel et al., 2020; Wu et al.,

2020). In the U.S., COVID-19 deaths have disproportionately impacted Black people and communities (APM Research Lab, 2020; Bassett et al., 2020; Gravelle, 2020; Johnson and Buford, 2020; Khazanchi et al., 2020). Among older adults, COVID-19 death rates of people who are Black or Latinx have been 3 or 2 times higher, respectively, than those who are White (Garcia et al., 2021). Racial and ethnic disparities in COVID-19 exposure, susceptibility, and treatment have been shown to be driven by factors of systemic racism (Tan et al., 2021), including reduced access to transportation and education, food insecurity, increased environmental exposures, and psychological trauma resulting from chronic exposure to discrimination (Egede and Walker, 2020), as well as reduced access to employment, housing, and healthcare (Yearby and Mohapatra, 2020), as described by the Fundamental Cause Theory (Garcia et al., 2021; Tan et al., 2021). These inequitable distributions in viral exposure and access to financial or health-related resources experienced by Black, Indigenous, Latinx, and other People of Color are a result of systemic racism long present in the country (Bell and Ebusu, 2012; Feagin and Elias, 2013; Singh et al., 2017). Furthermore, racism in the U.S. has been considered a second pandemic and a public health crisis (Stolberg, 2020).

Beyond the sociopolitical climate of the period in which our research study was conducted, recent publications have revealed correlations between social distancing compliance and several other sociodemographic and household characteristic factors. For example, research has found that indicators of individuals who are less likely to comply with social distancing guidelines include Republican orientation (Alcott et al., 2020; Kavanagh et al., 2020; Painter and Qiu, 2020), younger males (Tomczyk et al., 2020), lower educational attainment (Narayanan et al., 2020; Tomczyk et al., 2020), and lower per capita income (Kavanagh et al., 2020), as well as believing in conspiracies, having to run errands for friends or family, seeing many people out on the streets, feeling stressed or alone, and being unable to work remotely (Coroiu et al., 2020). Indicators of those more likely to comply with social distancing include liberals (Christensen et al., 2020), Democratic partisanship (Pedersen and Favero, 2020), older age (Coroiu et al., 2020; Pedersen and Favero, 2020; Tomczyk et al., 2020), females (Tomczyk et al., 2020), median household income, households with children, population density (Narayanan et al., 2020), as well as health literacy, prosocial attitudes, feeling responsible for protecting the community, and wanting to protect oneself (Coroiu et al., 2020). The following household compositional variables were not found to be significantly correlated with loneliness during the pandemic: household size, household composition (i.e., living with a partner), living with pets, being a caregiver, and social or physical distancing (Okabe-Miyamoto et al., 2021).

Although a so-called shared experience of the COVID-19 pandemic could, in theory, foster a sense of shared social identity, thus improving the likelihood of sharing, the reality appears to be more complicated. Increasingly, the uneven distribution of pandemic-related stresses, intensified by political polarization and racial injustices, appears to reinforce strong divisions between social groups, resulting in the emergence of new beliefs and behavioral patterns. We anticipate that these growing social divisions will contribute to varied and unanticipated impacts on the willingness to engage in social distancing, use protective gear and, thus, to share an evacuation ride with a stranger during the COVID-19 pandemic.

### 2.1.3. Overlapping and interacting vulnerabilities

The risk of the COVID-19 pandemic overlaps with existing racial and socioeconomic inequities in the U.S. Factors correlating with an increased risk for severe illness associated with COVID-19 include older adults, with the greatest risk being for those 85 years of age and older, and people with underlying medical conditions, such as cancer, obesity, diabetes, serious heart conditions, and an immunocompromised state (Centers for Disease Control and Prevention, July 21, 2020). Furthermore, potential risk factors may include being a racial

or ethnic minority (such as an Indigenous, Black, or Latinx American), poverty, pregnancy, and homelessness (Centers for Disease Control and Prevention, July 21, 2020). Accordingly, age, race, ethnicity, income, and employment status are controlled for in our study.

Environmental stressors, increasingly worsened by climate change, compound the pandemic risks that threaten health and resources. Environmental disasters exacerbate resource inequities, constraining access to preparedness measures and federal financial aid, especially in low-income communities and communities of color (Baker, 2011; Cleetus et al., 2015; Emrich et al., 2020; Howell and Elliott, 2019). Evacuation in itself presents additional challenges in the way of financial costs (Pei et al., 2020), especially to vulnerable socioeconomic groups. Social isolation has been shown to worsen these impacts during disaster evacuations (Howard et al., 2018), especially among older adults (Armitage and Nellums, 2020; Santini et al., 2020). Effectively, the pandemic- and disaster-related risk factors have significant overlap. As such, existing socioeconomic vulnerabilities related to age, race, and income are likely to intensify during multi-hazard disasters.

### 2.1.4. Perceptions of risk

In addition to the interactions between measurable vulnerability factors, an important area that requires understanding is the perceptions of risk during simultaneous evacuation and pandemic events. Throughout the course of the pandemic, this completely novel public health crisis has presented great uncertainty. At the time of this study (i.e., the summer of 2020), the mechanism of disease spread (i.e., airborne versus contact) was not well-understood. In an evacuation context, this could translate to uncertainties regarding how long one could be in a car with an infected person before contracting the virus. In addition to the uncertainties already involved in no-notice flood evacuations, pandemic-related uncertainties are expected to heighten levels of anxiety and stress. The overlap of these simultaneous hazards is anticipated to impact risk perception in complex ways.

The high stress scenario of an evacuation paired with increased uncertainty during a pandemic is likely to be accompanied by strong emotions that will influence the processes and outcomes of evacuation decision-making. These feelings may include four primary negative emotions: fear, anger, sadness, and anxiety (Jin, 2009; Jin et al., 2016; Kim and Cameron, 2011; Lerner and Keltner, 2000). It is important to note that during disasters, decision-making is still rational, and emergency-based panicking is a rare occurrence (Auf der Heide, 2004; Clarke and Chess, 2008; Mileti and Peek, 2000; Omori et al., 2017; Quarantelli, 2001; Quarantelli and Dynes, 1977; Sorensen and Mileti, 1988; Tierney et al., 2006). With that in mind, prior research does support the effect of emotion on decision-making in terms of rule switching (Chorus et al., 2013; Hess and Stathopoulos, 2013), behavioral adaptation (Gutteling et al., 2018), instructional compliance (Liu et al., 2017), and perceptions of certainty (Bodenhausen et al., 1994; Lerner and Keltner, 2000; Tiedens and Linton, 2011). We anticipate that a complex interaction between socioeconomic vulnerabilities and uncertainty-driven emotional states will influence sharing decisions during this multi-hazard event.

### 2.1.5. Resource abundance

While the question of willingness to share an evacuation ride presupposes the decision to evacuate, we anticipate the factors that have been shown in prior works to be significant for evacuation decision-making will also likely influence the decision of ridesharing during a pandemic-concurrent evacuation. Specifically, we expect these factors to relate to the overall perceived difficulty of the evacuation process and access to resources that would facilitate evacuation.

Factors influencing the evacuation decision in a single-hazard event are *situational* like official warnings, *environmental* like observational cues, *social* like the behavior of others, and *personal* like risk perceptions, according to a literature review of hurricane evacuation studies by Huang et al. (2016). *Demographic* characteristics evidenced

to be generally nonsignificant in the decision to evacuate include gender, age, race and ethnicity, marital status, household size, children at home, education level, and income (Huang et al., 2016). However, some findings show female gender, children at home, and education level to be positively correlated with the decision to evacuate, as well as age and household size to be negatively correlated with the decision to evacuate (Huang et al., 2016). Homeownership is shown consistently to be negatively correlated with the decision to evacuate (Huang et al., 2016). In more recent research, hurricane evacuation decision-making is shown to be influenced by hurricane experience, duration of residence, homeownership, age, income, race, employment status, level of social connectivity, social cues, perceived levels of self-efficacy and risk, and storm conditions (Collins et al., 2018; Demuth et al., 2016; Lazo et al., 2015; Metaxa-Kakavouli et al., 2018; Pei et al., 2020).

The co-occurrence of a pandemic further complicates the issue of access to evacuation-facilitating resources given the disruption to supply chains. Preparedness measures for health-based emergencies and flooding-related emergencies may involve the stockpiling of supplies, such as drinking water, non-perishable foods, paper goods, cleaning supplies, electric generators, prescription medications, and tanks of gas (Shultz et al., 2020b). Many of these supplies are frequently in high demand given the global reach of the COVID-19 pandemic and its long duration. Therefore, we anticipate that access to resources and levels of emergency preparedness will influence evacuation ridesharing willingness.

## 2.2. Key literature gaps

In summary, traditional factors known to impact evacuation decision-making and willingness to share during a single-hazard emergency include shared social identity, vulnerability, risk perception, and resource abundance. Evacuation decision-making during the COVID-19 pandemic is expected to differ somewhat from that observed in previous studies given the economic and health-related impacts of the ongoing pandemic. Early pandemic-related research has demonstrated significant declines in shared mode ridership levels, including public transit, subways, and bikesharing systems (Abdullah et al., 2020; Teixeira and Lopes, 2020), as well as reduced inter-county travel (Yilmazkuday, 2020). A few studies have begun to examine evacuation decision-making during the COVID-19 pandemic. The findings indicate that concerns about the COVID-19 pandemic dominate those related to flood risks, and older individuals are less likely to evacuate voluntarily due to heightened concerns of COVID-19 exposure (Botzen et al., 2020). This finding is especially true for older individuals who have a heightened vulnerability to the consequences of COVID-19 (Meng et al. 2020).

Interest in the use of the sharing economy to provide evacuation resources during the COVID-19 pandemic while maintaining social distancing has been expressed (Pei et al., 2020). However, to date little is known about the influence of COVID-19 related factors on the decision to share an evacuation ride with a stranger. Given the ongoing nature of the pandemic and the worsening frequency and intensity of climate events (Intergovernmental Panel on Climate Change, 2018), this work is timely and important. While acknowledging the limitations inherent in stated preference surveys, our findings offer an early look into the

sociodemographic and social factors influencing willingness to share in this novel context.

## 3. Methodology

### 3.1. Internet survey overview

Internet-based surveys can provide improved cost savings and timeliness in comparison with other modes but have raised concerns about noncoverage and self-selection (Dever et al., 2008; Mercer et al., 2017). In the era of COVID-19, much behavioral research has relied on the Internet-mode to obtain timely data, and comply with social distancing restrictions (e.g., Schaurer & Weiß, 2020). Although online sampling can result in *coverage bias*, specifically related to Internet access, (Sterrett et al., 2017) show that while gaps in coverage persist, there is an overall decline in coverage bias associated with income, education, race, ethnicity, and age compared to other means of data collection. Moreover, Schaurer & Weiß (2020) point to a risk of sample *self-selection*, which may attract low-effort respondents to web surveys. This can lead to behavioral bias where models are not reflective of real-life behaviors, including social distancing compliance. However, despite these limitations, research has shown that web-based survey samples are often more representative and diverse than intercept surveys or traditional convenience samples (Casler et al., 2013; Gosling et al., 2004; Smith et al., 2015). More importantly, web surveys are shown to result in findings that are behaviorally accurate, valid, and comparable to traditional survey methods (Campbell et al., 2018; Sheehan, 2018).

### 3.2. Survey instrument

Our stated preference survey was administered online from June 30th through July 2nd, 2020 to residents of six states in the Midwest (i.e., Illinois, Michigan, and Wisconsin) and Southern U.S. (i.e., Georgia, Louisiana, and Mississippi) with high risk of flooding according to the National Oceanic and Atmospheric Administration (2020). These states were selected to represent three different phases of pandemic restriction measures (i.e., reopened, reopening, and paused) in order to reflect the general distribution of case-rate severity. The COVID-19 statistics for the six states included in this study are presented in Table 1. Following a pilot study with 30 respondents, the survey was distributed via Qualtrics to 600 individuals using the platform Prolific. After excluding failed attention responses and missing or low-quality responses, our survey sample consists of 586 individuals (a 98% retention rate).

The survey describes a flood evacuation scenario during the COVID-19 pandemic and asks all respondents to indicate their willingness to share an evacuation ride as a driver or passenger with a neighbor they do not know. This scenario was designed to reflect the sharing of a ride with an individual who was nearby but unfamiliar. The survey also collects data on evacuation attitudes and sociodemographics. The goal of our study is to identify the sociodemographic and situational factors influencing the willingness to share flood evacuation rides with unknown neighbors during the COVID-19 pandemic.

**Table 1**  
COVID-19 statistics for July 2020 in surveyed U.S. states.

State	New Cases	7-Day Avg	New Deaths	7-Day Avg	Total cases	Total deaths	Order Began	Order Ended	Current Status	Governor
Georgia	2309	1900	21	17	124,267	3071	4/3/20	4/30/20	Reopening	Republican
Illinois	880	788	24	25	160,898	7468	3/21/20	5/29/20	Reopening	Democrat
Louisiana	2083	1099	17	12	88,700	3509	3/23/20	5/15/20	Pausing	Democrat
Michigan	429	367	5	12	80,759	6358	3/24/20	6/1/20	Pausing	Democrat
Mississippi	652	639	9	10	40,829	1332	4/3/20	4/27/20	Reopened	Republican
Wisconsin	584	522	1	4	44,181	841	3/25/20	5/13/20	Reopened	Democrat



Specifically, the willingness-to-share question is first asked from the perspective of a driver offering a ride to an unknown evacuating neighbor and then from the perspective of a passenger accepting a request to share their ride with an additional evacuee in their neighborhood. Survey respondents are asked, “As a driver, would you offer a ride to another evacuating individual in your neighborhood who you do not know if you had the spare capacity?” followed by, “As a passenger in a shared ride, would you allow another evacuating individual from your neighborhood who you do not know to join the ride?” For brevity, this unknown, evacuating neighbor will be referred to hereafter as an “evacuee”.

The explanatory variables considered include individual *sociodemographics* (i.e., gender, age, income, employment, race, ethnicity, marital status, and political affiliation), *household demographics* (i.e., household size, number of vehicles per household, residential area type, duration of residence, housing situation, household constraints, phone type, and internet access), *evacuation parameters* (i.e., evacuation experience, destination, and belongings), *ridehailing experience* (i.e., as a driver or passenger), *COVID-19 risk factors* (i.e., perceived risk, region, state, and state reopening status), *emotion* (i.e., fear, sadness, anger, and anxiety), *social network characteristics* (i.e., size, proximity, duration, frequency, and homogeneity), and *resource accessibility* (i.e., emergency preparedness and attitudes related to sharing and borrowing).

### 3.3. Survey participants

The sociodemographic distribution of the survey sample is shown in Table 2. The sample is skewed more heavily toward respondents from Illinois and Georgia and those from the Midwest in general. Com-

pared to the overall U.S. census population, the sample has a good gender representation and somewhat over-represents those under the age of 45, those who identify as Asian, and those with a gross annual household income of over \$50 k, while under-representing those who identify as Black (U.S. Census Bureau, 2018). The use of convenience sampling limits our ability to generalize findings. However, our study provides timely insight on evacuation rideshare behavior during dueling emergencies in a rapidly changing decision environment where randomized sampling can be challenging to carry out.

## 4. Results

### 4.1. Sharing attitudes

General attitudes toward sharing evacuation rides during the COVID-19 pandemic in terms of willingness to share, time allotments, cost expectations, and other concerns are analyzed descriptively. With regard to time and cost, drivers and passengers display analogous sharing attitudes overall. A majority of survey respondents report they would be willing to offer a ride to an evacuee as a driver (68%) and as a passenger (76%). It is important to note that given the hypothetical nature of the question this should not be taken as the actual willingness-to-share. Whether sharing a ride in the position of a driver or passenger, the maximum acceptable waiting time to pick up the additional passenger is nearly identical (for drivers: a median of 15 and mean of 17 min; for passengers: a median of 15 and mean of 18 min).

**Table 2**

Sociodemographics of survey sample population compared to the American Community Survey 1-year estimates (U.S. Census Bureau, 2018).

	Survey	Georgia	Illinois	Louisiana	Michigan	Mississippi	Wisconsin
<i>Residence</i>							
Georgia	23.4%						
Illinois	30.5%						
Louisiana	7.1%						
Michigan	15.9%						
Mississippi	4.1%						
Wisconsin	13.4%						
<i>Gender</i>							
Male	46.3%	48.6%	49.1%	48.8%	49.0%	48.5%	49.4%
Female	51.9%	51.4%	50.9%	51.2%	51.0%	51.5%	50.6%
Other	1.0%						
<i>Age</i>							
18–24	30.1%	9.9%	9.3%	9.4%	9.6%	10.2%	9.4%
25–34	31.4%	13.7%	13.9%	13.8%	12.9%	12.7%	12.7%
35–44	16.2%	13.3%	12.9%	12.6%	11.6%	12.8%	12.1%
45–54	11.9%	13.3%	12.8%	12.2%	12.9%	12.1%	12.7%
55–65	6.8%	12.2%	13.1%	12.9%	14.0%	12.8%	14.2%
65 +	3.5%	13.8%	15.6%	15.5%	17.2%	15.9%	17.0%
<i>Race</i>							
White	65.0%	58.2%	71.7%	61.8%	78.3%	58.1%	85.3%
African American	14.5%	31.2%	13.8%	32.2%	13.6%	37.8%	6.3%
Asian	13.6%	4.1%	5.6%	1.6%	3.2%	0.9%	2.8%
Two or more	3.3%	2.2%	2.0%	2.0%	2.5%	1.4%	0.5%
American Indian	1.0%	0.2%	0.1%	0.5%	0.5%	0.4%	0.8%
Other	0.8%	2.5%	5.4%	1.2%	1.0%	0.9%	2.0%
<i>Income</i>							
< \$10 k	8.6%	11.1%	11.2%	11.9%	13.0%	12.6%	12.2%
\$10 k to \$20 k	8.8%	13.2%	11.5%	15.6%	13.4%	16.1%	11.3%
\$20 k to \$30 k	10.4%	15.6%	13.6%	16.1%	14.0%	16.6%	13.1%
\$30 k to \$40 k	7.8%	13.5%	12.3%	11.6%	13.4%	15.3%	14.0%
\$40 k to \$50 k	9.4%	10.4%	10.2%	10.6%	10.1%	12.0%	13.0%
\$50 k to \$60 k	9.8%	8.2%	8.8%	8.6%	8.4%	8.0%	10.2%
\$60 k to \$80 k	12.1%	11.1%	12.3%	11.1%	11.5%	9.5%	12.6%
\$80 k to \$100 k	8.8%	5.9%	7.1%	5.4%	6.2%	3.8%	5.9%
\$100 k to \$120 k	6.4%	3.8%	4.6%	3.4%	3.7%	2.4%	3.1%
\$120 k to \$150 k	6.3%	2.7%	3.3%	2.5%	2.7%	1.4%	2.0%
\$150 k to \$200 k	2.8%	2.1%	2.3%	1.5%	1.7%	1.0%	1.2%
> \$200 k	4.1%	2.4%	2.9%	1.6%	1.8%	1.3%	1.6%

In terms of financial compensation, a sizable group (35%) report they do not believe the driver should be compensated at all for providing a ride to another evacuee. The majority of respondents (44%) believe the evacuee should compensate the driver directly, 14% indicate the government should be responsible, and 7% think an affiliated ridehailing organization should provide compensation. As for the amount of compensation, the median opinion is \$10/hour, and the average is \$30/hour.

Fig. 1 shows the ranking of eleven potential evacuation ridesharing concerns by importance on a 5-point scale. The top concerns respondents have about evacuation ridesharing during a pandemic are: (1) that the driver wear a mask, (2) that the rider's personal information is not collected, (3) the ability of the rider to track the driver's vehicle, (4) the ability of the driver to navigate without GPS, and (5) that the driver has passed a background check.

Survey respondents are also asked the following two open-ended response questions: (1) *What factors might prevent you from sharing a ride with someone you do not know during a mandatory evacuation considering the current state of the COVID-19 pandemic?* (2) *What factors might encourage you to share a ride with someone you do not know during a mandatory evacuation considering the current state of the COVID-19 pandemic?*

Based on an exploratory analysis using word frequency clouds, as shown in Fig. 2, the top themes for *encouragement* to share an evacuation ride with a stranger during the pandemic (Fig. 2a) are mask-wearing, desire to help those in need, wanting to help individuals with children, monetary incentives, and logistics such as time and distance to pick up. Themes related to the *prevention* of sharing rides (Fig. 2b) include a lack of mask-wearing, the risk of being exposed to COVID-19, the inability to know with certainty who may be infected with COVID-19, reliance on visible cues such as displays of symptoms, not having the space available to physically distance, and logistics such as time and distance to pick up. While the open-ended responses in Fig. 2 confirm the themes of mask-wearing and compensation covered in our closed-category survey questions, we note that this analysis provides further insight for our formal modeling by highlighting the importance of family constraints and perceptions of risks and cues to indicate ride safety.

#### 4.2. Random parameter evacuation ridesharing logit model

To analyze the willingness to share flood evacuation rides as a driver and passenger, we estimate a random parameter multinomial logit (RPL) discrete choice model (Ben-Akiva and Lerman, 2018) using BIOGEME (Bierlaire et al., 2009). The four choice alternatives are to: (1) share the evacuation ride as both a driver and passenger (hereafter

denoted 'super-sharing'), (2) share as a passenger only, (3) share as a driver only, and (4) not share as either. The final systematic utility equations, including the specification of *Total Preparedness* as a random parameter varying across respondents  $i$ , are shown in Eqs. (1)–(4), and the variable definitions are listed in Table 3.

$$\begin{aligned} V_{\text{SuperShare}} = & ASC_{\text{SuperShare}} + \beta_{\text{Black}} \text{Black} \\ & + \beta_{\text{HouseholdChildren}} \text{HouseholdChildren} + \beta_{\text{Republican}} \text{Republican} \\ & + \beta_{\text{COVIDThreat}} \text{COVIDThreat} + \beta_{\text{Fear}} \text{Fear} \\ & + \beta_{\text{LocalBorrowing}} \text{LocalBorrowing} \\ & + \beta_{\text{NeighborSharing}} \text{NeighborSharing} \\ & + \beta_{\text{NetworkProximity}} \text{NetworkProximity} \\ & + \beta_{\text{Black,Employed}} (\text{Black} \times \text{Employed}) \\ & + \beta_{\text{Republican,Millennial}} (\text{Republican} \times \text{Millennial}) \end{aligned} \quad (1)$$

$$\begin{aligned} V_{\text{DriverOnly}} = & ASC_{\text{DriverOnly}} + \beta_{\text{Black}} \text{Black} \\ & + \beta_{\text{TotalPreparedness},i} \text{TotalPreparedness} \\ & + \beta_{\text{Black,Female}} (\text{Black} \times \text{Female}) \end{aligned} \quad (2)$$

$$\begin{aligned} V_{\text{PassengerOnly}} = & ASC_{\text{PassengerOnly}} + \beta_{\text{HouseholdChildren}} \text{HouseholdChildren} \\ & + \beta_{\text{Millennial}} \text{Millennial} + \beta_{\text{Republican}} \text{Republican} \\ & + \beta_{\text{Under25}} \text{Under25} + \beta_{\text{COVIDThreat}} \text{COVIDThreat} \\ & + \beta_{\text{LocalBorrowing}} \text{LocalBorrowing} \\ & + \beta_{\text{NeighborSharing}} \text{NeighborSharing} \\ & + \beta_{\text{Millennial,Fear}} (\text{Millennial} \times \text{Fear}) \end{aligned} \quad (3)$$

$$\begin{aligned} V_{\text{NoShare}} = & ASC_{\text{NoShare}} + \beta_{\text{Black}} \text{Black} + \beta_{\text{HighIncome}} \text{HighIncome} \\ & + \beta_{\text{Fear}} \text{Fear} + \beta_{\text{TotalPreparedness}} \text{TotalPreparedness} \end{aligned} \quad (4)$$

#### 4.3. Analysis of willingness to share evacuation rides

The specification testing process included variables identified from the literature analysis of evacuation modeling, as well as the current understanding of shared mode acceptance and COVID-19 behavior strategies. Table 4 presents the model results, which provide a richer understanding of super-sharing and passenger-sharing behaviors and more limited insights into driver-sharing and non-sharing behaviors. The model includes significant parameters with a confidence level of 91% or higher (a p-value of 0.09 or less) given the novelty of the

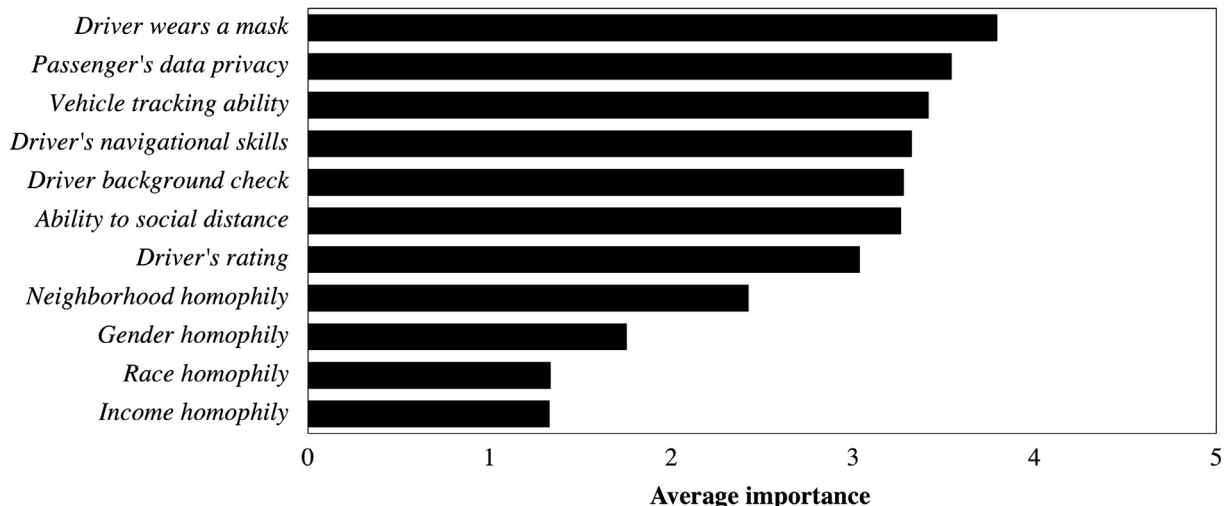
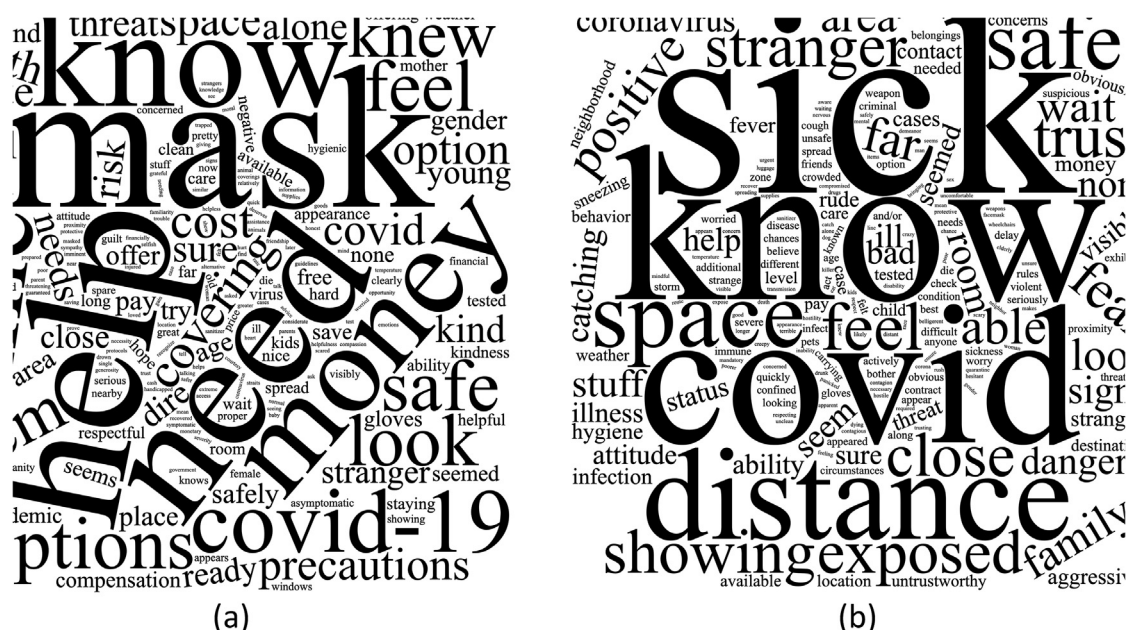


Fig. 1. Importance ratings of potential concerns regarding evacuation ridesharing during a pandemic averaged across all survey respondents.



**Fig. 2.** Word frequency clouds indicating primary factors that would (a) encourage or (b) prevent the sharing of evacuation rides with a stranger during the COVID-19 pandemic.

**Table 3**  
Summary statistics for variables included in the final model estimation.

Variable name	Variable description	Max	Min	Mean	Standard deviation
Black	Black or African American indicator (1 if respondent is Black, 0 otherwise)	1	0	0.14	3.5E-04
COVID-19 threat	Perceived threat to respondent's personal health of evacuating during a COVID-19 outbreak (4 if major, 1 if not a threat)	4	1	3.19	7.9E-04
Employed	Employment indicator (1 if respondent is employed, 0 otherwise)	1	0	0.63	4.8E-04
Fear	Likelihood of respondent feeling fear in response to a major flood evacuation scenario (5 if extremely likely, 1 if extremely unlikely)	5	1	4.37	1.0E-03
Female	Female indicator (1 if respondent is female, 0 otherwise)	1	0	0.52	5.0E-04
High income	Annual household income indicator (1 if respondent's gross annual household income is more than \$100,000/year, 0 otherwise)	1	0	0.20	4.0E-04
Household with children	Children indicator (1 if respondent's household contains one of more child 17 years old or under, 0 otherwise)	1	0	0.30	4.6E-04
Local borrowing	Likelihood of respondent accessing resources from unknown neighbors (5 if extremely likely, 1 if extremely unlikely)	5	1	2.28	9.6E-04
Millennial	Age indicator (1 if respondent is between 26 and 35 years old, 0 otherwise)	1	0	0.32	4.7E-04
Neighbor sharing	Number of resources respondent would be willing to share with neighbors who chose to stay home and take shelter during a flood (10 if all, 0 if none)	10	0	6.76	2.9E-03
Network proximity	How close respondent lives to each person in their social support network on average (6 if same building, 1 if different countries)	5.4	0	2.57	1.3E-03
Republican	Republican indicator (1 if respondent is Republican, 0 otherwise)	1	0	0.17	3.8E-04
Total preparedness	Number of flood preparedness measures respondent currently has (7 if all, 0 if none)	7	0	2.96	1.9E-03
Under 25	Age indicator (1 if respondent is 25 years old or younger, 0 otherwise)	1	0	0.30	4.6E-04

research question. To facilitate interpretation, the marginal effects at the parameter means are computed and displayed by decision-context in Fig. 3 (Train, 2009; Wulff, 2015). In the following, we summarize our findings to be further discussed in Section 5.

#### 4.3.1. Influence of sociodemographic characteristics

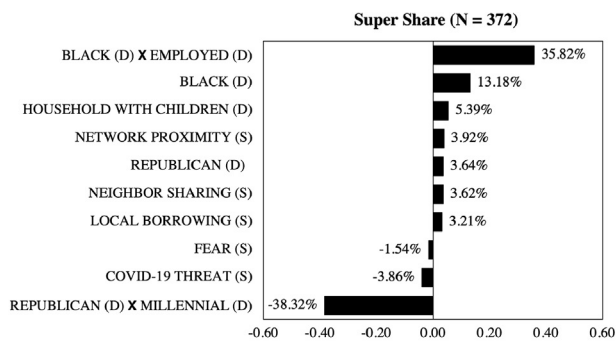
The most impactful personal factors were related to age, race, and income. From Fig. 3 we note that individuals under the age of 25 had a 7.6 percentage higher probability of sharing an evacuation ride as a passenger only, while the status of millennial corresponded to a 10.28 percent increase in the probability of sharing. Interestingly, the interaction with emotion reveals that millennials who are more likely to experience fear during the evacuation event had an even higher implied percentage change in the probability of sharing

(15.36 percent) as a passenger only. In terms of race, individuals who are Black had a 13.18 percentage higher probability of sharing as both a driver and passenger, a 0.97 percent increase in probability of sharing as a driver only, and a 4.07 percentage lower probability of not sharing at all. Black women had an additional 3.63 percent increase in the probability of sharing as a driver only. Those who are Black and employed had a 35.82 percent increase in the probability of sharing as both a driver and a passenger. In terms of income, households earning over \$100 k per year had a 14.83 percentage higher probability of not sharing in either scenario.

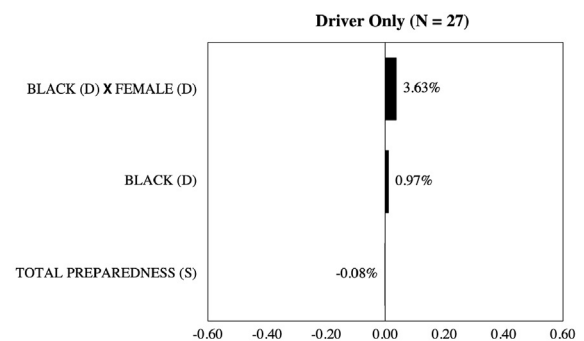
Smaller impacts were observed for political affiliation and household characteristics. People identifying as republican had a 5.48 percentage higher probability of sharing as a passenger only and a 3.64 percent increase in probability of sharing as both a driver and

**Table 4**  
Random Parameter Logit Evacuation Ridesharing Model Results.

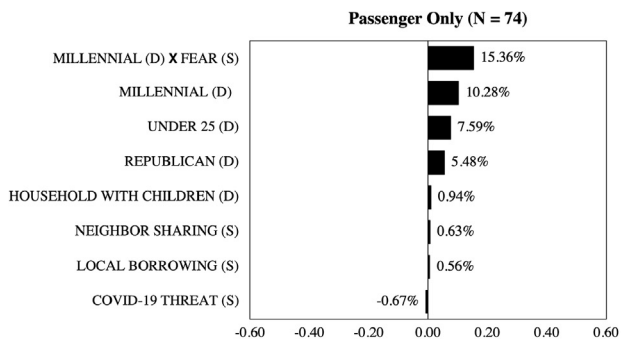
Name	Alternative Specific Attributes				Estimate	Robust t-test	p-value
	No Share	Driver Only	Passenger Only	Super Share			
Alternatives							
$ASC_{NoShare}$	×				−0.118	−0.27	0.79
$ASC_{DriverOnly}$		×			−3.71	−3.47	0.00
$ASC_{PassengerOnly}$			×		−3.09	−2.92	0.00
$ASC_{SuperShare}$				×	0.00		
Random coefficient							
$\beta_{TotalPreparedness}$	×	×			0.14	2.18	0.03
$\alpha_{TotalPreparedness}$		×			−0.29	2.90	0.00
Parameters: Sociodemographics							
$\beta_{Black}$	×	×			0.95	1.81	0.07
$\beta_{HighIncome}$	×				0.90	3.31	0.00
$\beta_{HouseholdChildren}$			×	×	0.45	1.78	0.08
$\beta_{Millennial}$			×		3.01	2.42	0.02
$\beta_{Republican}$			×	×	1.01	2.97	0.00
$\beta_{Under25}$			×		0.64	1.95	0.05
Parameters: Circumstantial							
$\beta_{COVIDThreat}$			×	×	−0.358	−2.46	0.01
$\beta_{Fear}$	×			×	−0.356	−1.69	0.09
$\beta_{LocalBorrowing}$			×	×	0.29	2.34	0.02
$\beta_{NeighborSharing}$			×	×	0.24	6.09	0.00
$\beta_{NetworkProximity}$				×	0.19	2.66	0.01
Interactions							
$\beta_{Black} \times \text{Employed}$				×	0.71	1.83	0.07
$\beta_{Black} \times \text{Female}$		×			1.74	2.98	0.00
$\beta_{Millennial} \times \text{Fear}$			×		−0.527	−1.97	0.05
$\beta_{Republican} \times \text{Millennial}$				×	−1.08	−2.25	0.02
Type of draws					Hess-Train		
Number of draws (normally distributed)					500		
Number of observations					584		
Rho-square					0.351		
Log likelihood at convergence					−525.609		



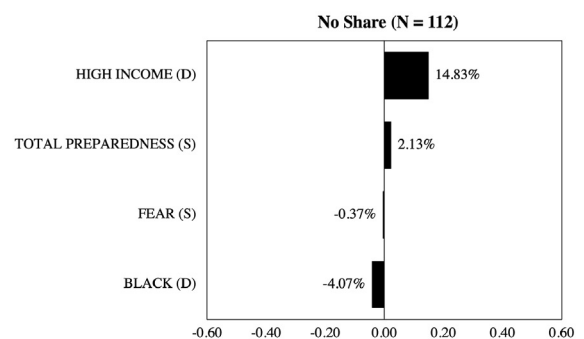
(a)



(b)



(c)



(d)

**Fig. 3.** Marginal effects for model parameters and interactions for (a) super-sharing, (b) driver-only sharing, (c) passenger-only sharing, and (d) non-sharing; “D” represents dummy variables, and “S” represents continuous variables.



passenger. However, republicans who were also millennials had a 38.32 percent decrease in probability of sharing as both a driver and passenger. Households with children had a 5.39 percentage higher probability of sharing both as a driver and a passenger and a 0.94 percent increase in probability of sharing as a passenger only.

#### 4.3.2. Influence of situational variables

In terms of risk perception, those who perceived an evacuation during the COVID-19 pandemic to be a greater threat to their personal health had a 3.86 percent lower probability of sharing overall and a 0.67 percent decrease in probability of sharing as a passenger only. It is worth noting that the emotions surrounding the flood evacuation led to weaker effects on willingness to share compared to risk perception related to the pandemic, although both were negatively correlated with sharing (and were measured according to different scales). Those who were more likely to experience fear during the flood evacuation had a 1.54 percent lower probability of sharing as both a driver and passenger.

In terms of access to resources, those who were more prepared for flooding had a 2.13 percentage higher probability of not sharing at all and a 0.08 percent decrease in the probability of sharing as a driver only. Those with more proximal social networks had a 3.92 percent higher probability of sharing in either scenario. Those who were willing to share more resources with their neighbors during a flood had a 3.62 percent higher probability of sharing a ride in either scenario, as well as a minor 0.63 percent increase in the probability of sharing as a passenger only. Those who were more willing to borrow resources from neighbors they did not know had a 3.21 percentage higher probability of evacuation ridesharing in both scenarios and a 0.56 percent increase in probability of sharing as a passenger only.

#### 4.3.3. Role of super-sharing versus non-sharing

Differences in traits between those who would share an evacuation ride as both a driver and a passenger versus those who would not share in either case appear to be related primarily to *sociodemographics* (i.e., income, race, political affiliation, employment, household characteristics, age, and gender) and *situation* (i.e., threat perception, fear, preparedness, attitudes about sharing or borrowing, and network proximity). Those who are more likely to be super-sharers tend to be Black, republican, employed, have households with children, have more positive sharing attitudes, more proximal networks, and lower perceptions of COVID-19 threat and evacuation fear. On the other hand, those who are more likely to be non-sharers tend to have higher income and greater emergency preparedness.

#### 4.3.4. Role of passenger-sharing versus driver-sharing

Given the relatively low sample size of respondents opting to share exclusively in the role as either passenger or as driver, our ability to draw strong conclusions from these results is limited. Yet, the notable differences suggest that the minor change in perspective (from driver to passenger) is impactful. From our findings, those who are more likely to be passenger-sharers tend to be republican, below the age of 35, residing in households with children, and having more positive sharing attitudes and lower perceptions of COVID-19 threat. On the other hand, those who are more likely to be driver-sharers tend to be Black and female. In the following section, we will relate these findings back to the theoretical framework outlined in Section 2.

## 5. Discussion

### 5.1. Influence of social identity on willingness to share

Several significant variables related to social identity have appeared as reoccurring themes in the pandemic conversation. These include being a republican, a millennial, or person of color. These

social identities have been meaningful during the pandemic for reasons that differ from typical evacuation events. Our findings suggest that they play a role in how overlapping hazards are navigated, multiple perceived risks are weighed, and sharing behavior is evaluated.

Traditionally, generosity or sharing behavior has corresponded positively with being a woman, a parent, or Black. However, these trends are limited in their ability to inform sharing behavior during the novel COVID-19 pandemic. Compared to typical trends in sharing behavior, republican and millennial identities have an elevated importance in the pandemic sharing narrative, while being Black, a woman, or a parent remain important sharing factors. The former may be due to shifts in perceptions of risk unique to the pandemic period, while that latter may reflect perceptions of responsibilities common to disaster scenarios.

During the pandemic, political polarization has resulted in reduced perceptions of pandemic severity and risk to public health associated with a republican political identity compared to a democratic party identity (Tyson, 2020). Our finding that those leaning toward a republican political affiliation are more likely to share an evacuation ride may result from beliefs about appropriate behavior during the pandemic shaped by a political party ideology. It is important to note that the perceived personal risk of the COVID-19 pandemic is also controlled for in the model. This shows that, even controlling for individual COVID-19 risk perception, those leaning further right on the political spectrum are still more likely to share evacuation rides. These results point to a new identity dimension affecting mobility choice that is typically not covered in the literature. In other words, political identity seems to upstage COVID-19 risk when evaluating shared rides. This suggests that the desire to uphold the common beliefs of one's in-group can be more influential than individual perceptions of health risk. Interestingly, for super-sharing this finding is dramatically reduced when intersected with the identity of being a millennial. This conveys that despite strong impacts of political identity, there is systematic variation along the division of age.

In the early months of the COVID-19 pandemic when this survey was conducted, news reports of younger individuals contracting severe cases of the virus were rare (Maragakis, 2020). Therefore, the public perception was that the risk of the virus to young people was low, although they could still spread it to more vulnerable individuals. Under ordinary circumstances, our finding that those under the age of 35 are more likely to share an evacuation ride would be surprising. For example, it contradicts pre-pandemic findings on shared evacuation rides (Wong et al., 2020a). However, there are a few interesting caveats to our finding. First is that this age group is significantly more likely to share a ride as a passenger only, which may be related to non-emergency ridehailing being higher among this age group in general (Rayle et al., 2016). Second, the interaction with evacuation fear actually increases the likelihood of millennials to share an evacuation ride as a passenger. This calls to mind the concept that there can be safety in numbers, which has an interesting connotation in the context of a global pandemic. It is possible that, as a passenger in a shared ride, more fearful millennials may actually feel safer inviting a third stranger into the vehicle, suggesting that for millennials evacuation-related fears overshadow the perceived risk of COVID-19. This notion is similar to findings in previous work showing that young people are more likely to feel unsafe on public transit when they are traveling alone (Casadó et al., 2020). Indeed, trust has been shown to be particularly important to millennials for sharing encounters of longer durations and involving social interaction (Mittendorf et al., 2019).

As a social identity, being Black in the time of the COVID-19 pandemic has many implications. While people of color have been disproportionately affected by the pandemic (Millett et al., 2020), potentially reducing the willingness to share face-to-face, the Black Lives Matter movement has given rise to solidarity in communities across the U.S. (Creosote Maps, 2020), potentially enhancing willingness to share

within neighborhoods. Prior research on Hurricane Katrina shows higher likelihood among Black respondents to emphasize the importance of connection to and caring for others during an evacuation (Stephens et al., 2009). Indeed, our findings show a positive correlation between identifying as Black and the willingness to share an evacuation ride. Two interactions are found to boost this effect. First, being employed increases this effect on super-sharing. This finding may be related to access to financial and healthcare resources, reducing vulnerability in the pandemic context. Likewise, prior studies show a positive correlation between employment status and disaster volunteerism (Cvetković et al., 2018). Second, being a woman boosts this effect on driver-sharing. This finding is somewhat surprising given that women statistically face greater risks of harassment and violence in ridehailing (Brown, 2016). However, sharing in the role of a driver may allow for some level of control over the route selection and in-vehicle spacing, as well as enough distance from the passenger to provide protection from physical harm and viral exposure. Additionally, it is possible that a passenger could alleviate some evacuation-related fears related to navigation or mechanical challenges, such as the vehicle breaking down or encountering a flat tire.

The role that the social identity of parenting plays during the pandemic is somewhat less clear. However, prior research shows that the presence of school-aged children in a household can increase the neighborhood involvement and community engagement of parents (Miller, 2007), which may potentially lead to a greater willingness to share evacuation rides with unknown neighbors. Indeed, our findings show a positive correlation between households with children and evacuation ridesharing. However, this finding contradicts prior research that shows households with children are less likely to share evacuation transportation during a wildfire (Wong et al., 2020a). It is difficult to know the exact reason for this difference, but one possible explanation may be related to the different causes of evacuation (i.e., flooding versus wildfire).

## 5.2. Influence of overlapping vulnerabilities on willingness to share

While many potential socioeconomic vulnerabilities were taken into account in this study, the vulnerability factor impacting willingness to share that is most apparent from our findings is social isolation. Our analysis includes three measures of social connectedness (i.e., the reverse of isolation) and shows that each is positively correlated with willingness to share evacuation rides. First, network proximity is positively correlated with super-sharing. Individuals who receive more resources from people living near them could be considered more socially connected within their neighborhood, and this connectedness appears to have a positive effect on sharing. Second, a greater likelihood of borrowing resources from unknown neighbors is positively correlated with sharing evacuation rides with unknown neighbors. This may be thought of as a type of social reciprocity. Third, a greater willingness to share emergency preparedness supplies with neighbors is positively correlated with sharing evacuation rides. This is not entirely surprising, although in a pandemic context, the longer duration of face-to-face sharing endured during an evacuation ride potentially poses greater risks compared to the sharing of other emergency preparedness supplies. In general, the importance of social connectedness for evacuation ridesharing is not surprising considering previous findings that access to social resources impacts evacuation decision-making (Riad et al., 1999). However, it is interesting within the pandemic context. Although social isolation presents a hindrance to accessing resources, it may also present the benefit of protecting oneself from viral exposure. In other words, social isolation may intensify some vulnerabilities to an evacuation emergency while alleviating some vulnerabilities to a health emergency. This is one of the curious contradictions of multi-hazard disasters.

## 5.3. Influence of risk perception on willingness to share

Two measures of risk perception were considered in this multi-hazard event: the threat of COVID-19 exposure to personal health and the emotion of fear arising in response to the evacuation scenario. Both are negatively correlated with evacuation ridesharing, while the effect of COVID-19 risk perception has a greater magnitude (although the measurement scales were not identical). This finding is in line with early research showing that concerns about the COVID-19 pandemic dominate those concerning flood risks (Botzen et al., 2020). The initial replicability of this finding is promising, and it presents an opportunity for improved communication. We note that these risk perceptions are likely influenced in part by political identity and networked news reports rather than reflecting actual probabilistic outcomes. For this reason, clear communication that addresses these conflicting risks together is essential.

## 5.4. Influence of resource abundance on willingness to share

Two factors related to resource accumulation are significantly correlated with willingness to share evacuation rides: income and preparedness. Surprisingly, both negatively impact sharing. First, earning over \$100 k per year is positively correlated with non-sharing. High income likely reflects access to financial resources, employment benefits, and employment security, all of which would be beneficial during both an evacuation and a pandemic. Second, the amount of flood preparedness items a household has is positively correlated with non-sharing and negatively correlated with driver-sharing. These items include food, water, and medical supplies, which would be advantageous during both an evacuation and a pandemic. These findings can appear surprising, because access to resources is a prerequisite for the sharing of resources; to the authors these findings are also somewhat disappointing, because spontaneous resource sharing during a disaster can be an effective way to redistribute resources, especially considering the supply chain disruptions and challenges that have occurred during the COVID-19 pandemic (Grida et al., 2020). However, analysis of past pandemic episodes reveals not only resultant national economic contractions but also increased economic inequality (Furceri et al., 2020). Moreover, there is evidence of a COVID-19 *two-speed economy* wherein wealthier and more educated population segments are better able to successfully work remotely and remain shielded from pandemic exposure (Beck and Hensher, 2020). Thereby, we note that material resources, such as wealth and preparedness stock, do not appear to lead to increased evacuation ridesharing, unlike social resources.

## 5.5. Exploratory post-hoc analysis of narratives

The open-ended narratives identifying factors that encourage and prevent the sharing of an evacuation ride with a stranger during the pandemic are further examined in a post-hoc analysis. The goal is to draw additional insights to contextualize and gain better understanding of some of the more unexpected or contradictory findings. This is done using word frequency clouds and analysis of selected respondent quotes, as shown in Fig. 4. The following presents a deep dive into six categories of sharing.

There is a common narrative among surveyed participants identifying as Black who, despite being disproportionately affected by the COVID-19 pandemic (Millett et al., 2020), are willing to share a ride as both a driver and passenger, shown in Fig. 4a. This narrative appears to revolve around concepts of compassion, politeness, and general amiability toward fellow evacuees. A case-agnostic analysis of the commentary from this group when asked what would encourage them to share their evacuation ride shows that common words include “polite”, “friendly”, “beliefs”, and “neighbor”. Specifically, one participant answered that they would be encouraged to share a ride with a



**Fig. 4.** Word frequency clouds describing encouragement (as circles) or prevention (as crosses) for (a) Super-sharing Black, (b) Super-sharing households with children, (c) Passenger-sharing millennials, (d) Passenger-sharing republicans, (e) Driver-sharing Black women, and (f) Non-sharing high-income.

neighbor “if they [the evacuee(s)] are a really close neighbor or a vulnerable person like [a] single mom or children.” This style of narrative is seen throughout the comments left by other participants, as well, suggesting one of the driving sentiments encouraging Black neighbors to share their evacuation ride is empathy expressed through compassion toward others (Wong et al., 2020a).

Compassion also seems to be a shared sentiment among individuals belonging to households with children who are willing to share a ride as both a driver and passenger, shown in Fig. 4b. A narrative of help-

ing other evacuees emerged in the commentary left by participants with common words being “help”, “children”, and “family.” When asked what would encourage them to share an evacuation ride, one participant answered, “If they [the evacuee(s)] have children, if they [the evacuee(s)] will fit in the car.” This narrative suggests concern for vulnerable populations, particularly children, and an inquiry of capacity or an individual’s ability to offer a ride. This may be due to households with children presumably having children of their own in the evacuation vehicle with them. Furthermore, the compassion



exhibited by these individuals may be attributed to their ability to empathize with others who have children and who are undergoing the same struggles of evacuating while caring for others.

Compassion also appears to be exhibited by millennials (ages 25 to 34 years old) who were only willing to offer a ride as a passenger, shown in Fig. 4c. When asked what would encourage them to share a ride with other evacuees, feeling a moral obligation to aid others appears as a common theme using words such as “guilt”, “caring”, and lack of “options.” According to one of the respondents, “I would feel bad for them [the evacuee(s)] being trapped without a way out.” Others commented similarly with an emphasis on caring about the safety of people without evacuation options. This finding is consistent with prior studies that have shown charity and caretaking behaviors among millennials to be strongly motivated by feelings of guilt, pressure, and obligation (Davies, 2017; Kluijver, 2017).

Morality and financial compensation are common narratives among individuals identifying as republican who were only willing to share a ride as a passenger, shown in Fig. 4d. As stated by one respondent, a “lack of other options [and] money” would encourage republicans to share an evacuation ride. Witnessing the desperation of others for a way to evacuate may trigger a sense of moral obligation, encouraging them to offer a ride. One element that sets the narratives apart is the indication that monetary incentives would also serve as an effective form of encouragement with common words in these narratives being “money”, “desperate”, and “necessity.” This finding is consistent with earlier works showing economic or financial considerations to be one of the motivating factors in peer-to-peer car-sharing (Barbour et al., 2020).

Themes of danger and evacuation threat perception are common in responses from Black women who were only willing to share an evacuation ride as a driver, shown in Fig. 4e. Reoccurring words suggesting these themes in the narratives were “danger”, “stranded” and “safer.” When asked what would encourage them to share an evacuation ride, one individual responded, “Only if we are in great danger [and] must evacuate.” This reoccurring narrative of obligation, but also caution, may suggest that the willingness to help prevails over the perception of pandemic-related danger once a threshold for evacuation-related danger has been met.

A more conservative narrative is observed from high-income participants who were not willing to share an evacuation ride as a driver or passenger, shown in Fig. 4f. Concerns over the possible contraction of COVID-19 and a general sense of safety are commonly mentioned among these individuals using words such as “fear”, “sick” and “hostile”. When asked what would prevent them from sharing a ride, one of the participants responded, “The fear of them [the evacuee(s)] being sick or having bad intentions.” This type of response suggests a higher salience of perceived pandemic-related and evacuation-related risks by high-income individuals, likely related to the greater ability to remain shielded from pandemic exposure on the whole.

## 6. Conclusions

### 6.1. Summary of findings

In this study, we examine the willingness to share flood evacuation rides during the COVID-19 pandemic from the perspective of drivers and passengers. Our findings suggest the willingness to share in this context is related to *social identity* (i.e., being republican, a millennial, Black, or a parent), *vulnerability* (i.e., social isolation), *risk perception* (related to both the pandemic and flood evacuation), and *access to resources* (i.e., income and preparedness). While some traditional sharing factors remain significant in this multi-hazard scenario (such as being Black, female, or a parent), new factors emerge that have present-day significance within this novel context (including being a republican or a millennial). This work begins to shine light on the pri-

oritization of risk factors impacting the decision to share resources face-to-face during a viral pandemic that requires physical distancing.

### 6.2. Transportation policy implications

Evacuation planning for car-less individuals is a crucial matter of social equity. Race, income, disability, and healthcare status are known factors in the inability to evacuate (Renne et al., 2011). Likewise, racial minorities, low-income workers, and the elderly often suffer from lower transit accessibility, such as in Chicago (Ermagun and Tilahun, 2020). Our results suggest that the organization and implementation of shared evacuation rides between neighbors in areas with fewer mobility options could improve evacuation ability and thereby disaster resilience. In our study, drivers who identify as Black have a greater willingness to offer evacuation rides, which seems to hint at the possibility of this spontaneous sharing behavior to fill gaps in evacuation mobility. While not diminishing the responsibility of emergency and transportation agencies to address inequities in disaster resilience head-on, spontaneous evacuation ridesharing does show potential to improve evacuation response, even amidst the additional challenges presented by a viral pandemic.

On-demand ridehailing companies and transportation network providers have offered their services in many past evacuation events. Uber and Lyft both provided free or discounted rides during Hurricane Michael and the California wildfires in 2018, as well as during Hurricane Dorian and the California wildfires in 2019. When our survey was deployed, coastal states were preparing for hurricane season amidst the COVID-19 pandemic. There was discussion of using ridehailing companies to evacuate car-less individuals instead of mass transportation to reduce crowding (Miller, 2020; SoCo Emergency, 2020), which illustrates the consideration of on-demand ridehailing as a viable evacuation mode despite challenges presented by the COVID-19 pandemic. Our findings offer insights for applied public health practices and transportation policies, including the recruitment of drivers and incentives to share or pool rides that may be acceptable to both drivers and riders, while following current pandemic protocols for ridehailing, such as limiting passengers to the backseat and wearing a facial covering (Centers for Disease Control and Prevention, April 17, 2020).

In terms of policies, our findings indicate that drivers providing evacuation rides during the pandemic should be compensated \$30/hour on average, and the payments should come from the individual accepting the ride. While this suggestion presents serious challenges of social equity, it reveals a public perception of this evacuation mode as a commodified service. Additionally, we find that ridehailing drivers and passengers are willing to allow an additional 15 to 18 min on average to pick up another evacuee. From the rider's perspective, the most important public health policy emerging from this research is to have drivers wear a face covering. Additional transportation network provider policies for ridehailing should include: (1) not collecting passenger data, (2) allowing the passenger to track the ridehailing vehicle, and (3) performing background checks on all drivers. Additionally, for emergency evacuations, drivers should be able to navigate without the use of GPS.

Our findings suggest that the sharing or pooling of evacuation rides may be encouraged through the use of face coverings, monetary incentives, the prioritization of passengers who are in greatest need (e.g., individuals with children), and the pooling of riders who could be picked up close together. However, during the COVID-19 pandemic, it will be important to refrain from attempts to encourage the pooling of evacuation rides among passengers from groups who are at greater risk of COVID-19 severity, such as older adults and people with underlying medical conditions. Although our findings suggest that individuals who are Black are more likely to offer an evacuation ride under these multi-hazard circumstances, it may be advisable to refrain from attempts to recruit drivers from groups who are at greater risk of COVID-19 consequences.



To address the threats presented by this dual emergency event, it would be beneficial to phrase communications in terms of its compounding hazards to guide the public's perceptions of competing pandemic-related and flood-related risks in order to overcome the paralyzing inertia of chronic and acute emergency-induced fears (Shultz et al., 2020a). It is important to influence risk perception in thoughtful ways, because it is this perception of risk that informs decision-making in a time of profound uncertainty (Shultz et al., 2020b).

### 6.3. Limitations and prospects

The main limitations of this work relate to our data collection method. There is a demographic imbalance in our survey sample that is skewed toward individuals under the age of 45, those who are Asian, and those of higher income. Given the use of *non-probabilistic* sampling, there is limited potential to generalize the findings from our study. An important motivation for using convenience-based sampling is to capture rapidly changing behaviors as they take shape. This approach is justified for evacuation modeling (e.g., Wong et al., 2020b) and for COVID-19 travel behavior (e.g., Parady et al., 2020), both of which apply to our study. We note that the primary contribution of our work is to provide insight on behavior during dueling emergencies, and we encourage more research to examine the impact of sampling strategies and sampling and behavioral biases.

Moreover, there is a risk of *hypothetical bias* stemming from the stated evacuation ridesharing acceptance in this study. We note, however, that the consistent differences uncovered in the identified factors driving the three different levels of sharing suggest that respondents took the experiment seriously. This research lays groundwork for the future study of distinct simultaneous emergencies that require context-sensitive policy solutions and strategies. Specifically, our analysis of a flood evacuation co-occurring with a viral pandemic gives early evidence of how different population segments navigate dueling disasters.

### CRedit authorship contribution statement

**Elisa Borowski:** Conceptualization, Methodology, Data curation, Writing - original draft, Writing - review & editing, Visualization, Investigation, Formal analysis. **Victor Limontitla Cedillo:** Visualization, Writing - review & editing. **Amanda Stathopoulos:** Conceptualization, Methodology, Investigation, Supervision, Resources, Writing - review & editing, Project administration, Funding acquisition.

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The survey was approved by Northwestern's IRB with number STU00211228.

### Author contributions

Elisa Borowski developed the initial research idea, designed the survey, cleaned the data, produced the tables, estimated the models, and led the manuscript writing. Victor Limontitla Cedillo performed

the narrative analysis, along with its figures and interpretation, and contributed to the manuscript writing and revisions. Amanda Stathopoulos guided the idea development and survey design, oversaw the data collection, provided advice on the modeling analysis, and contributed to the interpretation of results and manuscript revisions. All authors discussed the results and contributed to the final manuscript.

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