Disasters, Displacement, and Housing Instability: Estimating Time to Stable Housing 13 Years after Hurricane Katrina

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ABSTRACT: Catastrophic disasters disrupt the structural and social aspects of housing, which can lead to varying lengths of displacement and housing instability for affected residents. Stable housing is a critical aspect of postdisaster recovery, which makes it important to understand how much time passes before displaced residents are able to find stable housing. Using the Gulf Coast Child and Family Health Study, a longitudinal cohort of Mississippi and Louisiana residents exposed to Hurricane Katrina (n = 1079), we describe patterns of stable housing by identifying protective and prohibitive factors that affect time to stable housing in the 13 years following the storm. Survival analyses reveal that median time to stable housing was 1082 days—over 3 years after Katrina. Age, housing tenure, marital status, income, and social support each independently affected time to stable housing. Findings suggest that postdisaster housing instability is similar to other forms of housing instability, including eviction, frequent moves, and homelessness.

SIGNIFICANCE STATEMENT: Climate change is expected to increase gradual-onset events like sea level rise, as well as the frequency and intensity of acute disasters like hurricanes. Such events when coupled with population growth, coastline development, and increasing inequality will lead to high levels of displacement and housing instability. Using longitudinal data, we wanted to understand how much time passed until residents who were displaced by Hurricane Katrina were able to find permanent and stable housing and identify factors that either prolonged or accelerated respondents' time to stable housing. Addressing this gap can help to improve resident recovery and create targeted postdisaster housing policy, especially as displacement from disasters becomes increasingly common among those living in regions susceptible to the effects of climate change.

KEYWORDS: Social Science; North America; Statistics; Vulnerability

1. Introduction

The United States is currently on a collision course between the natural and built environments. It is now understood that climate change will increase gradual-onset events such as sea level rise, as well as the frequency and intensity of acute disasters like hurricanes and wildfires (Meyer 2013; Bouwer 2011). Such events when coupled with population growth, coastline development, and increasing inequality will lead to high levels of displacement following catastrophic disasters (Raleigh et al. 2008; Gutmann and Field 2010; Curtis et al. 2015). Although such events have been rare in the past, recently there has been a noticeable increase in the number of disasters that have destroyed homes, businesses, and communities. The past four years alone have seen several catastrophic disasters, domestically, including Hurricane Harvey (Texas), Hurricane Maria (Puerto Rico), and Hurricane Michael (Florida); extreme flooding in the Gulf and Midwest regions; and wildfires throughout California. It is estimated that Hurricane Harvey (2017) displaced approximately 32 000 people from their homes (Simmons 2017) while Hurricane Maria (2017) displaced more than 400 000 people (Melendez and Hinojosa 2017). The 2018 wildfires in California displaced from 52 000 (Camp Fire) to more than 250 000 people (Woolsey Fire) (Passy 2018). An estimated 20 000 residents were left homeless in the weeks after Hurricane Michael (2018) slammed into the Florida Panhandle as the fourth strongest U.S. hurricane on record (Schneider 2019).

Catastrophic disasters disrupt both the structural and social aspects of housing. A disaster may destroy, disrupt, or severely degrade structural aspects of a community including its housing stock, as well as its critical infrastructure (i.e., energy, water systems, and wastewater/sewage). The degradation of social institutions that support households (i.e., community, schools, public safety departments, and religious institutions), while not as visible as the destruction of physical infrastructure, can dissuade residents from returning and contribute to long-term postdisaster displacement. Housing damage and displacement can also disrupt social networks that provide resources and support, leading to a sense of instability and uncertainty for affected residents. In addition, there are sociodemographic factors that prevent residents from returning to their predisaster neighborhoods and homes, and lead to varying levels of displacement and housing stability (i.e., race, ethnicity, gender, religion, socioeconomic status, pre-event housing tenure, and mental health). Market factors, including the pre-event availability of affordable housing and postdisaster profiteering by development interests can also shape the availability of affordable housing in disaster-affected

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areas, and exacerbate social and racial inequalities (Klein 2007; Adams et al. 2009; Peacock et al. 2007; Arcaya et al. 2020; Wyczalkowski et al. 2019). Such individual, household, and community-level factors can hamper displaced residents' ability to reestablish housing after a disaster and leave them unstably housed for varying lengths of time.

Despite the recent series of catastrophic disasters, Hurricane Katrina (2005) remains the largest environmental displacement in the United States since the 1930s dust bowl migration. The storm destroyed or badly damaged 800 000 housing units across the Gulf Coast (Plyer 2016) and led to the largest evacuation in U.S. history with approximately 1.5 million people leaving their homes and communities prior to the storm's arrival (Groen and Polivka 2010). Additionally, the flooding and related damages caused by the storm—coupled with slow storm debris removal—led to unprecedented levels of displacement. Previous reports estimate that over 440 000 Louisiana and Mississippi residents were displaced from their homes for at least four months (Redlener et al. 2007). The sheer number of destroyed housing units, along with the slow pace of housing recovery and high levels of poverty in the affected Gulf Coast region, caused many displaced residents to reside in temporary housing arrangements for several years following Katrina (Hori et al. 2009; Cutter and Gall 2006). Disaster-induced displacement—best understood as the displacement of people due to a disaster that causes extreme disruption to the functioning of a community (U.N. Office for Disaster Risk Reduction 2020)—can have far-reaching effects on individual health and well-being, including elevated levels of psychological distress, depression, and post-traumatic stress (Uscher-Pines 2009). Locating permanent and stable housing, especially if it is in the same predisaster communities, can help accelerate the recovery process (LaRock 2005; Peek and Fothergill 2008; Picou and Marshall 2007; Meyer 2013; Peacock et al. 2017). Estimating disaster recovery can involve multiple measures—relief of stressors, mitigation of vulnerability, enhancement of individual buffering capacities, and increased adaptive capacities—but stable housing is understood to be a critical predictor of the recovery and well-being of residents who have been displaced or highly impacted by disasters (Abramson et al. 2010; Comerio 2014; Peacock et al. 2017).

Although previous research has considered the relationship between disaster-induced displacement and recovery (Peacock et al. 2014), questions remain as to exactly how much time passes before displaced residents are able to find stable housing following a major disaster. Stable housing can enable rapid community recovery, prevent avoidable injuries, and limit potential adverse behavioral health outcomes that occur when large numbers of individuals are housed in shelters for extended periods of time (Institute of Medicine 2015). For these reasons, understanding time to stable housing is critical in understanding the widespread impact of Hurricane Katrina. Additionally, there is little empirical evidence about which sociodemographic characteristics are correlated with the greatest difficulty in locating stable housing after displacement. We address this empirical gap by applying methods from survival analysis to examine median time to permanent and stable housing for a population displaced by Hurricane Katrina and identify factors that either prolonged or reduced residents' time to stable housing. This gap is critical to address in order to improve recovery and create targeted postdisaster housing policy, especially as environmental displacement becomes increasingly common among those living in regions susceptible to the effects of climate change.

We apply survival analysis to five waves of data from the Gulf Coast Child and Family Health (G-CAFH) Study, a longitudinal cohort of 1079 households from Mississippi and Louisiana who were displaced or highly affected by Hurricane Katrina. Although survival analysis has been a common statistical tool to model human mortality and other life experiences (Cox 1972; Kalbfleisch and Prentice 1973; Singer and Willett 1991; Cox and Oakes 1984) and social transitions (Allison 1985; Blossfeld and Hamerle 1989; Heckman and Singer 1985; Tuma and Hannan 1984), this analytic technique has yet to be used to study housing stability following displacement from disaster. The benefit of using survival analysis is that it allows researchers to identify time to event, particularly when the event is unknown or confounded at the time when data are being collected. In this case, residents exposed to Hurricane Katrina and living in unstable housing may find stable housing after the point of interview, making time to stable housing an unknown or "censored" variable. Survival analysis considers the censoring effect of event occurrence when estimating time to stable housing.

In addition to examining median time to stable housing, we consider whether displaced respondents were able to achieve stable housing within 18 months following Katrina. It is well documented that the Federal Emergency Management Agency (FEMA) extended the 18-month limit of housing assistance to 26 months in the case of Katrina; however, this additional 8 months was fraught with uncertainty and confusion that often caused additional challenges for survivors (Mueller et al. 2011). We use 18 months postevent in our analyses since it is often a critical turning point for disaster survivors, as this is when interim housing assistance from FEMA typically ends. These analyses will contribute to discussions on whether postdisaster housing assistance should be limited to a predetermined fixed time.

Last, we identify subgroups who have struggled in the 13 years since Katrina to find permanent and stable housing and contribute to understandings as to how pre- and post-event sociodemographic inequalities shape housing stability. Examining social and structural characteristics that influence displaced residents' time to stable housing has implications for long-term, targeted postdisaster housing recovery programming.

a. The importance of housing stability

Stable housing in the United States has become increasingly precarious, especially following the housing market crash of 2008 and the growing affordable housing crisis. Yet, the importance of ensuring the availability of stable housing goes beyond providing individuals and families with physical shelter. Stable housing provides essential economic, social, and psychological resources to residents often through attachment to communities and social networks (Lewicka 2011;

Easthope 2004). Housing—and the opportunity to create a "home"—is deeply rooted in social life, and as such, these meaningful spaces have economic, emotional, and physical health effects for residents (Gans 2002; Mallett 2004). Those who lack stable housing are often trapped in stressful circumstances that produce negative effects for their mental health and immunological functioning (Aidala et al. 2007).

The term *housing instability* can include a range of housing problems, including frequent moves, difficulty paying rent, homelessness, eviction, foreclosure, or displacement (Burgard et al. 2012; Gilman et al. 2003; Kushel et al. 2006; Ma et al. 2008; Phinney et al. 2007; Tsemberis et al. 2007). Previous research has noted that despite housing stability being a key concept in housing and homelessness policy, research, and service provision, the concept remains poorly defined and conceptualized (Frederick et al. 2014). In general, definitions of housing stability relate to the potential for sudden change, including threats to housing security (Frederick et al. 2014). At the most basic level, housing stability can be measured as the presence or absence of housing (i.e., housed vs homeless). It has also been measured as whether individuals had uninterrupted housing for the 6 months prior to data collection; moving in the year or months prior to the interview; number of weeks housed; frequency of evictions; and frequent moves because of an inability to make rent (Bolton 2005; Cook-Craig and Koehly 2011; Dickson-Gomez et al. 2008; North et al. 2010). The common thread across these studies is that they equate length of stay with stability.

Disaster-induced displacement often precipitates unstable housing; however, most disasters lead only to evacuation—the sudden and unexpected move from one's home. After an evacuation, survivors are generally able to return to their homes and communities within days, and likely do not experience housing instability. Yet for many Katrina survivors, their dwellings and communities experienced such high levels of damage that they were unable to return for several weeks, months or years (Fussell et al. 2010; Groen and Polivka 2010; Myers et al. 2008). This type of mid- to long-term displacement—or in some cases, forced migration—often results in housing instability. For many residents displaced by Katrina, returning home or even finding temporary or semitemporary housing became a major challenge; however, analyses have yet to examine how long it took displaced residents to find stable housing after the storm.

Disaster-induced displacement and subsequent housing instability has been found to stifle recovery following a disaster (Cernea 1997). It can lead to a loss of social support and severed social ties, which often operate as protective factors following a traumatic event (Manzo and Perkins 2016; Popkin et al. 2004, 2005). More generally, housing instability has also been associated with poorer mental and physical health, including anxiety attacks, minor and major depression, and a higher likelihood of reporting poor self-rated health (Burgard et al. 2012). The implications of the link between housing instability and health can serve as evidence for the harmful long-term effects that disaster exposure can have on displaced residents.

b. Barriers to permanent and stable housing following a disaster

Many of the barriers that individuals and families encounter during a standard housing search are amplified when trying to secure stable housing following a disaster. Race, gender, age, marital status, household income, immigrant status, physical or cognitive disability, and regional nativity are structural factors related to the ability to find stable post-disaster housing (Adams et al. 2009; Anastario et al. 2009; Elliott and Howell 2017; Elliott and Pais 2006; Frankenberg et al. 2013; Fussell and Lowe 2014; Fussell et al. 2010; Landry et al. 2007; Mueller et al. 2011; Peacock et al. 2014; Peek and Fothergill 2008; Reid 2011; Sastry and Gregory 2014; Sastry 2009; Sterett 2011; Stough et al. 2016). Socially vulnerable groups are especially susceptible to housing instability, and often experience high rates of mobility following a disaster (Meyer 2013). In particular, racial and ethnic minority and low-income homeowners often encounter barriers to stable and affordable housing following a disaster (Meyer 2013; Finch et al. 2010). This sets in motion a cascading effect: the inability to find housing causes socially vulnerable groups to relocate frequently after their initial displacement, which in turn reduces financial, emotional, and educational resilience, and makes it harder to secure permanent and stable housing (Meyer 2013; LaRock 2005; Peek and Fothergill 2008; Picou and Marshall 2007; Arcaya et al. 2020).

There have been several studies examining the influence of sociodemographic factors on whether or not residents experienced displacement following Katrina, as well as their likelihood of return to pre-Katrina neighborhoods (Cutter et al. 2006; Elliott et al. 2010; Elliott and Pais 2006; Fussell et al. 2010; Graif 2016; Groen and Polivka 2010; Myers et al. 2008). However, factors related to displacement, including race, housing tenure, children in the household, age, and income have not been explored in relation to postdisaster housing instability. Specifically, we do not know how social vulnerability influences time to stable housing following a catastrophic event. A goal of these analyses is to examine whether such factors found to be associated with likelihood of displacement and return to pre-Katrina neighborhood are also associated with displaced residents' time to stable housing following Hurricane Katrina.

c. Research objectives and expectations

Stable housing is one of the most—if not *the most*—critical aspects of the disaster recovery process because it allows displaced residents to reestablish economic, educational, and social stability. It is important to note that housing instability exists on a spectrum, from precarious housing to homelessness. For the purposes of these analyses, we have measured instability as it relates to its precariousness—uncertainty as to whether a respondent can stay in his or her home for 12 months or more. Such a definition incorporates being homeless, doubled-up (i.e., an adult child living at home, two related or unrelated families living together or a parent living with an adult child), or living in emergency or transitional housing, and reflects previous studies that equate housing

stability with length of stay (Bolton 2005; Cook-Craig and Koehly 2011; Dickson-Gomez et al. 2008; North et al. 2010).

From previous findings about the relationship between disaster exposure and housing displacement, there are two aims of our analyses. The first aim is to examine the proportion of displaced residents in stable housing in the 13 years since Katrina occurred, and whether a majority were able to reach stable housing within 18 months after Katrina. Our second aim is to explore whether time to stable housing is significantly related to theoretically relevant variables, including individual and household factors, that have been linked to postdisaster displacement. To address these aims, we present the following hypotheses (H1–H4):

H1: A majority of displaced G-CAFH respondents did not achieve stable housing within 18 months of Hurricane Katrina.
H2: Particular individual-level characteristics, including income (i.e., below $20,000 annually), homeownership status (i.e., not homeowner), and housing damage (i.e., destroyed), will be associated with a greater median time to stable housing.
H3: Particular household characteristics (i.e., not being partnered; having children) will decrease time to stable housing.
H4: Being a homeowner prior to Katrina and having an annual income over $20,000 will exert the strongest independent effects on decreased time to stable housing.

The recovery process is complex, and the time needed to find stable housing is a previously unexplored aspect of this process. To assess the impact of disasters on displacement and recovery, we must begin to shift our focus from simply whether or not a resident is housed to whether a resident resides in stable housing. Similarly, research must consider the amount of time it takes to find permanent and stable housing following disaster-induced displacement, as this is a window into the true length of the recovery process. Overall, these findings contribute to remaining questions about displacement, housing, and recovery following a catastrophic disaster.

2. Data and methods

We use G-CAFH to examine time to permanent and stable housing in the 13 years following Hurricane Katrina. G-CAFH follows a cohort of 1079 respondents in order to assess postdisaster recovery via indicators such as economic recovery, social reengagement, individual health, resilience, and recovery. Because of the child component of the survey, interviewers were instructed to speak with the adult who was most knowledgeable about all household members at baseline, which is the same respondent interviewed at each wave. The study focuses on identifying health and recovery among this displaced and heavily impacted population.

G-CAFH employed a stratified cluster sampling strategy to enroll subjects in the study in two phases: Louisiana in February 2006 (n = 555) and Mississippi (n = 524) in August 2006 (Abramson et al. 2008). Across the two states, 26 sites were selected as primary sampling units that included 12 FEMA group sites, 10 commercial trailer sites, and 4 hotel sites. Additionally, the sampling frame in Mississippi was supplemented with an aerial sample. FEMA damage assessment maps and databases of the state's three coastal counties hardest hit by the hurricane were used to randomly select 150 of 650 census blocks that FEMA designated as having sustained moderate, extensive, or catastrophic damage. Overall, we sampled 4284 housing units as secondary sampling units, and of those, 985 were deemed ineligible because they were destroyed, vacant, abandoned, or under construction, which left 3299 eligible housing units. Among those, 1587 housing units had an eligible adult present to whom the study was presented; at the remaining 1712 housing units, no contact was made despite repeated efforts. Among the 1587 contacted in both Louisiana and Mississippi, 1079 agreed to be enrolled in the longitudinal study, corresponding to a response rate of 32.6% (1079/3299) and a cooperation rate of 67.9% (1079/1587). For further information see Abramson et al. (2008).

The 1079 respondents in Louisiana and Mississippi were followed for five rounds of data collection after Katrina. All Louisiana respondents were displaced at initial recruitment and were living either in group trailer parks or hotels. Mississippi respondents were either still displaced in emergency housing conditions in FEMA-supported trailer parks at initial recruitment, community-based respondents—some of whom had been displaced but had returned home—or had only briefly evacuated their homes. Additionally, some Mississippi residents were living in FEMA trailers on their property while their homes were being repaired, which was considered stable housing because residents knew they could eventually move back into their homes. At baseline (2006), surveys were completed in person and lasted approximately 1 h. The second wave was conducted in 2007, 20–23 months post-Katrina, and focused on respondents' physical and mental health, and social and economic consequences resulting from exposure to the hurricane. A third survey (wave 3) was conducted in 2008, 33–38 months post-Katrina and was completed with 777 respondents, and wave 4 was completed in 2009 with 844 respondents. Further details on the first four waves of data collection can be found in Abramson et al. (2008, 2010). Last, to examine long-term recovery, a final round of data was collected (wave 5) in 2017–18 with 647 respondents. Data collection for waves 2–5 was each conducted both in person and over the phone. G-CAFH was designed as a longitudinal cohort study with repeated measures. Over this period, G-CAFH retained 82% of the initial study cohort who were eligible to be surveyed (i.e., living, no cognitive impairment, and not incarcerated). Among 1079 respondents in G-CAFH, 134 respondents were not displaced during Katrina, and survival data (i.e., the variable measuring time to stable housing) were missing for 195 respondents. This resulted in survival data for 750 respondents for time to stable housing analysis. By 13 years after the hurricane, 652 of 750 respondents (87%) had reached stable housing.

a. Target event

The target event used in these analyses is time to permanent and stable housing following Hurricane Katrina. At each

of the five waves (2006, 2007, 2008, 2009, 2017–18), respondents were asked if they currently lived in permanent and stable housing. The survey defined living in permanent and stable housing as whether a respondent believed that he or she could stay in their current housing for a year or longer. If a respondent answered that they lived in permanent and stable housing, the interviewer asked for the date that they moved into this housing. We believe that our measurement of housing stability aligns with measures used in prior research (Bolton 2005; Cook-Craig and Koehly 2011; Dickson-Gomez et al. 2008; North et al. 2010) as it captures the presence or absence of housing, as well as length of stay. The variable *time to stable housing* is continuous and measured in number of days, which ranges from 0 to 3973 (median = 1082). Hurricane Katrina's landfall, 29 August 2005, is used as the start date for all time to stable housing estimates and includes the first observation of stable housing for respondents, not whether it is a permanent state.

b. Explanatory variables

To analyze different characteristics that previous research suggests may influence time to stable housing, we examined several individual-level and household factors. We considered variables known to influence housing stability, including gender, race/ethnicity, child in household, age, mental health, physical health, household income, and housing tenure. *Gender* is a dichotomous variable (1 = female; 0 = male). *State* is a categorical variable, which was recorded as either "Mississippi" or "Louisiana." We believed this variable was important to include because of each state's different policy and programmatic approaches to housing assistance (Green and Olshansky 2012; Louisiana Division of Administration 2020; Mississippi Disaster Recovery Agency 2020), as well as variation in respondent recruitment. Respondents were asked to identify their *race/ethnicity* at baseline, which was recoded as either "African American" or "other" given the distribution in responses. *Age* was measured continuously and recoded into a categorical variable (18–34; 35–49; 50–65; 66+). *Home damage* is a categorical variable that was coded as destroyed (unable to be repaired), major damage (home could not be lived in and required extensive repairs), and minor/minimal (in a short period of time the home could be repaired) or no damage. *Mental health* and *physical health* are both derived from the short-form 12 (SF-12), version 2, of the Medical Outcome Study. The SF-12 is a multipurpose survey with 12 questions selected from the SF-36 Health Survey (Ware et al. 1996). These 12 questions were combined, scored, and weighted to create two physical and mental health summary measures, denoted as the physical and mental health composite scores (PCS-12 and MCS-12, respectively; hereinafter PCS and MCS). These scales have been validated in both domestic and international populations and are computed using the scores of 12 questions that range from 0 to 100, with 0 indicating the lowest level of health and 100 the highest level of health (Ware et al. 1996). The cutoff score of 42.0 is often used to distinguish psychological distress and 45.0 is often used to distinguish physical health problems, which we used in our analyses. Annual *household income* is a dichotomous variable aimed at examining the influence of poverty on stable housing (1 = household earning less than $20,000; 0 = household earning more than $20,000). We dichotomized this variable at $20,000 as it is an approximate average of the 2010 federal poverty level for a household of 3 ($18,000) to 4 ($22,000). *Children in the household* is a dichotomous variable (1 = kids under 18; 0 = no kids under 18). *Salary or wage* is a dichotomous variable intended to distinguish between those who receive income from work as compared with retirement savings or government benefits (1 = salaried; 0 = not salaried). *Partner status* (1 = partnered; 0 = not partnered), *household child(ren) less than 13 years* [1 = young child(ren); 0 = no], *household size* (1 = less than 3; 0 = 3 or more), *homeowner* at the time of Katrina (1 = yes; 0 = no), *living in same area as prior to Katrina* (1 = yes; 0 = no), *currently live in safe community* (1 = not safe; 0 = safe), and *social support* (1 = low; 0 = medium/high) have each been operationalized as dichotomous variables. G-CAFH includes a five-item measure of perceived social support employed by Litwak et al. (1989). These items ascertain the informal support systems that are often critical for disaster recovery, including everyday needs, health difficulties, monetary issues, relationship troubles, and housing difficulties. All variables used in our analyses are self-reported.

c. Analytic methods

We use survival analysis to describe patterns of event occurrence (stable housing), compare patterns among groups, and examine factors affecting time to stable housing over time (Klein and Moeschberger 2006; Singer and Willett 1991; Wei 1992). Time to stable housing follows the same data characteristics as survival data, because individuals exposed to Hurricane Katrina spent some duration in one state (unstable housing) until they transitioned to another state (stable housing). Yet, because time to stable housing is unknown for some respondents during time of interview, data are right censored (i.e., generalized type-I censoring) (Skrondal and Rabe-Hesketh 2004); that is, for some households, stable housing is not observed before the end of the study period. These data characteristics make the application of survival analysis ideal for analyzing time to stable housing and understanding factors that may accelerate or hinder stable housing.

We used Kaplan–Meier (KM) survival curves to estimate median time to stable housing. The KM method estimates the survival time, considering the censored nature of time to stable housing variable. Survival probabilities corresponding to time to stable housing were calculated for all households and stratified by respondent, household, and community characteristics. KM survival curves were analyzed and the median time to stable housing was estimated for each predictor (corresponding to time when survival probability is 0.50). The log-rank test was used to test for differences in survival functions between groups.

We examined the effect of explanatory variables on stable housing using a regression framework, to simultaneously study the contribution of the different factors. The accelerated

TABLE 1. Factors associated with stable housing. Among 1079 respondents in G-CAFH, 134 respondents were not displaced during Hurricane Katrina. Survival data were missing for 195 respondents. The p values are based on a χ^2 test: $p < 0.05$ is indicated with one asterisk, $p < 0.01$ is indicated with two asterisks, and $p < 0.001$ is indicated with three asterisks. Cross tabulations are based on data collected at wave 1. When data were not available from wave 1, data shown in the table were collected at wave 2. "Returned to pre-Katrina neighborhood" indicates that the respondent returned to the neighborhood/community prior to Katrina.

Characteristics	Not displaced (%; $n = 134$)	Stable housing: within 18 months (%; $n = 165$)	Stable housing: >18 months (%; $n = 585$)	Total (%; $n = 884$)	p value
Overall	15.16	18.67	66.18	100.00	—
Gender					
Female	15.37	18.70	65.93	61.09	0.973
Male	14.83	18.60	66.57	38.91	
State*					
Mississippi	17.91	16.51	65.58	48.64	0.043
Louisiana	12.56	20.70	66.74	51.36	
Race/ethnicity*					
Non–African American	18.72	18.48	62.80	49.30	0.022
African-American	11.98	18.89	69.12	50.70	
Age***					
18–34	2.82	7.75	89.44	16.82	<0.001
35–49	13.97	15.44	70.59	32.23	
50–65	18.36	20.00	61.64	36.14	
66+	28.80	20.00	51.20	14.81	
Home damage***					
Destroyed	8.14	16.01	75.85	45.30	<0.001
Major damage	24.86	16.22	58.92	44.00	
Minor/none	12.22	20.00	67.78	10.70	
Mental health**					
Good (>MCS 42)	18.62	19.22	62.16	68.22	0.007
Bad (<MCS 42)	12.73	18.75	68.52	31.78	
Physical health					
Good (>PCS 45)	13.18	20.47	66.35	47.51	0.134
Bad (<PCS 45)	17.94	17.06	65.00	52.49	
Household income***					
Below $20,000	10.13	15.20	74.67	46.44	<.001
Above $20,000	23.00	24.33	52.67	53.56	
Child(ren) in the household*					
No child	17.65	18.66	63.69	77.48	0.014
Child	13.39	13.39	73.22	22.52	
Salary or wages**					
No salary	12.77	15.66	71.57	60.56	0.004
Salary	17.51	21.66	60.83	39.44	
Partner status**					
Partnered	19.94	21.54	58.52	32.71	0.003
Nonpartnered	13.60	15.47	70.93	67.29	
Household child(ren) less than 13 years					
No	16.28	19.00	64.72	75.31	0.068
Young child(ren)	9.52	17.01	73.47	24.69	
Household size					
Less than 3	15.93	19.91	64.17	59.32	0.102
3 or more	12.99	15.15	71.86	40.68	
Homeowner***					
Not owner	3.76	15.79	80.45	48.13	<0.001
Owner	33.22	21.59	45.18	51.87	
Returned to pre-Katrina neighborhood***					
Not return	0.50	21.36	78.14	45.02	<0.001
Return	27.16	16.46	56.38	54.98	
Safe community*					
Not safe	9.02	9.84	81.15	21.68	0.020
Safe	18.45	14.88	66.67	78.32	
Social support**					
Low	9.20	16.56	74.23	29.44	0.007
Medium/high	18.77	18.77	62.45	70.56	

failure-time (AFT) model was used because it provides an ideal framework for incorporating both censored survival data and time-varying covariates (Wei 1992; Lillard 1993), allowing for all five waves of G-CAFH longitudinal data to be used. AFT models have been used widely in various disciplines, such as child and adolescent research (e.g., Palli et al. 2012), transportation (e.g., Weng et al. 2014), medicine (e.g., Ghosh et al. 2012; Kim et al. 2013; Ng et al. 2015; Sayehmiri et al. 2008), and public health (e.g., Siahpush et al. 2010). In the AFT model, explanatory variables (covariates) can be expressed as a parametric log-linear model for survival time, T_i (time to stable housing for respondent i) as follows: $T_i = \exp(\beta_2 x_i)\exp(\alpha_0 + \varepsilon_i)$ such that $\tau_i \equiv \exp(\alpha_0 + \varepsilon_i)$. In this study, τ_i was examined using five parametric models (lognormal, log-logistic, exponential, Weibull, and generalized gamma) to identify the best model. In AFT models, the survival function can be expressed as follows: $S(t|x_i) = S_o[t\exp(-\beta_2 x_i)]$. Here, the estimated coefficient β_2 is a time ratio (TR) of covariate x_i, which indicates change in median survival time, as x_i changes from a to $a + 1$: $\exp(\beta_2) = \{\exp[\beta_2(a + 1)]/\exp[\beta_2(a)]\}$.

Measures of likelihood-based information criteria [Akaike information criterion (AIC) and Bayesian information criterion (BIC)] were used to select the best parametric model. Once a model was selected, three sets of explanatory variables were examined. In model 1, only individual characteristics (i.e., age, race/ethnicity, income, and homeownership status) were analyzed as part of the AFT model, to estimate the time ratios; next in model 2, household factors (i.e., partner status, household with young children, children in the household, and household size) were added; last, in model 3, factors that have been found to have strong independent effects on stable housing (i.e., mental health, social support, and return to same community prior to Katrina) were added.

3. Results

a. Descriptive statistics

Table 1 shows the cross tabulations by individual, household, and stable housing factors. Table 1 reports cross tabulations that examine differences in proportions between respondent households that were not displaced, those that were stably housed within 18 months, and those that did not achieve stable housing within 18 months by various individual and household characteristics. We created descriptive statistics to examine differences in proportions among G-CAFH respondents for the three displacement categories with row percentages presented. Results demonstrate that it took a majority of displaced G-CAFH respondents over 18 months to reach stable housing. Additionally, state of residency (Mississippi vs Louisiana), race/ethnicity (African American vs others), age (18–24, 35–49, 50–64, and over 66), mental health status (MCS scores above or below 42), household income (above or below $20,000), children in the household, having salary or wages, partner status, homeowner status, returned to pre-Katrina neighborhood, perceiving one's community as safe, and having social support had significant differences for length of housing stability.

b. Estimates of time to stable housing

The median overall time to stable housing, estimated using the KM method ($n = 750$, excluding respondents who were already in stable housing at baseline, and including those for whom survival data were available), was 1082 days or nearly 3 years. Table 2 presents the median time to stable housing (i.e., number of days), stratified by the same characteristics used in Table 1. Differences in time to stable housing are noted using the log-rank test.

When examining significant age group difference, younger respondents (18–34 years old) exhibited the longest median time to stable housing (1355) while older adults (66 years and older) had the shortest (838). It is important to note that this difference may be attributed to more general patterns of housing stability and age—including that younger adults move more frequently, on average, than older adults—rather than a result of displacement due to Katrina (Frey 2019). Those with mental health distress (MCS < 42) were significantly more likely to take more time to locate stable housing (1089 days) than those without mental health distress (1021 days). There was a significant difference between median time to housing for those living in a household with less than $20,000 annual income (1143 days) and those earning greater than $20,000 annually (929 days). There was a significant difference between median time to stable housing for respondents with a child in the household (1174 days) and those without a child (1051 days). For households with young children (1204 days), there was also a significant difference in time to stable housing when compared with to those without young children (1051 days). Homeowners had a shorter time to stable housing (808 days) than those who were not owners at the time of Katrina (1174 days). Those who returned to the area in which they were living prior to Katrina had a significantly shorter time to stable housing (1021 days) than those who did not (1143 days). Those with medium or high social support had a shorter time to stable housing (1021 days) than those with low social support (1235 days). Other characteristics did not produce significant differences.

c. KM survival curves

For the overall survival function and for groups with significant differences in survival functions, as derived using the log-rank test, the KM survival curves are presented in the 11 graphs in Fig. 1. The KM survival functions present the survival probability of stable housing (y axis) by time to stable housing (x axis). When time = 0, the survival probability is 1.00, when everyone in the analysis is displaced and unstably housed; the survival probability then diminishes as time increases; however, because of censoring of the survival data, the KM curves may not reach 0 (Singer and Willett 1991). Median survival time (median time to stable housing) corresponds to time when survival probability is at 0.50. These graphs provide information to answer the descriptive question of how many days pass before a respondent is in permanent and stable housing and are a way to show median time to event. Kaplan–Meier curves are presented for several individual and household factors including race, age, housing

TABLE 2. Time to stable housing: median survival time and equality test for survivor functions (log-rank test of equality). Among 1079 respondents in GCAFH, 134 respondents were not displaced during Hurricane Katrina. Survival data were missing for 195 respondents. This resulted in survival data for 750 respondents for time to stable housing analysis. By wave 5, 652 (86.93%) respondents reached stable housing. Values in parentheses are standard errors (SE). Time to stable housing is expressed in number of days; p values are based on comparison of survival functions using a log-rank test of equality, and significance is indicated as in Table 1.

Characteristic	n	Median (SE)	p value
Overall	750	1082 (25.76)	—
Gender			
Female	457	1021 (35.26)	0.221
Male	293	1113 (33.98)	
State			
Mississippi	353	1113 (26.98)	0.906
Louisiana	397	1021 (43.69)	
Race/ethnicity			
African-American	343	1082 (34.06)	0.615
Non–African American	382	1082 (39.82)	
Age***			
18–34	138	1355 (43.18)	<0.001
35–49	234	1143 (41.33)	
50–65	249	1021 (43.85)	
66+	89	838 (79.97)	
Home damage			
Destroyed	350	1143 (33.67)	0.089
Major damage	278	1082 (53.92)	
Minor/none	79	1113 (64.07)	
Mental health**			
Good (>MCS 42)	271	1021 (47.82)	0.021
Bad (<MCS 42)	377	1089 (39.31)	
Physical health			
Good (>PCS 45)	369	1082 (36.22)	0.138
Bad (<PCS 45)	279	1051 (45.95)	
Household income***			
Below $20,000	479	1143 (33.89)	<.001
Above $20,000	231	929 (66.01)	
Child(ren) in the household**			
No child	406	1051 (28.11)	0.093
Child	304	1174 (38.91)	
Salary or wages*			
No salary	362	1113 (32.19)	0.021
Salary	377	1021 (48.92)	
Partner status			
Partnered	249	960 (56.32)	0.074
Nonpartnered	324	1113 (43.78)	
Household child(ren) less than 13 years			
No	617	1051 (27.20)	0.161
Young child(ren)	133	1204 (54.49)	
Household size			
Less than 3	549	1051 (26.56)	0.267
3 or more	201	1143 (57.88)	
Homeowner***			
Not owner	384	1174 (45.05)	<0.001
Owner	201	808 (36.39)	
Returned to pre-Katrina neighborhood*			
Not return	396	1143 (36.78)	0.011
Return	354	1021 (35.40)	
Safe community			
Not safe	111	1174 (113.25)	0.057
Safe	137	1204 (45.45)	
Social support**			
Low	148	1235 (89.64)	0.001
Medium/high	437	1021 (35.90)	

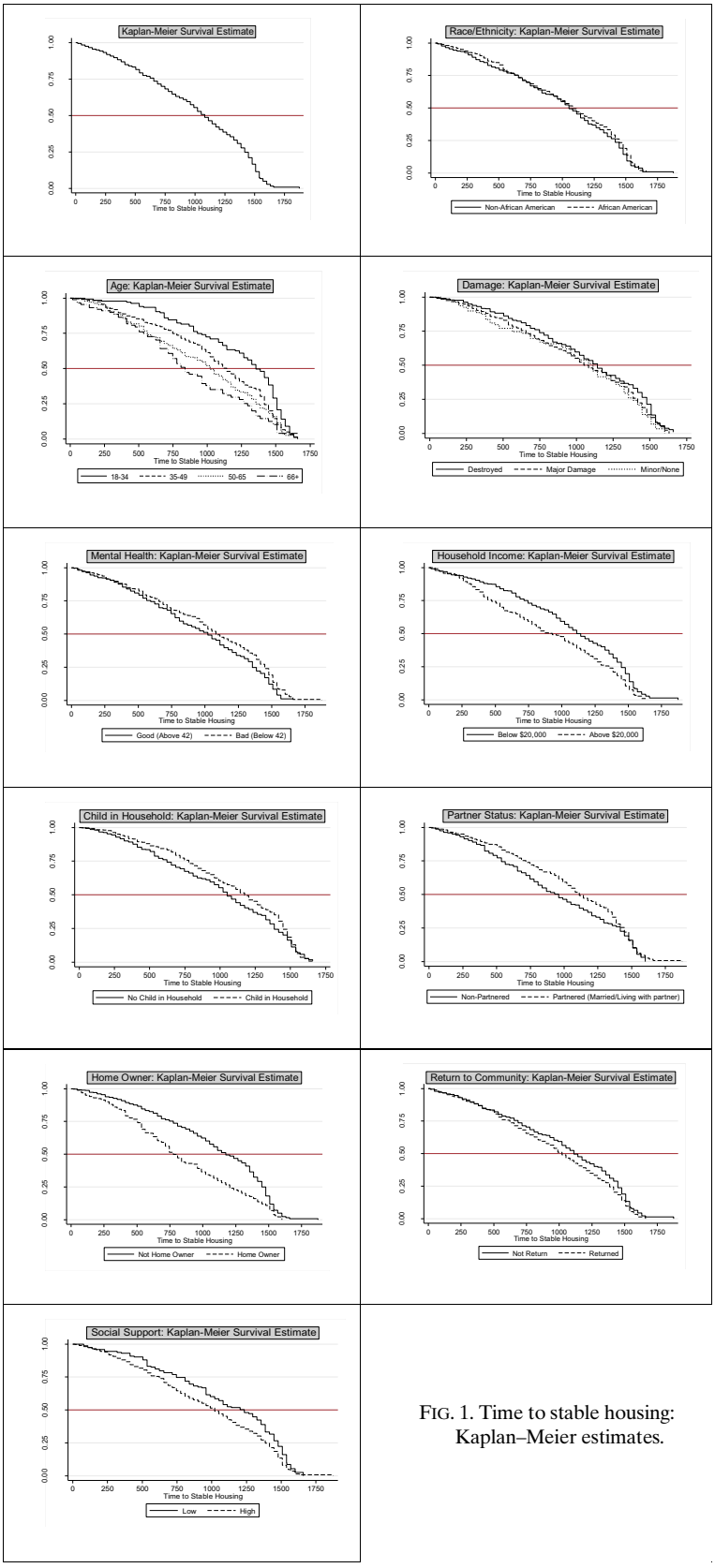

FIG. 1. Time to stable housing: Kaplan–Meier estimates.

TABLE 3. Factors affecting time to stable housing with time-varying covariates. The model was fit with an AFT model using a lognormal distribution. The estimated parameter σ is the standard deviation of the error term, $\varepsilon_I \sim N(0, \sigma^2)$. Models with a lower deviance and information criteria (AIC and BIC) indicate better fit. The full model including all factors best describes characteristics affecting survival time to stable housing. Home damage is dichotomized as "1" for destroyed and "0" for all others (major damage, minor damage, and no damage). Time ratios indicate the likelihood of increasing the median time to stable housing. For example, respondents with home damaged on average have an increased median survival time (time to stable housing) by 11% [=100% × (1.11 − 1)] across waves. Likewise, respondents without a partner have an increased median time to stable housing by 12% across waves. Significance: $p < 0.05$ is indicated with one asterisk, $p < 0.01$ is indicated with two asterisks, and $p < 0.001$ is indicated with three asterisks.

Factor	Model 1: individual factors		Model 2: individual + household factors		Model 3: full model	
	Time ratio	p value	Time ratio	p value	Time ratio	p value
Age	0.99 (0.00)***	<0.001	0.99 (0.00)***	<0.001	0.99 (0.00)***	<0.001
African American vs non–African American	1.03 (0.03)	0.418	1.01 (0.03)	0.676	1.03 (0.04)	0.453
Household income < $20,000	1.26 (0.04)***	<0.001	1.23 (0.04)***	<0.001	1.21 (0.04)***	<0.001
Not homeowner	1.31 (0.04)***	<0.001	1.29 (0.04)***	<0.001	1.27 (0.05)***	<0.001
Living in Louisiana at time of Katrina	0.95 (0.00)***	<0.001	0.95 (0.03)	0.105	0.93 (0.03)*	0.039
Home damage	1.10 (0.03)***	<0.001	1.10 (0.03)***	<0.001	1.10 (0.04)**	0.002
No partner (single/unmarried)[a]			1.14 (0.03)***	<0.001	1.13 (0.04)**	0.001
Young child(ren) in household (≤12 yr)[a]			1.00 (0.05)	0.977	0.98 (0.06)	0.687
Child(ren) in household[a]			1.03 (0.05)	0.594	1.06 (0.06)	0.269
Household size[a]			1.01 (0.01)	0.212	1.02 (0.01)	0.202
Poor mental health[a]					1.05 (0.03)	0.162
Social support[a]					0.90 (0.03)**	0.005
Not return to pre-Katrina neighborhood					1.04 (0.03)	0.216
Intercept	873.79 (57.59)***	<0.001	802.35 (65.63)***	<0.001	835.14 (83.44)***	<0.001
σ	0.63 (0.01)		0.62 (0.01)		0.62 (0.01)	
Deviance (−2 log likelihood)	−2212.63		−2088.82		−1605.14	
AIC	4441.27		4201.64		3240.29	
BIC	4487.48		4270.33		3322.26	

[a] Time-varying covariates (data from waves 1 to 4, except for social support, which was measured from waves 2 to 4). Data for homeownership were taken from wave 2.

damage, mental health, household income, child in household, partner status, homeownership status, return to pre-Katrina neighborhood, and social support.

d. Explanatory factors affecting time to stable housing

Table 3 presents the time ratios for the three models examined to test our hypothesis that particular individual-level characteristics, including income (i.e., below $20,000 annually), homeownership status (i.e., not homeowner), and housing damage (i.e., destroyed) will be associated with a greater median time to stable housing and that particular household characteristics (i.e., being partnered; having children) will decrease time to stable housing. Among parametric AFT models examined, the lognormal distribution had the best model fit (information-based criteria and residual-fit statistics) and was selected for explanatory analyses. Three AFT models were tested: one that only examined individual factors, one that examined individual and household factors, and one that explored individual and household factors, as well as factors that previous research suggests are independently associated with housing stability. In the final model, time-varying covariates were specified for partner status, young children in the household, children in the household, household size, mental health status, and social support.

Results indicate that model 3, which is the full model, had the best fit, based on deviance-based information criteria. Among individual factors, age, household income, homeowner status, state, and housing damage were significant predictors. Partner status was a significant household factor, and social support was a significant protective factor. Time ratios indicate the likelihood of increasing the median time to stable housing. Age was included as a continuous variable, which can be interpreted as for each year increase in age the median time to stable housing was one unit less. For the binary indicators in the model, such as household income, respondents with household income less than $20,000 had a 21% longer median time to stable housing than respondents with higher household income, controlling for other individual, household factors. Those who were not homeowners had a 27% longer median time to stable housing. Individuals living in Louisiana at the time of Katrina had a 7% shorter median time to stable housing than those in Mississippi. Respondents whose homes were destroyed by Katrina had an 10% longer median time to stable housing than those whose houses were not damaged. Respondents who were single or unmarried had a 13% longer median time to stable housing when compared with partnered respondents. Furthermore, respondents with medium to high social support had a 10% shorter median time to stable housing than respondents without social support.

4. Discussion

This study used an analytic sample of displaced residents from the G-CAFH Study to determine median time to stable housing following Hurricane Katrina. Previous studies have been limited in examining long-term postdisaster housing stability, as they have lacked the necessary data. To contribute to this gap, we used survival analysis to describe patterns of event occurrence (i.e., stable housing), compare patterns among groups, and examine factors affecting time to stable housing in the 13 years following Katrina. As stable housing is a critical aspect of recovery that establishes a sense of normalcy following a disaster it is important to determine whether and when displaced residents return to stable housing, and which factors are most influential.

Overall, G-CAFH respondents experienced high levels of housing instability following Hurricane Katrina. In fact, the median time to stable housing for the analytic sample was 1082 days or 3 years. As of 2018, 87% of respondents were stably housed. However, overall, 66% of respondents needed more than 18 months to find stable housing. When considering only those who were displaced, 78% took longer than 18 months to secure stable housing. This finding supports the first hypothesis that a majority of displaced G-CAFH respondents did not achieve stable housing within 18 months of Katrina. Eighteen months postevent is a critical turning point for disaster survivors, because this is when interim housing assistance from FEMA normally ends. This housing assistance is meant to cover the gap between sheltering and the return of disaster survivors to permanent housing (FEMA 2019). It is well documented that the housing recovery from Katrina presented unprecedented challenges, which is partly why FEMA extended the 18-month limit of housing assistance to 26 months of rent-free assistance. Even so, this falls well short of the 36 months that it took G-CAFH respondents on average to obtain stable housing.

Previous research suggests that FEMA housing policies have exacerbated the challenges of survivors—particularly of low income—by narrowly defining the scope of their assistance (Mueller et al. 2011; Bolin and Stanford 1990; Howell and Elliott 2019). In the context of Katrina, evolving FEMA rules and deadlines lead to diverging recovery patterns (Mueller et al. 2011). These findings highlight that a more rapid transition to permanent and stable housing and access to services regardless of homeownership status would alleviate many of the challenges that survivors face, especially those who are low income. Following Katrina, FEMA conducted the largest temporary housing operation in the history of the country and provided more than 750 000 households with housing assistance, including 114 000 families living in FEMA-provided manufactured homes (Plyer 2016). According to a 2009 Senate report, the agency paid more than $6 billion in financial and housing assistance to nearly 1.5 million survivors. To provide continuing aid, the Department of Housing and Urban Development (HUD) created the Disaster Housing Assistance Program (DHAP-Katrina), which included mandatory case management services. DHAP-Katrina was meant to help Katrina-affected households move into stable, permanent, and market-rate housing (Buron and Locke 2013). Despite efforts, most participants were not able to find stable housing at the conclusion of two additional years of assistance. In an evaluation of DHAP-Katrina, the review panel argued that postdisaster housing assistance needs to be linked to the expected availability of rental housing—rather than limited to a strict timeline—and that future disaster planning needs to consider that some survivors may need long-term or permanent housing assistance, even if they did not receive assistance prior to the event (Buron and Locke 2013).

Results from our analyses further support these findings. Despite these investments of time, money, and person resources, G-CAFH survivors struggled for years to find stable housing. Renters, in particular, faced some of the steepest challenges due to the limited supply of affordable rental housing and often found themselves excluded from the rebuilding process (Merdjanoff 2013; Finger 2008). Programs like Road Home, as well as Community Block Development Grants, did not allocate enough funding for the sheer number of renters displaced by Katrina to find comparable housing (Finger 2008). As disasters strike with greater frequency and intensity, coupled with the rise of income inequality and growing urban coastal populations, housing assistance should not be limited by housing tenure or restricted to a predetermined fixed time. There must be enough flexibility in the program to account for variation in disaster intensity, population, and pre and postevent housing stock.

To determine the characteristics that influence displaced residents' ability to establish stable housing following Hurricane Katrina we examined median time to stable housing considering factors such as age, race, household income, homeownership status, partner status, children in the household, household size, mental health, social support and whether the respondent returned to their pre-Katrina neighborhood. Respondents who were between 18 and 34 at the time of Katrina, had poor mental health, had income below $20,000 annually, had children in the household, and did not own their home reported significantly higher median time to stable housing. These findings support the second hypothesis that lower income and homeownership status are associated with a greater median time to stable housing but also suggest that additional factors can increase time to stable housing. Last, only living in Louisiana and social support operated as protective factors that decreased time to stable housing, which does not support the third hypothesis. It is possible that the impact of state is related to statewide differences in postdisaster response and recovery policies. Further investigation is needed to explore this difference. Social support has been found to operate as a protective factor for a host of disaster outcomes, including mental health and recovery (Chan et al. 2015). These results reinforce the overall importance of perceived social support in disaster recovery and provide evidence of its role in residents finding stable housing.

5. Limitations

There are several limitations to this study. G-CAFH does not have pre-Katrina data for those who were in stable

housing prior to the storm, nor do we know the durability of stable housing prior to Katrina. Therefore, we cannot identify causal relationships. However, the study contains pre-Katrina homeownership status, which is often used as a proxy for housing stability. Approximately, 40% of respondents were homeowners prior to the storm. Although homeownership status can be used as a proxy measure of stable housing, we believe that using this variable instead of time to stable housing loses the nuance that the main analytical variable allows. An additional limitation is that we do not know the types of housing instability displaced residents faced. There are a range of possibilities, including difficulty paying rent or mortgage, dislike of current neighborhood, concerns about future income, housing type (e.g., shelter, hotel, apartment, or single-family home) or family instability. Recent work has begun to qualitatively understand how households make mobility decisions following disasters, as well as to identify the drivers of postdisaster housing instability (Rhodes and Besbris 2021). Future research should continue to build upon these findings so that climate-related housing policy can develop solutions that reduce time to stable housing. We also do not know whether respondents received disaster housing assistance and what type (i.e., FEMA or Road Home), which could influence time to stable housing. Last, the Great Recession (2008) and the Deepwater Horizon Oil Spill (2010) may have presented additional challenges to G-CAFH respondents during their recovery and could have further complicated their ability to find stable housing. Overall, policy makers, emergency management officials, and businesses interested in continuity of operations planning, should be invested in assuring housing stability following disasters and understanding the factors that increase the likelihood of being unstably housed, which will allow for targeted recovery and postdisaster housing programing.

6. Conclusions

As previously mentioned, the climate crisis is pushing us toward a collision course between the natural and built environments. Approximately 80% of the nation's population live in urban areas that are densely populated (U.S. Census Bureau 2016). In 2017, nearly 95 million people—about 29% of the U.S. population—lived in coastline counties, which is a 15% increase since 2000 (Cohen 2019). The financial costs of the 2017 disaster season, including hurricanes, wildfires, and earthquakes, was $306 billion. Although 2017 was an outlier, the 10-yr average of economic losses from disasters is $190 billion. The challenges associated with finding stable housing in densely populated coastal areas following catastrophic disasters will only increase. Because housing is a critical aspect of mitigating the climate crisis (Klinenberg et al. 2020), policy makers must be deliberate in how they address the United States' environmentally at-risk housing stock. Managed retreat is gaining popularity as a possible climate mitigation strategy (Koslov et al. 2021; Koslov 2016). However, attention must also be paid to how we "build back better" following disasters to ensure it is done equitably and expeditiously so as not to exacerbate preexisting disparities but instead rethink land use, community design, and building safety.

Although 15% of G-CAFH respondents were not displaced by the storm and nearly 19% achieved stable housing within 18 months, over 65% of respondents remained unstably housed for more than 1.5 yr after the storm. The median time to stable housing was 1082 days and likely represents nearly three years of uncertainty and strain for affected individuals and families. Even though there were important group differences observed, these differences are relatively small (100–200 days) when most of the sample was displaced for more than 1000 days. Additionally, the focus on median time to stable housing obscures the large number of households that took four or more years to achieve stable housing. The important takeaway is that it took a significant amount of time for all displaced residents to find stable housing. Recently, scholars have argued that housing instability in the form of evictions can have severe and long-standing consequences, including damaged credit rating (Greiner et al. 2013), substandard housing conditions (Desmond et al. 2015), and residential instability (Burt 2001; Phinney et al. 2007). Because of the parallels in forced movement, it is possible that the long-term effects of disaster-induced displacement are similar to eviction, and its effects on economic indicators and well-being should be further examined. Future research should consider whether postdisaster housing instability operates similarly to eviction as a mechanism of enduring inequality and examine the long-term consequences of housing instability.

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Data availability statement. Because of their proprietary nature, supporting data cannot be made openly available. Further information about the data and conditions for access are available from the study principal investigator Dr. David M. Abramson at david.abramson@nyu.edu.

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