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Home Recovery In New Orleans After Hurricane Katrina

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Abstract

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I focus on three research questions. First, among socially vulnerable demographic groups identified in the literature (including Black, Hispanic, female heads of household, people ≥ age 65), which were most likely to suffer housing damage at the homeowner level? Second, among those suffering the most housing damage, how did their access to financial assistance differ from other homeowners? Finally, what role did these differences play in relative prevalence and speed of recovery for those suffering the most housing damage?

Data from the 2004 and 2009 American Housing Surveys in the New Orleans Metropolitan Statistical Area are used to model home damage by a series of nested logistic regressions, and to model home recovery by both logistic and Cox regressions. Analyses suggest the following. First, among the socially vulnerable groups, Black homeowners were most vulnerable to housing damage. Vulnerability was partially due to their older homes, which was strongly associated with damage from Katrina. Second, Black homeowners were less likely than others to receive private financial assistance and more likely to receive public financial assistance. They were also more likely to perceive financial gaps impeding their recovery process. Third, private financial assistance positively contributed to prevalence and speed of recovery whereas reliance on public financial assistance slowed speed of recovery. While prevalence of home recovery was similar between Black and non-Blacks, Black homeowners took much longer to start and complete recovery than non-Black homeowners. Delays were partially due to Blacks' relative lower incomes, higher number of replacements/additions, lack of private financial assistance, and financial gaps they perceived after the disaster.

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HOME RECOVERY IN NEW ORLEANS AFTER HURRICANE KATRINA

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School. With the financial support from this Fellowship, I was able to present preliminary findings from this dissertation at the London School of Economics and Political Sciences[6].

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ABSTRACT

HOME RECOVERY IN NEW ORLEANS AFTER HURRICANE KATRINA

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Roberta Rehner Iversen, PhD, MSS

Hurricane Katrina, the costliest hurricane in U.S. history, hit the New Orleans metropolitan area in 2005. Many studies have examined differences in both damage and recovery with respect to more socially vulnerable groups, and have identified lack of access to financial assistance as a key explanatory factor. But studies to date have focused only on differences at the community level and have concentrated exclusively on Orleans Parish. This dissertation investigates recovery prevalence and speed at the individual homeowner level and to broadens to the New Orleans metropolitan area.

I focus on three research questions. First, among socially vulnerable demographic groups identified in the literature (including Black, Hispanic, female heads of household, people ≥ age 65), which were most likely to suffer housing damage at the homeowner level? Second, among those suffering the most housing damage, how did their access to financial assistance differ from other homeowners? Finally, what role did these differences play in relative prevalence and speed of recovery for those suffering the most housing damage?

Data from the 2004 and 2009 American Housing Surveys in the New Orleans Metropolitan Statistical Area are used to model home damage by a series of nested logistic regressions, and to model home recovery by both logistic and Cox regressions.

Analyses suggest the following. First, among the socially vulnerable groups, Black homeowners were most vulnerable to housing damage. Vulnerability was partially due to their older homes, which was strongly associated with damage from Katrina. Second, Black homeowners were less likely than others to receive private financial assistance and more likely to receive public financial assistance. They were also more likely to perceive financial gaps impeding their recovery process. Third, private financial assistance positively contributed to prevalence and speed of recovery whereas reliance on public financial assistance slowed speed of recovery. While prevalence of home recovery was similar between Black and non-Blacks, Black homeowners took much longer to start and complete recovery than non-Black homeowners. Delays were partially due to Blacks' relative lower incomes, higher number of replacements/additions, lack of private financial assistance, and financial gaps they perceived after the disaster.

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CHAPTER 1. INTRODUCTION and LITERATURE REVIEW

Hurricane Katrina, the costliest hurricane in U.S. history, hit the New Orleans metropolitan area on August 29, 2005, killing nearly 1,000 people (Plyer, 2015) and damaging more than 250,000 homes (US Department of Urban and Housing Development [HUD] & US Bureau of Census [US Census], 2009). Both the extent of damage and the process of recovery have been widely studied in the literature. In particular, many studies have examined disparities in both housing damage and housing recovery between socially vulnerable groups and others (Green, Bates, & Smyth, 2007; Finch, Emrich, & Cutter, 2010; Kamel, 2012). But such studies to date have focused only on differences at the community level, and in addition, have concentrated exclusively on the Orleans Parish. I discuss each of these limitations in turn.

First, with respect to community-level analyses, it is not possible at this aggregate level to relate the demographic characteristics of individual homeowners to the level of damage they suffered from Katrina. Similarly, it is not possible to relate the characteristics of individual homes to the level of damage suffered. Moreover, since the task of rebuilding and repairing housing structure is the responsibility of homeowners, the distribution of financial assistance to such reconstruction activities is done at the homeowner level, and not the community level. In view of these limitations, one major objective of this study is to explore these relationships at the individual homeowner level.

Turning next to the spatial extent of the analysis, it is well known that substantial damage from Katrina occurred throughout the New Orleans Metropolitan Statistical Area

(NOMSA), and not just in Orleans Parish.[1] The most widely cited study by the U.S. Department of Housing and Urban Development (HUD) done in 2006 for Katrina together with two minor hurricanes (Rita and Wilma in 2005) estimated, for example, that 81% of occupied houses in the St. Bernard Parish were damaged, and that 46% in St. John the Baptist Parish were damaged. Thus a second objective of this study is to extend my analysis to the entire NOMSA.

The achievement of these objectives was made possible by analyzing the household-level panel data collected by the American Housing Survey (AHS) for the New Orleans Metropolitan Statistical Area Public Use File (AHS NOMSA PUF) in 2004 and 2009 (HUD & U.S. Census, 2005; U.S. Census, 2011). In particular, this data includes responses from individual survivors of Katrina who lived in the New Orleans MSA on the eve of Hurricane Katrina who were also residing in this area in 2009. Moreover, the questions addressed to these respondents allowed the identification of individual homeowners within this data set. In addition, such questions provide a wealth of information regarding not only the relevant demographic characteristics of these homeowners, but also both the degree of housing damage they suffered from Katrina and the nature of their recovery (or non-recovery) process following this disaster.

My conceptual framework for analyzing this data is summarized graphically in Figure 1.1 below. Each box represents a major component of the analysis, and the arrows between them depict the key relations to be studied (in Chapter 3 below). For the present

[1] New Orleans MSA, defined by the US Census, includes seven parishes: Jefferson, Orleans (coterminous with the city of New Orleans), Plaquemines, St. Bernard, St. Tammany, St. Charles, and St. John the Baptist.

purposes, this figure provides a convenient way of organizing the discussion of my approach.

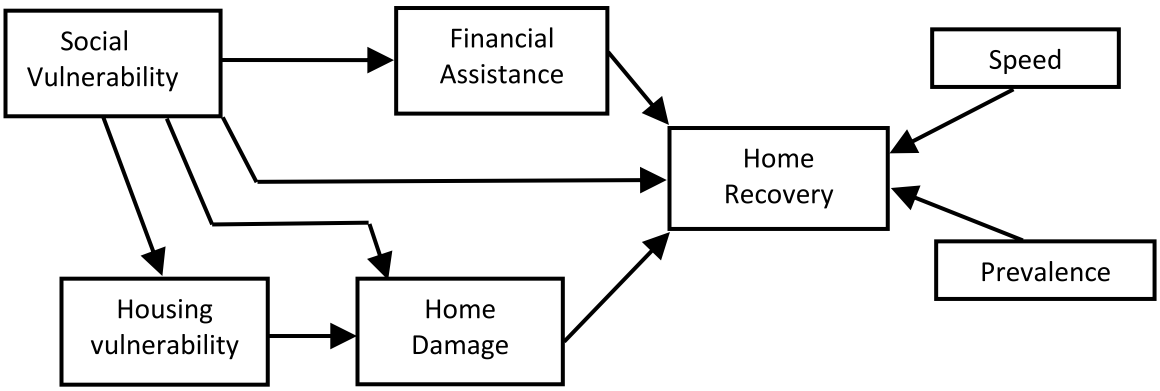

Figure 1.1. Conceptual Framework

Basically my study consists of two parts: a home damage study and a home recovery study. With respect to the first, I am primarily interested in the relationship between the social vulnerability of individual homeowners and the home damage they suffered from Katrina. Here I hypothesize that the housing characteristics of socially vulnerable homeowners, i.e., their housing vulnerability, is a key factor in this relationship. Turning next to home recovery, I hypothesize that in addition to home damage, the financial assistance received by homeowners is also a key determinant of their home recovery. Finally, with respect to home recovery itself, I hypothesize that both the likelihood (prevalence) of home recovery by individual homeowners and their speed of recovery constitute distinct dimensions of home recovery (as detailed further in Figure 1.2 below). In this context, the above influences on home recovery can be meaningfully analyzed for each of these dimensions.

Given this conceptual framework, I now discuss each of its major components in turn, namely social vulnerability, housing vulnerability, financial assistance, and home recovery.[2] My objectives here are both to develop working definitions of these concepts, and to review the existing literature relating to each.

1.1 Social Vulnerability

Broadly defined, vulnerability is the potential for loss of life or property due to hazards (Cutter, 1996; Hazards and Vulnerability Research Institute, 2013). According to Cutter et al. (2003), social vulnerability "is most often described as the individual characteristics of people" such as race and ethnicity, age, and gender; however, "social vulnerability is partially the product of social inequalities—those social factors that influence or shape the susceptibility of various groups to harm and that also govern their ability to respond" (p. 243). My present conceptual framework is largely based on this view of social vulnerability. I start with those characteristics of individual homeowners (Blacks, Hispanics, Female heads of household, and Seniors aged 65 or older) that are (i) available in the AHS 2009 data, and (ii) were also found by Finch et al. (2010) to exhibit higher percentages in communities where housing damage from Hurricane Katrina was more prevalent. With respect to these classes of homeowners, the types of social inequalities most relevant for home recovery following Katrina are here taken to be: (i)

[2] Note that the component, *home damage*, is missing here. This is based entirely on the "home damage" and "severe damage" responses in the AHS 2009 data, as detailed in the measurement discussion in Chapter 2 below.

differences in housing vulnerability to damage, and (ii) differences in access to financial assistance for repairing/rebuilding damaged homes.

1.2 Housing Vulnerability

While there are a host of physical characteristics that render houses more vulnerable to damage in natural disasters, I focus here on three characteristics that (i) are particularly relevant in the present setting, and (ii) are available in the AHS 2004 survey data (just prior to Hurricane Katrina). These characteristics, namely *Housing Age*, *Housing Adequacy*, and *Housing Location*, are taken to constitute my working definition of *Housing Vulnerability*. Notably, this characterization of housing vulnerability is similar in spirit to the notion of "physical vulnerability" of structures (with respect to catastrophic disasters) proposed by Levine, Esnard, and Sapat (2007), which includes "age of structures", "poor or inadequate construction of buildings", and "location with respect to potential hazards". I briefly discuss each of the characteristics in turn.

Housing Age. In the New Orleans MSA, housing age appears to have played a particularly important role in terms of vulnerability to storm damage. As noted by Kates et al. (2006), while international building codes for wind resistance were adopted by the city of New Orleans prior to Hurricane Katrina, enforcement of these codes was insufficient, and they were not applied to older buildings. A similar study of Hurricane Andrew by Fronstin & Holtmann (1994) found that housing with poor physical infrastructure, especially older buildings, was more likely to be damaged.

Housing Adequacy. According to the American Housing Survey (2009) *inadequate housing* is defined as “an occupied housing unit that has moderate or severe physical problems”, such as “leaking roof, missing shingles, missing bricks, or problems with the foundation”. Using this definition, the CDC National Center for Environmental Health (Raymond, Wheeler, & Brown, 2011) found that nationwide, racial and ethnic minorities and disadvantaged groups are more likely to live in inadequate housing. Of special interest for my purposes was their finding that “non-Hispanic Blacks had the highest odds of householders living in inadequate housing” (p.21) throughout the nation. Moreover, with respect to the likelihood of home damage in disasters, catastrophe modeling suggests that home damage (total property loss) may be correlated with the structural vulnerability of housing as well as the likelihood of hazard exposure (Grossi & Kunreuther, 2005). In view of these general findings, I postulate that housing inadequacy may also contribute to home damage from Hurricane Katrina.

Housing Location. Turning finally to locational considerations, it is well known that much of the New Orleans MSA is below sea level. In particular, elevation studies show that “of the terrestrial surface of the contiguous urbanized portions of Orleans, Jefferson, and St. Bernard parishes …49 percent lies below sea level” (Campanella, 2007, p.3). So it may be inferred that a substantial fraction of housing in these urbanized areas is highly vulnerable to flood damage. Since location in *flood plain* is one of the (dichotomous) housing attributes available in the AHS 2004 survey, I adopt this as the third characteristic of housing vulnerability.

1.3 Financial Assistance

In addition to housing characteristics, this study also analyzes the impact of public and private financial assistance on housing recovery following Hurricane Katrina. On the private side, I focus on the single most common form of insurance covering individual residences, namely *Homeowner Insurance* (HI). On the public side, I focus on the two most relevant sources of financial assistance for Katrina survivors, namely the *Federal Flood Insurance* (FFI) program and the *Road Home Grant* (RHG) program.[3] In addition, I consider possible *financial gaps* over and above such levels of financial assistance as perceived by homeowners in their recovery process. I consider each of these aspects of financial assistance in turn.

Homeowner Insurance (HI). Existing literature suggests that individual owners who receive HI assistance tend to rebuild their homes on the original sites after a disaster (Comerio, 1997). More generally, HI is often a “primary driver for recovery” (Peacock et al., 2015, p.369). But in spite of its positive effects, there is evidence to suggest that certain socially vulnerable groups have less access to HI assistance than others. For example, many disaster studies have found that Blacks are less likely than others to be covered by Homeowner Insurance (Peacock and Girard, 1997; Green, Bates, & Smyth, 2007; Zakour and Gillespie, 2013). With respect to hurricanes in particular, Peacock and Girard (1997) found that Blacks were less likely than others to be covered by HI after Hurricane Andrew.

[3] Here I note that other types of financial assistance (as detailed in Table 2.8 of the Appendix) are included as controls in all models of Chapter 3 that involve financial assistance.

Federal Flood Insurance (FFI). Turning next to public insurance programs, the extensive flood damage caused by Hurricane Katrina underscores the importance of Federal Flood Insurance as a source of assistance for survivors. In Louisiana alone, according to HUD (2006), more than 180,000 homes suffered flood damage from Katrina (together with damage from the smaller hurricanes Rita and Wilma in 2005-2006). Moreover, typical homeowners' insurance in Louisiana does not cover losses caused by flooding (Bayot, 2005; Green et al. 2007; Logan, 2008; Kunreuther, 2006). So it can reasonably be inferred that following Katrina, many homeowners relied primarily on FFI for financial assistance. In particular, those homeowners living in FEMA-designated flood plains with federally backed mortgages were required to have FFI (Michel-Kerjan & Kunreuther, 2010).

However, there is also evidence to suggest that certain socially vulnerable groups suffering flood damage were in fact not covered by FFI. For example, at the time of Katrina, the population of the Lower 9th Ward was at least 95% Black (Barrios, 2016). Moreover, this area was *not* a FEMA-designated flood plain (Kunreuther, 2006), even though the entire area was submerged by flooding. So in this instance it would appear that many Blacks suffered flood damage not covered by FFI. More generally, at least 40% of all Katrina victims in Louisiana and Mississippi had no flood insurance to cover their housing damage (Kunreuther, 2006).

Road Home Grants (RHG). For those homeowners who were not covered by either FFI or HI at the time of Katrina, the Road Home Grant (RHG) program was the primary financial resource for their housing recovery (Finger,2008; Spader & Turnham, 2014). RHG is the largest housing recovery program in US history (Gotham, 2008), and the official "Declaration of Purpose" of this program is to provide housing recovery grants that are "principally for persons of low and moderate income" (Finger, 2008, p. 64). With respect to Katrina in particular, RHG thus explicitly targeted certain socially vulnerable groups of victims, particularly low-income Black homeowners. However, as pointed out by Green and Olshansky (2012), the cash benefits awarded by the RHG varied significantly. Because the award levels were calculated according to a formula using previous home value as a benchmark, those homeowners with higher valued homes prior to the hurricane were likely to receive larger grants than others. As a result, certain socially vulnerable groups were likely to receive lower grants on this basis. For example, property values for Black homeowners in the New Orleans MSA were substantially below those of non-Blacks prior to Katrina (U.S. Census, 2000). So Black homeowners in particular were likely to receive lower levels of RHG assistance than non-Blacks.

Financial Gaps. Finally, even among those receiving financial assistance for home recovery following Katrina, many experienced a financial gap in terms of recovery costs. For in spite of the vast amounts of funding provided for repairing and rebuilding homes damaged by Katrina (together with Rita and Wilma), including $45 billion by the Federal government, $6 billion from charitable assistance, and roughly $20 billion from private insurance, there was still a financial gap of more than $60 billion between housing damage and funding received by homeowners (Ahlers, Plyer, & Weil, 2008). In addition, there were inequities in the gaps reported by certain socially vulnerable groups. For example, in an ethnographic field study by Iversen & Armstrong (2006; 2008) in New Orleans, Black homeowners reported their inability to afford the costs of repairing home damage from Hurricane Katrina, even after receiving some forms of financial assistance. With respect to RHG in particular, Finger (2008) found that "Statewide, the gap between the road home grant amount received and the dollar amount needed to rebuild was notably higher among African American homeowners, who had average shortfalls of $39,082, compared with $30,863 for white applicants" (p.70).

1.4 Home Recovery (Prevalence and Speed)

The final, and in many ways most important component of my conceptual framework in the process of home recovery by survivors of Hurricane Katrina, is the prevalence and speed of recovery. Here I focus on *permanent home recovery*, which unlike temporary home recovery, involves "disaster victims returning either to their repaired or rebuilt original homes, or moving into new quarters in the [*same*] community" (Quarantelli, 1995, p.45). In this context, I distinguish between two aspects of home recovery, namely the achievement of recovery itself and the speed with which this recovery process is carried out. This distinction is largely inspired by the general "resilience" framework proposed by Bruneau et al.(2003) and refined by Chang and Shinozuka, (2004). In particular, my notion of recovery *speed* is similar to the "rapidity" component of this resilience framework. But since I am primarily interested in recovery by homeowners within specific socially vulnerable groups, it is more convenient to measure recovery achievement in terms of the *prevalence* of recovery by homeowners within specified groups. This is similar in spirit to studies of home recovery at the community level, where "recovery" is also measured in terms of prevalence [such as the studies of Finch el al. (2010) and Kamel (2012) at the zip code level]. But unlike these studies, I am primarily interested how the recovery process of *individual* homeowners within relevant groups contributed to the prevalence of recovery in these groups.

Turning next to the speed of recovery, while some authors have discussed possible factors affecting the speed of recovery, there has been little attempt to analyze recovery speed in a quantitative manner. For example, some authors have speculated that the speed of recovery is influenced by the severity of physical damage (Dacy & Kunreuther, 1969, p. 72; Aldrich, 2012, p. 58). Of more relevance for the present purposes, Morrow (1997) postulated that the slower recovery process of certain socially vulnerable homeowners might be due to their lack of accessibility to private insurance. But to my knowledge, the only study which has attempted to quantify the speed of home recovery is that of Zhang and Peacock (2010). These authors analyzed the appraised value of the damaged homes before and after Hurricane Andrew, and implicitly measured recovery time in term of the number of years required for appraised values to return to pre-Andrew levels.

In the present study however, "recovery" is taken to be *event based* rather than value based. Moreover, there are two key events that need to be distinguished: namely, the *initiation* of the recovery process and the *completion* of this process. The time dimensions of both these events are particularly relevant for the recovery of socially vulnerable homeowners following Hurricane Katrina. For example, as noted by Green et al. (2007), Black homeowners were less likely to initiate reconstruction within the first two years after Katrina. An important goal of this study is thus to identify those factors contributing to such starting delays. But initiating construction does not necessarily mean that rebuilding or repairs are completed. For example, as noted by Bolin and Stanford (1998; 2012), reconstruction after a disaster can be halted if financial resources are depleted or insufficient. So an equally important goal of this research is to identify factors such as financial gaps that may delay completion of the recovery process.

Thus to analyze the speed of home recovery following Hurricane Katrina, it is important to consider both the *starting times* and *completion times* of the rebuild/repair process (in months following Katrina). These key dimensions of the recovery process are summarized Table 1.1 below.

Table 1.1

Dimensions of Housing Recovery

Response to Home Damage	Home Recovery achieved?	Time to initiation of construction	Time to completion of construction
Rebuilt or Repaired	*Yes or No*	*Number of months*	*Number of months*

1.5 Research Questions

In summary, the conceptual framework developed above characterizes home recovery as a dynamic social process. As shown in Figure 1.1, this process proceeds from the pre-disaster conditions of homeowners to their post-disaster outcomes. In terms of pre-disaster conditions, I focus on socially vulnerable homeowners living in the NOMSA on the eve of Katrina (who were residing in this area in 2009). I then identify those socially vulnerable homeowners who suffered the most damage from Katrina, and study their post-disaster recovery process relative to other homeowners. Here I hypothesize that the pre-disaster housing characteristics of these homeowners were a key factor influencing the degree of home damage they suffered. With respect to post-disaster recovery, I hypothesize that, in addition to housing damage, the relative access of these homeowners to financial assistance played a key role in their recovery process. More specifically, this study will address the following three research questions:

- First, among those socially vulnerable demographic groups that have been identified in the literature (including Black, Hispanic, female heads of household, people aged 65 and over), which groups were most likely to suffer housing damage at the homeowner level?

- Second, among those suffering the most housing damage, how did their access to financial assistance differ from other homeowners?

- Finally, what role did these differences play in both the relative prevalence and speed of recovery for those suffering the most housing damage?

The remainder of this dissertation is organized as follows. In Chapter 2, I begin with an overview of the data and sampling methods used, together with a full specification of all variables employed in the analyses to follow. The statistical models constructed to address the three research questions above are then developed in Chapter 3, together with the analytical results of these models. Finally, the implications of these results are discussed in Chapter 4, together with possible directions for further research.

CHAPTER 2. DATA METHODS AND MEASUREMENT

In this chapter I begin with an overview of the data used, together with the sampling methods and measurement conventions employed for each of the relevant variables. Section 1 summarizes the basic survey data set employed for this study, together with a brief description of both the sampling procedures used and the treatment of missing data. Section 2 then details the specific measurement conventions employed for each of the key variables used in the analyses to follow.

2.1 Data and Sampling

This study uses household-level panel data collected by American Housing Survey (AHS) for the New Orleans Metropolitan Statistical Area (NOMSA) in 2004 and 2009 (HUD & U.S. Census, 2005; U.S. Census, 2011). The purpose of the 2004 survey is to determine housing characteristics of homeowners prior to Katrina, as detailed further in Section 2.2 below. The unweighted response rates for the survey are above 50%, which is considered adequate for analysis and reporting in social welfare and policy research (Rubin & Babbie, 2010).

The AHS for the NOMSA uses a complex stratified multistage probability random sampling method. The sample is stratified in two ways: by strata and primary sampling unit. Strata were identified using four criteria: housing unit, group quarters, building permit, and geographic area. The primary sampling unit refers to the New Orleans counties or parishes that are separated into three groups: two singular parishes, Orleans Parish and St. Tammy Parish, and one group of smaller parishes and counties: Jefferson, Plaquemines, St. Bernard, St. Charles, and St. John the Baptist. A systematic sample of housing units was selected at the Census block level (HUD & U.S. Census, 2005; U.S. Census, 2011).

2.1.1 Inclusion and Exclusion Criteria

The units of analysis for studying home damage in the first section of Chapter 3 below are housing units with homeowners living in the NOMSA in the month of August, 2005. The units of analysis for studying home recovery in subsequent sections of Chapter 3 include only damaged housing within this set of housing units.

To be consistent with the conceptual notion of "home recovery", I exclude homeowners who did not return to New Orleans**,** as well as homeowners who lived in NOMSA on the eve of Hurricane Katrina but who moved away after the hurricane. Because this study focuses on recovery of the homes damaged by Hurricane Katrina within the NOMSA exclusively, I also exclude homeowners who moved into New Orleans *after* Hurricane Katrina.

2.1.2 Sample Sizes

For the home damage analyses in the first section of Chapter 3, the survey sample includes 1,525 homes that are representative of the 248,302 homes within the catchment area of NOMSA (and meet the inclusion and exclusion criteria above). The remaining analyses in Chapter 3 will be tested with the 1,177 units in the above sample that were damaged by Katrina. These samples are here assumed to be representative of the 192,398 homes that sustained damage by Katrina. However, it should be emphasized that our exclusion criteria above may in principle influence the representative nature of this sample. This issue is discussed further in the next section.

2.1.3 Missing Data

First, it should be noted that 1811 cases in the 2004 American Housing Survey were dropped from the 2009 survey by the US Census "in order to protect the privacy these households" [as discussed further in Section 3.1 and Section 4.3.2 below]. More specifically, these 1811 cases from the 2004 NOMSA Public Use File (PUF), which are all in the central city [2004 zones 1 through 5] of Orleans parish were dropped in the 2009 NOMSA PUF because these zones no longer met the minimal population criterion for PUF (>100,000) set by US Census after Hurricane Katrina (HUD Office of Policy Development and Research, 2015). Instead, the 2009 AHS in NOMSA recruited 1844 new cases from Orleans parish (2009 zones 6 and 7).

In addition, many of the cases in each of these surveys involved missing data with respect to one or more of the variables used in the present study. For consistency across the regression models developed in Chapter 3, all sample units involving missing data for at least one of these regression models were dropped from the analysis. The justification for this list-wise deletion technique is discussed further in the introduction to Chapter 3.

Finally, with respect to the representative nature of our final sample, it should be emphasized that the additional sample of 1844 new cases by the American Housing Survey was designed to rebalance the representative nature of their sample after the removing the 1811 cases from the Orleans parish. However, no such adjustment is possible for the list-wise deletion of missing-data cases in our analyses below. It should thus be emphasized (as discussed further in Section 4.3.2 below) that such deletions will necessarily influence the representative nature of our data to some degree.

2.2 Measurement of Variables

As mentioned above, the variables in this study are derived from two data sources: the 2004 and the 2009 AHS, focusing only on the NOMSA. AHS collected information about the heads of household in each residence surveyed and asked whether they owned the property. Because this analysis is concerned only with homeowners, all non-homeowners were excluded. The 2009 AHS asked homeowners if they were living in New Orleans in August 2005 at the time of Hurricane Katrina. As mentioned above, data were excluded for homeowners not living in New Orleans on the eve of Hurricane Katrina (i.e., those who moved to the area after the hurricane). Measurement procedures for each of the key variables in the analyses of Chapter 3 are now detailed as follows.

Home Damage. Home damage characteristics are described/defined by two dichotomous variables in AHS 2009. The first, designated as *damaged* homes, includes all homes suffering any damage from Hurricane Katrina. The second, designated as *severely damaged* homes, includes only those homes with sufficient damage to require demolition. Table 2.1 lists these home-damage variables, together with the survey questions used to construct them.

Demographic information. All demographic information is included in 2009 AHS New Orleans. Given that this study excludes all homeowners not living in NOMSA in August 2005, the variables of race, ethnicity, gender listed in Table 2.2 can be taken to represent homeowners' actual demographic characteristics on the eve of Hurricane Katrina. Given that the age variable in AHS 2009 reflects the age of homeowners in 2009, the present study adjusted this age variable to 2005 and generated the corresponding dummy variable: "homeowner aged 65 or older" (1=yes; 0=no).

Housing Characteristics. Information about housing characteristics on the eve of Katrina was collected using the 2004 AHS, by asking a series of questions related to housing adequacy, building age, and whether a home was located in a flood plain. Table 2.3 lists the resulting housing-characteristic variables (*housing adequacy*, *housing age*, and *housing location*) that were determined by the responses to survey questions.

Home recovery. The study defines a home to be *recovered* from Katrina-caused damage if it is either rebuilt or repaired. In terms of the survey data, a home is defined to be recovered (*home recovery* = 1) if the respondent answers "yes" to either of the questions in Table 2.4, and in addition gives an explicit anticipated completion date (month and year) in Table 2.5. Otherwise, a home is defined to be not recovered (*home recovery* = 0).

Time to Recovery. The anticipated completion dates of home recovery (as in Table 2.5) also provide temporal data for the survival analyses carried out in Section 3.4 below. To do so, it is convenient to transform this calendar data into two cardinal variables. The first, designated as *time to starting recovery*, represents the number of months from Hurricane Katrina to the actual or anticipated time of starting the recovery process (i.e., repairing or rebuilding). Here the initial month of August 2005 is given the value "zero". Similarly, the second variable, *time to completing recovery*, represents the number of months from Hurricane Katrina to the actual or anticipated time of completing the recovery process.

Family income in 2009. Given that family income may have an effect on the outcome of home recovery, the present study includes (controls for) this effect, to better identify the relationship between homeowner characteristics and home recovery. Family income is here defined as "the sum of the wage & salary income of householders and all related individuals age 14+ and all other reported income" (HUD Office of Policy Development and Research, 2015, p.535).

Rebuilding/repairing characteristics. To better identify the nature of home recovery, this study also includes data on the *number of replacements/additions* to the home as a result of Katrina damage. These cardinal variables are based on specific questions to homeowners, as detailed in Table 2.7.

Financial Assistance. To analyze the effects of financial assistance on the recovery process of homeowners, each major type of assistance [Federal Flood Insurance (FFI), Homeowners Insurance (HI), and Road Home Grant (RHG)] is measured as a dichotomous variable ("received", "not received"). In a similar manner, the study also controls for other federal assistance (OFA), other state assistance (OSA), charitable/private assistance (CPA), or any other assistance (AOA) that might be received by some homeowners. The dichotomous definitions of these types of financial assistance are given in Table 2.8. In addition, the study includes a general "any financial assistance" (AFA) dichotomous variable to indicate whether the homeowner received any of the above types of financial assistance, also shown in Table 2.8.

Financial gap. To further articulate the financial aspects of recovery, a dichotomous *financial gap* variable is defined, which indicates whether a homeowner continued to perceive any financial difficulties in the recovery process after receiving any form of financial assistance (as in AFA above). Table 2.9 lists the original survey questions on which this dichotomous variable is based.[4] As discussed in Section 3.4.1 (Model 26) below, this variable is further refined to a categorical variable in many of the regressions models to be developed. The values of this (extended) *financial gap* variable are defined to be: 1 = "perceived financial gap after receiving financial assistance", 2 = "no perceived financial gap after receiving financial assistance", and 3 = "did not receive any financial assistance".

[4] It should be noted that the "financial gap" question in Table 2.9 appears to be directed only to respondents who were not able to complete their home repairs. However, the data indicates that many respondents answering "yes" to this question also recovered (i.e., gave a completion date for recovery). Here we regard these completion dates as meaningful responses, and thus interpret "financial gap" more broadly, as perceiving financial difficulties in the recovery processes even after receiving financial assistance.

CHAPTER 3. STATISTICAL ANALYSES AND RESULTS

The statistical analyses to be developed are grouped into four sections. Based on the conceptual framework of Figure 1.1, the first section focuses on housing damage from Katrina, and how this damage differed with respect to both the physical characteristics of housing and the social-vulnerability characteristics of homeowners developed in the Introduction. The main result of this section is to show that among all socially vulnerable groups in this study, Blacks were by far the most seriously affected by Katrina. My subsequent analyses thus focus on the nature of the recovery process for this most severely affected group. As shown in Figure 1.1, section 3.2 studies the relative accessibility of Blacks to both public and private financial assistance with respect to recovery. Section 3.3 and section 3.4 then analyze whether the characteristics of home recovery by blacks are its likelihood (prevalence) and its speed, as shown in Figure 1.1.

Before proceeding, I summarize here those aspects of the statistical methodology that relate to all analyses to follow. First, all analyses were performed using STATA 14 software: including parametric estimates (such as odds ratios in logistic regression), semi parametric estimates (such as hazard ratios in Cox regression), and non-parametric statistical analysis (such as log-rank tests, Kaplan-Meier estimates). Second, as mentioned in Section 2.1.3 above, many of my sample units involve missing data with respect to one or more variables. This is particularly relevant for the bivariate and multivariate analyses to be carried out below, where interrelationships between variables are of primary importance. As stated in Section 2.1.3 above, list-wise deletion is applied to all samples with missing data. Although this necessarily reduces the sample sizes used, list-wise deletion is nonetheless the most robust procedure to use in most regression setting (Allison, 2001).

3.1 Relation of Housing Damage to Homeowner and Housing Characteristics

My primary interest in this study is the relation between social vulnerability characteristics of homeowners and the housing damage they suffered from Katrina. To do so, I begin with a brief consideration of the overall statistics for relevant homeowner characteristics in this study group, as detailed in Table 3.1. Notably, 77% of these homeowners did indeed suffer some degree of housing damage from Katrina. For the later purposes, I also note that 25% of this study group are Blacks. Next, I consider bivariate (contingency-table) relations between housing damage and homeowner characteristics, as summarized in Table 3.3. Here the primary result of interest (in terms of designed-based F-tests) is the highly significant relation between Blacks and housing damage (p-value < .001).

In addition to overall damage, recall from the measurement section above that AHS distinguishes damage levels requiring demolition, designated as *severely damaged* homes. Given this distinction, it is also of interest to consider the relative prevalence of severe home damage among socially vulnerable groups, as detailed in Table 3.4. Here my results show that for Katrina, the *only* demographic group significantly related to severely damaged homes was *Black* homeowners. (p-value < .05).

To further sharpen these findings, I develop two logistic regression models that allow us to identify the relative home damage effects and severe home damage effects among socially vulnerable groups. The formal models are as follows:

Model 1 $P_{damage}(y = 1|X) = G(\beta 0 + \beta_{black}X_{black} + \beta_{hisp}X_{hisp} + \beta_f X_f + \beta_{ag}X_{ag})$

Model 2 $P_{severe\ damage}(y = 1|X) = G(\beta 0 + \beta_{black}X_{black} + \beta_{hisp}X_{hisp} + \beta_f X_f + \beta_{ag}X_{ag})$

where the left-hand sides denote, respectively, the conditional probability of *damage* and *severe damage* for a homeowner, given an appropriate vector of homeowner characteristics, *X*. Here *G* denotes the standard logistic function (i.e., $G(X) = \exp(X)/[1 + \exp(X)]$ for a scalar variable, *X)*, and the relevant (social vulnerability) characteristics in *X* are specified as follows:

- X_{black} is a Black homeowner;
- X_{hisp} is a Hispanic homeowner;
- X_f is a female homeowner; and
- X_{ag} is a homeowner aged 65 or older.

The results of these two regressions can be seen, respectively, in Table 3.5. Here it is evident that these results are essentially the same as the contingency-table results above. Thus, even when controlling for all other socially vulnerable groups, Black continue to be the only significant group with respect to housing damage (p-value = .001) and severe housing damage (p-value = .015). These results are of fundamental importance for the present study. Among all socially vulnerable groups in this study, both home damage and severe home damage effects among Blacks were by far the most significant. In my subsequent analyses, these results motivate my focus on this most affected socially vulnerable group.

My second objective here is to clarify the implicit role of physical housing characteristics in determining levels of home damage by Katrina. In particular, if Blacks suffered the most home damage among socially vulnerable groups, then it is natural to ask whether this is reflected by the housing characteristics of this group. To address this question, I begin by examining the relation of each housing characteristic to housing damage. Then I examine the relations between socially vulnerable groups and each of these housing characteristics. Finally, I conclude with an analysis of the relation between home damage and social vulnerability while *controlling* for housing characteristics.

For the purposes of this study, the relevant housing characteristics include the cardinal variable, *housing age*, and the two categorical variables, *housing adequacy* and *housing location*. Turning first to *housing age* (as summarized for all homeowners in Table 3.2), the relations between housing age and both home damage and severe home damage are analyzed by the following pair of bivariate logistic models:

Model 3 $P_{damage}(y = 1|X) = G(\beta 0 + \beta_{ha}X_{ha})$

Model 4 $P_{severely\ damage}(y = 1|X) = G(\beta 0 + \beta_{ha}X_{ha})$

where X_{ha} is housing age.

The results of these two regressions, presented in Table 3.6, show that housing age is significantly related to home damage (p-value = .003), but not to severe home damage. The difference between these results will be discussed below, in terms of the relations between housing characteristics.

The two categorical housing characteristics, housing adequacy and housing location, are summarized for all homeowners in Table 3.1. Here it is important to note that the effective sample sizes of both housing adequacy and housing location (n=867, n=210, respectively) are much smaller than those in the models above. Two major factors contribute to this missing data. First, these variables are only available in the 2004 AHS survey. Moreover, of the 1525 cases meeting the inclusion/exclusion criteria in 2009, 538 homeowners were part of the 1844 cases added in 2009 (as discussed in Section 2.1.3 above). So for these homeowners, no data on housing characteristics was available. In addition, 120 respondents chose “not applicable” for the housing adequacy question and 746 chose “not applicable” for the housing location question. In fact, the AHS Public Use File (PUF) codebook (U.S. Department of Housing and Urban Development [HUD] Office of Policy Development and Research, 2015) does not speculate as to why the respondents chose “not applicable” for these particular variables. Hence, the study treats them as missing values.

Notice that for housing adequacy (Table 3.1), less than 3% of all homeowners indicated any form of inadequate housing condition. But of these, at least 35% were Black (Table 3.10), which is substantially greater than their 25% share of all homeowners (Table 3.1). As for housing location, even though the sample size is small (n = 210), a substantial portion of these houses (48%) were located in flood plains (Table 3.1).

As for the relations of these variables to both home damage and severe home damage (Table 3.3 and Table 3.4), housing adequacy exhibits no significant relationship with either home damage or severe home damage. With respect to housing location however, in spite of the small sample size mentioned above, there is indeed a significant relationship between homes in the flood plain and severe home damage (p-value = .03).

In particular, the prevalence of severely damaged homes in flood plains is about five times higher than those not in flood plains (7.43% vs 1.60%). Finally, it is worth noting that among all homes in flood plains, about 80% suffered some degree of damage from Katrina.

Next, to examine the housing characteristics of socially vulnerable groups, I develop a sequence of three regression models (Models 5, 6, and 7, with results reported together in Table 3.7). The first model (Model 5) examines the relation between *housing age* and socially vulnerable groups. Given the cardinal nature of the dependent variable, this model is a *linear regression* of the form:

Model 5 $E_{ha}(y|X) = \beta 0 + \beta_{black}X_{black} + \beta_{hisp}X_{hisp} + \beta_f X_f + \beta_{ag}X_{ag}$

where $E_{ha}(y|X)$ is expected housing age given attributes *X*. As seen in Table 3.7, there is a significant relation ($p = .051$) between Blacks and older housing. In addition, the most significant finding (as expected) is that older homeowners tend to have older homes ($p < 0.001$).

The second model (Model 6) examines the relation between *housing adequacy* and socially vulnerable groups. Given the ordinal nature of the dependent variable, this model is an *ordered logistic regression* of the form:

Model 6 $P_{ad}(y > j|X) = G\big(\beta 0 + \beta_{black}X_{black} + \beta_{hisp}X_{hisp} + \beta_f X_f +$

$\beta_{ag}X_{ag}\big), \;\; j = 1,2$

where $P_{ad}(y > 1|X)$ is the probability of either inadequate or extremely inadequate housing given socially vulnerable attributes, *X*, and $P_{ad}(y > 2|X)$ is the probability of extreme housing inadequacy given *X*. Here *G* is the logistic function, and the *X* values correspond to each of the four socially vulnerable groups (as in Model 1). In this context, each β represents a common log odds for each of these two probabilities.[5] For example, a significantly positive value of a β in the present model implies that the corresponding socially vulnerable group is both (i) more likely to have moderately or extremely inadequate housing than adequate housing, and (ii) more likely to have extremely inadequate housing than either adequate or moderately inadequate housing. The key result of this regression (in Table 3.7) is to show that Blacks are not only significantly more likely to live in inadequate housing (p = .009), but also that they are the *only* socially vulnerable group to do so.

The third model (Model 7) relates *housing location* to socially vulnerable groups, while controlling for both housing adequacy and housing age. Given the categorical nature of the dependent variable, this model is a *logistic regression* of the form:

Model 7 $$P_{fp}(y = 1|X) = G\left(\beta 0 + \beta_{black} X_{black} + \beta_{ag} X_{ag} + \beta_{hisp} X_{hisp} + \beta_f X_f\right)$$

where $P_{fp}(y = 1|X)$ is the conditional probability that a house is located in a flood plain given attributes X. As seen from Table 3.7, black homeowners and homeowners under age 65 are significantly more likely to live in a flood plain (p = .036; p = 0.040, respectively). But given the dramatically smaller sample size of this regression (n = 210) discussed above, it is somewhat more difficult to identify significant relations.[6] This is particularly evident with respect to Blacks, where in addition to a small sample size, I am

[5] Here the existence of a common log odds implicitly assumes a *parallel* condition between these two logit expressions (Cohen, Cohen, West, & Aiken, 2003), which in the present case was verified by an application of the Brant test.

[6] This is also the main reason for placing flood-plain analyses last in such nested regressions, in order to allow larger sample sizes in earlier regressions.

again controlling for housing adequacy. However, it is somewhat difficult to identify whether such significant results were due to the partial effects of other covariates (Hispanic and Female homeowners) included in this model. In this regard, two simple logistic regressions of housing location on Blacks (not reported) show that Blacks and those under age 65 are indeed more likely to live in flood plains, all else being equal.

Given these preliminary findings, the main objective of this section is to analyze the relation between home damage and socially vulnerable groups while controlling for housing characteristics. This is carried out in terms of a sequence of regressions, involving all socially vulnerable groups together with each housing characteristic. Given the sample-size limitations of severely damaged homes (only 3% of the study group, as in Table 3.1), these regressions focus on all damaged homes (including severely damaged). In this setting, three *logistic regression models* take the following form:

Model 8 $$P_{damage}(y=1|X) = G\big(\beta 0 + \beta_{black}X_{black} + \beta_{hisp}X_{hisp} + \beta_f X_f + \beta_{ag}X_{ag} + \beta_{ha}X_{ha}\big)$$

Model 9 $$P_{damage}(y=1|X) = G\big(\beta 0 + \beta_{black}X_{black} + \beta_{hisp}X_{hisp} + \beta_f X_f + \beta_{ag}X_{ag} + \beta_{ad}X_{ad}\big)$$

Model 10 $$P_{damage}(y=1|X) = G\big(\beta 0 + \beta_{black}X_{black} + \beta_{hisp}X_{hisp} + \beta_f X_f + \beta_{ag}X_{ag} + \beta_{fp}X_{fp}\big)$$

The results of these three regressions are displayed in Table 3.8. Turning first to Model 8, *housing age* is a significant positive predictor of housing damage (p = .003), showing that the positive relation between housing age and damage in Table 3.6 (p

= .003) continues to hold in the presence of demographic variables. More important here is the fact that after controlling for housing age, Blacks continue to be the single significant socially vulnerable group (p = .001). With respect to other socially vulnerable groups, what is somewhat more striking is that homeowners *younger* than 65 are seen to experience significantly more damage than those over 65. This contrasts with Table 3.1 where the relation between age variable and damage is seen to be insignificant in the absence of housing age. However, a closer analysis reveals that within the smaller sample size of the present regression (1416 versus 1494), younger homeowners are more significantly related to damage even without controlling for housing age.

Turning next to Model 9 where housing age is replaced by *inadequate housing*, the most striking feature of this model is the insignificance of Blacks. However, the missing data associated with housing inadequacy (discussed in the context of Model 4 above) has now substantially reduced the present sample size from 1494 to 847. Even so, the key feature of this subsample for the present purposes is its composition of Blacks and non-Blacks with respect to damage. While the prevalence of damage was significantly greater among Blacks than non-Blacks in the full sample (86% versus 77% in Table 3.3), this is no longer true in the smaller subsample, where damage prevalence is now almost identical (81% versus 79% in Table 3.9). Moreover, since Blacks are strongly associated with inadequate housing in Model 6 (p = .009) [as shown in Table 3.7], this probably also accounts for the lack of significance of housing inadequacy within this subsample. But because the AHS codebook (HUD Office of Policy Development and Research, 2015) provides no additional information as to why respondents chose "not applicable” for housing inadequacy, it is difficult to speculate further on the reasons for these changes in damage-prevalence relations.

The situation is even more dramatic with respect to Model 10, where the relevant housing characteristic is now *housing location*. Here the missing data resulting from “not applicable” choices by respondents to the housing location question leaves only a sample size of 210 (as discussed in the context of Model 4 above). Within this small subsample, it turns out that damage prevalence among Blacks versus non-Blacks (90% versus 71% in Table 3.9) is more similar to that of the original 1494 sample, thus accounting for the renewed positive significance of Blacks in this subsample ($p = .044$). But again it is not possible to speculate about the reasons for these damage-prevalence relations.

So with respect to housing characteristics, the main findings are those of Model 8, namely that housing age is a significant predictor of housing damage, and that Blacks continue to be the only socially vulnerable group significantly related to damage, even after controlling for this housing-age variable. The missing-data problems leading to inconclusive results for Models 9 and 10 are discussed further in Section 4.3.2 of Chapter 4 below.

More generally, my major finding in this section is the strong significance of Blacks relative to other socially vulnerable groups with respect to home damage (Model 1). Given the severity of damage to this group, I now focus exclusively on the recovery process of Blacks versus non-Blacks.

3.2 Prevalence of Financial Assistance to Blacks versus non-Blacks

Among all homeowners in the study group, 83% received some form of financial assistance during the recovery process (Table 3.11). In this context, the first question relates to the prevalence of financial assistance among Blacks versus non-Blacks. I begin by considering overall prevalence, and then refine this analysis in terms of the major public and private sources of financial assistance. Given the categorical nature of financial assistance ("received", "not received"), our first logistic model takes the form

Model 11 $P_{anyfinance}(y = 1|X) = G(\beta_0 + \beta_{black}X_{black})$

where $P_{anyfinance}(y = 1|X)$ denotes the probability of any financial assistance given attributes, X.

The results in the first column of Table 3.16 show that there is no significant difference between Blacks and non-Blacks with respect to overall financial assistance. However, when such assistance is refined to types of public and private assistance, some distinctions emerge. The three models here (Models 12, 13, and 14) focus on the major forms of financial assistance, namely:

(i) private financial assistance, i.e., *Homeowners' Insurance* (HI):

Model 12 $P_{HI}(y = 1|X) = G(\beta_0 + \beta_{black}X_{black})$

(ii) public financial assistance, i.e., *Road Home Grants* (RHG),

Model 13 $P_{RHP}(y = 1|X) = G(\beta_0 + \beta_{black}X_{black})$

and (iii) public-private financial assistance[7], i.e., *Federal Flood Insurance* (FFI)

Model 14 $P_{FFI}(y = 1|X) = G(\beta_0 + \beta_{black}X_{black})$

The results of Table 3.16 show that there is a significantly *lower* prevalence of private (HI) assistance among Blacks (p=.035), and a significant *higher* prevalence of both public (RHG) assistance (p < .0005) and public-private (FFI) assistance (p = .023). Note in particular the *strong* association between Blacks and RHG. As will be seen below, these distinctions have consequences for the relative prevalence of home recovery by Blacks versus non-Blacks.

In addition, 17% of all homeowners in the study group who received some form of financial assistance for Katrina-related housing damage continued to experience a *financial gap*, i.e., could not afford to complete the repair/rebuilding of their home (Table 3.12). In this context, my next question relates to the prevalence of a financial gap among Blacks versus non-Blacks. Given the categorical nature of financial gap ("perceived", "not perceived"), this question is addressed in terms of the following logistic model,

Model 15 $P_{Gap}(y = 1|X) = G(\beta_0 + \beta_{black}X_{black})$

where $P_{Gap}(y = 1|X)$ denotes the probability of a perceived financial gap given attributes, X.

The results in the last column of Table 3.16 show that there is a significant difference between Blacks and non-Blacks with respect to perceived financial gap. Indeed, Table 3.15 shows that the prevalence of perceived financial gaps among Blacks (29.63%)

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[7] While Federal Flood Insurance is essentially public in nature, it does require premium payments, and constitutes "private" insurance in that sense.

is almost twice that of non-Blacks (15.92%). This is of course reflected by the strong significance of X_{black} in Model 15 (OR= 2.223, p<0.0005). But as we shall see below, perceived financial gap plays an important role in the home recovery process of both Blacks and non-Blacks.

3.3 Factors Influencing Home Recovery by Blacks versus non-Blacks

Turning next to the home recovery process itself, I begin by observing that 91% of the study population recovered from Katrina, i.e., either completed the rebuild\repair process or specified a completion date (month/year). In terms of Blacks versus non-Blacks, these percentages are virtually the same [90% for Blacks and 91% for non-Blacks (Table 3.12)]. So in terms of the overall prevalence of home recovery, there is essentially no difference between Blacks and non-Blacks. However, it is still of interest to ask whether there were any key differences among the factors contributing to these recovery rates for Blacks and non-Blacks.

The first series of models examine possible differences in the effects of major public and private financial assistance,

- X_{HI} = Homeowners Insurance
- X_{FFI} = Federal Flood Insurance
- X_{RHP} = Road Home Grant

on the recovery for these groups, where $P_{recover}(y = 1|X)$ denotes the probability of recovery given attributes, X:

Model 16 (Black Subpopulation)

$$P_{recovery}(y = 1|X) = G(\beta_0 + \beta_{HI}X_{HI} + \beta_{FFI}X_{FFI} + \beta_{RHP}X_{RHP})$$

Model 17 (Non-Black Subpopulation)

$$P_{recovery}(y = 1|X) = G(\beta_0 + \beta_{HI}X_{HI} + \beta_{FFI}X_{FFI} + \beta_{RHP}X_{RHP})$$

The results of all these models, reported in Table 3.17, suggest that Homeowners Insurance (HI) is a positively significant predictor of home recovery for both groups: $(\beta_{HI} = .0776, p = .045)$ for the Black subpopulation and $(\beta_{HI} = 1.321, p < .0005)$ for the non-Black subpopulation. But in relative terms, it is clear that HI is a far more significant predictor of recovery for non-Blacks. Turning next to Road Home Grants (RHG), this is again a positively significant predictor of recovery for non-Blacks $(\beta_{RHG} = 1.002, p = .045)$, but is now totally insignificant for Blacks $(\beta_{HI} = -.180, p = .654)$. Finally, Federal Flood Insurance (FFI) is not significantly related to home recovery for either group.

Next I consider the role of *Perceived Financial Gaps* for both Blacks and non-Blacks:

Model 18 (Black Subpopulation) $P_{reovery}(y = 1|X) = G(\beta_0 + \beta_{gap}X_{gap})$

Model 19 (Non-Black Subpopulation) $P_{reovery}(y = 1|X) = G(\beta_0 + \beta_{gap}X_{gap})$

Here the results of these models (Table 3.18) show that among those homeowners who received financial assistance, perceived financial gap is a strongly negative predictor of recovery for both groups: $(\beta_{gap} = -1.895, p < .0005)$ for Blacks and $(\beta_{gap} = -1.530, p < .0005)$ for non-Blacks.

Finally, I combine *Perceived Financial Gap* with the *Financial Assistance* variables above as follows:

Model 20 (Black Subpopulation)

$$P_{reovery}(y = 1|X) = G\left(\beta_0 + \beta_{gap}X_{gap} + \beta_{HI}X_{HI} + \beta_{FFI}X_{FFI} + \beta_{RHP}X_{RHP}\right)$$

Model 21 (Non-Black Subpopulation)

$$P_{reovery}(y = 1|X) = G\left(\beta_0 + \beta_{gap}X_{gap} + \beta_{HI}X_{HI} + \beta_{FFI}X_{FFI} + \beta_{RHP}X_{RHP}\right)$$

Here results in Table 3.18 show that the negative significance of Perceived Financial Gap persists [$\left(\beta_{gap} = -1.873, p < .0005\right)$ for Blacks and $\left(\beta_{gap} = -1.530, p < .0005\right)$ for non-Blacks], and moreover, that all significant effects of both public and/or private financial assistance now vanish. These results suggest that Perceived Financial Gap is the single most influential factor with respect to home recovery for *both* Blacks and non-Blacks. But in spite of its overall significance, there is little evidence to suggest a differential effect between Blacks and non-Blacks. In this regard, one informative comparison is given in Table 3.19, where it is shown that within the subsample of 193 homeowners perceiving a financial gap, there is only a one percent difference in recovery rates between Blacks and non-Blacks (82% versus 83%).

3.4 Speed of Home Recovery by Blacks versus non-Blacks

While there was seen to be little difference between the overall prevalence of recovery between Blacks and non-Blacks, this is not true of their relative *rates* of recovery. This is most easily seen in terms of Figures 3.1(b) and 3.5(b) below which compare, respectively, the relative starting times and completion times of the rebuilding/repairing process for both Blacks and non-Blacks who did recover. Turning first to Figure 3.1(b), these two curves show the approximate percentages of Blacks and non-Blacks who have not yet started this process by each month following Katrina (on the horizontal axis). For example, (as shown by the dashed lines on the figure) after the first 6 months, 50% of Blacks had not yet started, while it took only 3 months for 50% of non-Blacks to start the process.[8] This is also documented in the first contingency-table analysis of Table 3.20, where the 50^{th} percentile of starting times for Blacks and non-Blacks are seen to be 3 months and 6 months, respectively. Note also that the results of the log-rank test on the right confirm that there is a very significant difference between these curves. More generally, since the curve for Blacks continues to be above that for non-Blacks down to about 10%, this indicates that (approximately) the first 90% of Blacks to start the rebuilding/recovery process took longer to do so than the first 90% of non-Blacks.

Turning next to completion times in Figure 3.5(b), a very similar relation can be seen. Here, while 50% of non-Blacks had completed the recovery process after the first 10 months, it took 20 months for the first 50% of Blacks to finish (also seen in the first contingency-table analysis of Table 3.21). Moreover, it is again seen that approximately the first 90% of Blacks took longer to finish than the first 90% of non-Blacks. The main task of this section is to identify the key factors influencing these time differences.

[8] Here it might be more appropriate to plot the percentages of each population who had started by each time period. But the present curves (Kaplan-Meier estimates of survival functions) are more closely related to the Cox regressions employed below.

Here the approach is to first analyze those factors influencing starting times, and then to repeat this analysis for completion times. To do so, I begin with a brief overview of the key analytical tool used for these analyses, namely *Cox regression*. If the rebuild/repair *starting time* for a homeowner is denoted by *T*, and the probability of start at time (month) *t* is denoted by $P(t) = P(T = t)$, then the probability of not starting by time *t* is by definition given by $P(T \geq t) = \sum_{s \geq t} P(s)$. It is these "survival" probabilities that are being estimated (in percentage terms) by curves such as in Figures 3.1(b) and 3.5(b), known as *Kaplan-Meier curves*, (Allison, 2010). In these terms, the conditional probability of starting at time *t* given that the homeowner has not started by time *t*, typically called the *hazard rate* (Allison, 2010), is then denoted by

(3.1) $$H(t) = P(T = t \,|\, T \geq t)$$

In the present context, $H(t)$, is best interpreted as the *starting rate* for the rebuild/repair process. But the term "hazard" is standard in the literature. In this context, Cox (1972) proposed the following model for charactering such hazard rates in terms of individual attributes, $X = (X_1, .. X_k)$:

(3.2) $$H(t \,|\, X) = H_0(t) \exp\left(\sum_{j=1}^{k} \beta_j X_j\right)$$

By construction, the term $H_0(t)$ represents the hazard rate for a fictitious homeowner with all "zero" attributes, and is thus referred to as the "baseline" hazard rate. The key feature of this *Cox regression model* is that the important attribute term, $\exp\left(\sum_{j=1}^{k} \beta_j X_j\right)$, defines a proportional relation between the hazard rate for each homeowner and this baseline rate. Moreover, this proportional relationship is assumed to be *independent* of time, called the *constant proportional hazard* assumption, or more simply, the *PH assumption* (see Section 3.4.3 below for tests of this assumption). To interpret this model in the present context, suppose that $X_j =$ Income and that $\beta_j > 0$. Then this would imply higher hazard rates, i.e., *faster starting rates,* for homeowners with higher incomes. This is precisely the interpretation given to the Cox regression results below.

3.4.1 Starting Times

As mentioned above, I now analyze factors influencing starting and completion times by means of a series of nested Cox regressions. While one could in principle start with the marginal effect of Blacks versus non-Blacks, this has in fact already been tested by the contingency-table results for Race in Tables 3.20 and 3.21 discussed above. So the strategy here is to sequentially add potentially relevant effects to this racial variable. The order of these additional explanatory variables is essentially determined by their temporal order in influencing the recovery process. The first variable, *Income*, is here assumed to be constant throughout the entire duration of the recovery process (dating from Katrina), and is thus taken to be a relevant factor from the beginning of this process. The importance of income in influencing recovery from disasters has of course been noted by many researchers [for example Comerio (1994), who reported that following the Loma Prieta earthquake, those victims with lower incomes had more severe housing problems during the reconstruction period]. With respect to the recovery process itself, I then consider (i) the extent of damage from Katrina in terms of *Severe Damage*, (ii) the

Number of Replacements/Additions required by this damage, (iii) the types of *Financial Assistance* obtained by homeowners for such rebuilding and repairing, and finally, (iv) any remaining *Financial Gap* perceived by those homeowners receiving financial assistance.

My first Cox model, which incorporates *Income* together with *Black* (versus non-Black), is thus the following instance of equation (3.2) above,

Model 22 $H_{Start}(t|X) = H_0(t)\exp(\beta_{black}X_{black} + \beta_{inc}X_{inc})$

where $H_{Start}(t|X)$ is the *starting rate* (hazard rate) at time *t* for a homeowner with attributes, $X = (X_{black}, X_{inc})$, where X_{black} is again the indicator for Black homeowners, and where X_{inc} denotes Income (in thousands of dollars).

The results of this regression (column 1 of Table 3.22) show that Income is indeed a significant positive factor influencing starting rates ($\beta = .001$, $p < .0005$). This is consistent with the survival curves depicted in Figure 3.1(c), which show that homeowners in the lower quartile income bracket took longer to start rebuilding/repairing than those with higher incomes. It is also consistent with the associated contingency-table analysis in Table 3.20, reporting a significant difference between these curves ($p < .01$). Note finally that Black continues to be significant in this regression ($\beta = -.208$, $p = .001$). So even though Blacks have significantly lower incomes than non-Blacks [($\beta = -.518$, $p = .001$) in Table 3.24], these results suggest that other factors must also be influencing the lower starting rates of Blacks.

This leads to the second model, in which the effects of *Severe Damage* are also included, yielding a Cox regression of the form

Model 23 $H_{Start}(t|X) = H_0(t)\exp(\beta_{black}X_{black} + \beta_{inc}X_{inc} + \beta_{svd}X_{svd})$

where the indicator variable, X_{svd} , now represents the presence of severe damage.

The results of Model 23 (column 2 of Table 3.22) show that homeowners with severe damage took much longer to start the rebuild/repair process than homeowners with less severe damage ($\beta = -.662$, $p < .005$). This is consistent with the findings of the log-rank test for differences between the survival functions of these two groups [(F=22.58; p<0.005), Table 3.20], and is also seen visually in the estimated survival functions of Figure 3.1(d). Notice by comparing Models 3.22 and 3.23 that the addition of this covariate has not influenced the significance of either Black homeowners or Income with respect to starting rates. This suggests that severity of damage does indeed add a new dimension to the factors influencing starting rates.

My third Cox model introduces the possible effects of the number of *Replacements/Additions*, X_{repl} , required in the rebuild/repair process itself:

Model 24 $H_{Start}(t|X) = H_0(t)\exp\big(\beta_{black}X_{bblack} + \beta_{inc}X_{inc} +$

$\beta_{svd}X_{svd} + \beta_{repl}X_{repl}\big)$

The results of this model (column 3 of Table 3.22) show that the number of such replacements/additions has little effect on starting times (which is consistent with the log-rank test for a categorical representation of this variable in Table 3.20). Moreover, a comparison with Model 23 shows that this variable also has little effect on the significance of Black, Income or Severity of Damage. An auxiliary regression [Table

3.25] of replacements/additions on the three other explanatory variables in Model 22 shows that this new variable is *only* significantly related to Blacks (p < .0005). This suggests that the main effect of replacements/additions in the present model is to account for a small portion of the Black effect, which is now slightly reduced (from p = .001 to p = .004).

My fourth Cox model introduces the possible effects of financial assistance. Here each type of financial assistance is treated as a categorical variable,

- X_{HI} = Homeowners Insurance
- X_{FFI} = Federal Flood Insurance
- X_{RHP} = Road Home Grant
- X_{OFA} = Other Federal Assistance
- X_{OSA} = Other State Insurance
- X_{CPA} = Charitable or Private Assistance
- X_{AOA} = Any Other form of Assistance.

where, for example, $X_{HI} = 1$, if the homeowner received Homeowner Insurance. With these designations, the Cox regression takes the form,

Model 25 $H_{Start}(t|X) = H_0(t)\ \mathrm{exp}\big(\beta_{black}X_{black} + \beta_{inc}X_{inc} +$

$\beta_{svd}X_{svd} + \beta_{repl}X_{repl} + \beta_{HI}X_{HI} + \beta_{FFI}X_{FFI} + \beta_{RHP}X_{RHP} +$

$\beta_{OFA}X_{OFA} + \beta_{OSF}X_{OSF} + \beta_{CPAi}X_{CPA} + \beta_{AOAi}X_{AOA}\big)$

The results of this model (column 4 of Table 3.22) show that Homeowners Insurance (HI) has significant positive effect on starting rates ($\beta = 0.586, p = <\ .0005$), which is by far the most significant effect of any type of financial assistance. In terms of starting rates, the hazard ratio (HR = 1.788) shows that homeowners with HI have starting rates about 80% faster than those without HI. In the opposite direction, Road Home Grants (RHG) have a weakly significant negative effect on starting rates ($\beta = -0.137, p = .077$). These results are also consistent with the log-rank tests in Table 3.20 [and their associated survival curves in Figures 3.3(a) and 3.3(c), respectively]. A homeowner receiving RHG assistance is estimated to face a hazard rate that is 87% of the hazard faced by a homeowner who does not receive this program assistance (HR= 0.872, p=0.077). Here it is also important to emphasize the diminishing effect of these financial assistance variables on the significance of Blacks (from *p* = .004 to p = .011). This is consistent with the results of Models 3.12 and 3.13 above (Table 3.16), which show that Blacks are significantly less likely to have Homeowner Insurance (*p* = .035) and more likely to have Road Home Grants (*p* < .0005). Thus, much of the distinction between Blacks and non-Blacks with respect to starting rates is now being captured by these financial assistance variables.

The final model focuses on the possible effects of a *Financial Gap* perceived by homeowners even after receiving financial assistance. Here it must be stressed that this variable is *conditioned* on receiving some receiving some form of financial assistance. So to maintain the same sample size in this nested sequence of models, it is necessary to employ three values for this variable: X_{gap} = "*Yes*", "*No*", and "*Without Assistance*". With these conventions, the final Cox regression is given by,

Model 26 $H_{Start}(t|X) = H_0(t)\exp\big(\beta_{black}X_{black} + \beta_{inc}X_{inc} +$

$\beta_{svd}X_{svd} + \beta_{repl}X_{repl} + \beta_{HI}X_{HI} + \beta_{FFI}X_{FFI} + \beta_{RHP}X_{RHP} +$

$\beta_{OFA}X_{OFA} + \beta_{OSF}X_{OSF} + \beta_{CPA}X_{CPA} + \beta_{AOA}X_{AOA} + \beta_{gap}X_{gap}\big)$

The single strongest result of this model (column 5 of Table 3.22) is to show that among those homeowners receiving financial assistance, those who perceived a financial gap took significantly longer to start their rebuild/repair processes than those who perceived no gap ($\beta = -0.440, p < .0005$). In addition, those homeowners who received no form of financial assistance (only 15% of the sample) took even longer to start their rebuild/repair processes. Both results are quite consistent with both the log-rank tests in Table 3.20 and the relative survival functions among these three groups in Figure 3.4 (d). The other key result of this model is to show that in the presence of the Financial Gap variable, Road Home Grants (RHG) now becomes much more significantly negative, from ($\beta = -0.137, p < .077$) to ($\beta = -0.218, p < .007$). This suggests that after controlling for homeowners receiving financial assistance, those with Road Home Grants experienced more significant delays in their starting times. Note finally, that the significance of Black is now diminished even further (from p = .011 to p = .026), suggesting that part of the difference between Blacks and non-Blacks is now being accounted for by perceived gaps. This is supported by the results of Model 15 (Table 3.16) which showed that among those homeowners receiving financial assistance, perceived gaps are far more prevalent among Blacks (p < .0005). It is also supported by a log-rank test (Table 3.21) showing longer starting times (p = .071) for Blacks than non-Blacks among those 193 homeowners perceiving a financial gap.

3.4.2 Completion Times

Given the above results for starting times, the present analysis of completion times closely parallels that development. In particular, the sequence of nested Cox models used here differs only by replacing *Starting rates*, $H_{Start}(t|X)$, with corresponding *Completion rat*es, $H_{Comp}(t|X)$, or the *completion rate* (hazard rate) at time *t* for a homeowner with attributes, *X*.

Model 27 $$H_{comp}(t|X) = H_0(t)\exp(\beta_{black}X_{black} + \beta_{inc}X_{inc})$$

Model 28 $$H_{comp}(t|X) = H_0(t)\exp(\beta_{black}X_{black} + \beta_{inc}X_{inc} + \beta_{svd}X_{svd})$$

Model 29 $$H_{comp}(t|X) = H_0(t)\exp\big(\beta_{black}X_{black} + \beta_{inc}X_{inc} + \beta_{svd}X_{svd} + \beta_{repl}X_{repl}\big)$$

Model 30 $$H_{comp}(t|X) = H_0(t)\,exp\big(\beta_{black}X_{black} + \beta_{inc}X_{inc} + \beta_{svd}X_{svd} + \beta_{repl}X_{repl} + \beta_{HI}X_{HI} + \beta_{FFI}X_{FFI} + \beta_{RHP}X_{RHP} + \beta_{OFA}X_{OFA} + \beta_{OSF}X_{OSF} + \beta_{CPAi}X_{CPA} + \beta_{AOAi}X_{AOA}\big)$$

Model 31 $$H_{comp}(t|X) = H_0(t)\exp\big(\beta_{black}X_{black} + \beta_{inc}X_{inc} + \beta_{svd}X_{svd} + \beta_{repl}X_{repl} + \beta_{HI}X_{HI} + \beta_{FFI}X_{FFI} + \beta_{RHP}X_{RHP} + \beta_{OFA}X_{OFA} + \beta_{OSF}X_{OSF} + \beta_{CPA}X_{CPA} + \beta_{AOA}X_{AOA} + \beta_{gap}X_{gap}\big)$$

Models 27. The key difference between this first completion model and its corresponding starting model (Model 22) is the decrease in significance of Income in the completion model (column 1 of Table 3.23). This is partly accounted for by comparing the starting and completion survival curves for both Income [Figure 3.1(c) versus Figure 3.5(c)] and for Blacks [Figure 3.1(b) versus 3.5(b)]. Here it is evident that the (vertical) differences in population percentages are much more dramatic for Blacks than for

Income, indicating that Black vs non-Black differences are relatively stronger determinants of completion times than Income differences. This suggests (as I shall see below) that factors other than Income differences between Blacks and non-Blacks are more relevant for completion times than starting times.

Model 28. Here the significance of Severe Damage effects seen in Model 23 continues to be very strong (column 2 of Table 3.23), as is further corroborated by a comparison of the starting and completion survival curves for Damage in Figures 3.1(d) and 3.5(d) respectively. Moreover, these effects on completion times appear to be relatively independent of either Black or Income effects, as evidenced by the similar significance levels of these variables in Model 28.

Model 29. Here the introduction of *Replacement/Addition* numbers is seen to have a far more dramatic effect than in the corresponding starting model (Model 24). Not only is this variable now much more negatively significant than in Model 24 ($p < .0005$ versus $p = .555$), but in addition, the significance levels of both Black and Income have also dropped. Of particular interest for my study purpose is the substantial drop in significance of Black (from $p = .004$ to $p = .067$). Here it is instructive to recall from the auxiliary regression [Table3.26] mentioned with respect to Model 20 that Black is far more significantly related to number of replacement/additions ($p < .0005$) than are either Income or Damage. This suggests that with respect to completion times versus starting times, this replacement/addition variable now constitutes a key additional factor accounting for differences between Black and non-Blacks. Moreover, given the strong negative relation between Black and Income (Table 3.25), this also helps to explain why even Income effects are now less significant.

Model 30. When types of *Financial Assistance* are added to the model, we now see that the significance of both Black and Income in the corresponding starting Model 25 have completely disappeared. With respect to Black in particular, this decrease (from $p = .011$ to $p = .217$) suggests that differences in types of financial assistance to Blacks versus non-Blacks now accounts for essentially all remaining differences with respect to their completion times. This is further confirmed by the continued positive significance ($p < .0005$) of Homeowner Insurance (HI), which has already been seen to be strongly associated with non-Blacks. Finally, while both Road Home Grants (RHG) and Federal Flood Insurance (FFI) are still negative, their relative significance has reversed (from $p = .077$ to $p = .106$ for RHG, and from $p = .549$ to $p = .022$ for FFI). Here the most dramatic change is with respect to FFI, which appears to contribute much more to delays in completion than to delays in starting. Further insight can be gained from the log-rank tests in Table 3.21 which show extreme negative significance for the marginal relations between both types of financial assistance and completion times. If one compares this with Table 3.20 for starting times, it is seen that while there is also a strong negative effect of RHG on starting times, this is not true of FFI. So it would appear that the factors contributing to longer completion times for those with FFI assistance are relatively independent of starting times. On the other hand, it would also appear that many of the factors delaying completion times for those with RHG were already present in delayed starting times. Moreover, since we have already seen (as for example in Table 3.16), that RHG is most strongly associated with Blacks, this suggests one reason why differences between Blacks and non-Blacks are more significant for starting times than completion times, even in the presence of these financial-assistance variables.

Model 31. Finally, when *Financial Gap* is added to the model, homeowners perceiving a financial gap are likely to experience more significant delays in completion times ($\beta = -0.716, p < .0005$) than was seen for starting times. Not surprisingly, the same is true for those receiving no financial assistance whatsoever ($\beta = -0.626, p < .0005$). With respect to the key variable, Black is now even more insignificant ($\beta = -0.027, p = .691$), suggesting that the addition of this Gap variable now accounts for essentially all differences between Black and non-Black. This is equally true of Income effects. With respect to the other explanatory variables, significance patterns generally remain the same. Note in particular that Federal Flood Insurance (FFI) continues to be significantly negative, reinforcing the observations made with respect to Model 30 above. The one noteworthy exception here is Road Home Grants (RHG), which now shows a very significant negative level ($\beta = -0.221, p = .006$) comparable to that in the associated starting Model 26 ($\beta = -0.218, p = .007$). Note also that this increase in significance between Models 3.30 and 3.31 is qualitatively similar to that between starting Models 3.21 and 3.22, suggesting that this increase in significance is more closely related to the addition of the Financial Gap variable than to differences between starting and completion time effects. But additional analyses here reveal no clear patterns between RHG, Financial Gap and Blacks. In particular, a log rank test (Table 3.22) of completion times for those 193 homeowners perceiving a financial gap showed no significant differences between Blacks and non-Blacks.

3.4.3 Tests of the Proportional Hazard (PH) Assumption.

Finally, given the fundamental importance of the *proportional hazard* (PH) assumption underlying Cox regression models, it is imperative to test the validity of this assumption. Given the use of weighted data in the present study, many standard methods for testing this assumption are not applicable (Heeringa, West, & Berglund, 2017). However, the simple graphical method based on log-log plots of (Kaplan-Meier) estimated survival functions, $\hat{S}(t)$, is in principle still applicable. In particular, if one compares estimated survival functions for two groups, $\hat{S}_1(t)$ and $\hat{S}_2(t)$ [such as Blacks and non-Blacks in Figure 3.5(b)] then it is well known that under the PH assumption a plot of $\ln(-\ln(\hat{S}_i(t))$, $i = 1, 2,$ against *t* should yield curves that differ by (approximately) a constant amount [such as seen for Blacks and non-Blacks in Figure 3.10(a)]. More generally, this informal graphical check is quite robust even for weighted data (Heeringa et al., 2017). With this in mind, the results of Figures 3.9 and 3.10 for my Starting Models and Completion Models, respectively, suggest that the PH assumption appears to be reasonable for most of the variables.

However, since some variables, such as Damage, appear to be questionable in this regard, I have carried out a second series of tests using time interactions. In particular, for any variable, *x*, it is well known that by adding a time interaction, $t\,x$, to the Cox regression, the pair of terms, $\beta x + \alpha t x = (\beta + \alpha t)x$, allow the regression coefficient for *x* to vary with time. In this setting, non-rejection of the null hypothesis, $\alpha = 0$, provides evidence for the constancy of the β coefficient over time, and thus for the PH assumption with respect to variable *x*. Moreover, even when α is found to be significantly non-zero, if this violation is seen to have no effect on the signs and significance levels of other variables, then it can be inferred that the given regression results are not sensitive to the non-proportionality of *x*. I have conducted tests of this type for all variables, and have found that none of the nested Cox regressions are sensitive to violations of the PH assumption. For example, in Completion Model 31, while Damage is found to be significantly non-proportional, the presence of this time variation has no effect on either the signs or significance levels of other variables. I take such findings to provide evidence for the validity of the Cox regression results above.

CHAPTER 4. DISCUSSION AND CONCLUSIONS

In this final chapter, I begin by summarizing and discussing the major findings of this study. This is followed by a brief consideration of the major implications of these results from theoretical, methodological and policy perspectives. I then explore some of the more important limitations of the present analysis, both in terms of methodology and data availability. Finally I sketch a number of directions for further research, including possible strategies for resolving the present data limitations.

4.1 Summary of Major Findings

In this study I have systematically investigated the home damage caused by Hurricane Katrina in the New Orleans Metropolitan Statistical Area (NOMSA), together with the recovery process experienced by individual homeowners. Using the 2009 American Housing Survey for the New Orleans Metropolitan Statistical Area Public Use File (AHS NOMSA PUF), I found that among all homeowners in this data base living in the NOMSA on the eve of Hurricane Katrina, 75% sustained some degree of damage, including 3% who were so severely damaged that their homes needed to be demolished. However, this destruction was not evenly distributed among homeowners with different demographic characteristics. In the present study, I have been mainly interested in demographic groups previously identified in the literature as *socially vulnerable* groups (Finch et al.,2010), which are here taken to include Blacks, Hispanics, female heads of households, and people aged 65 and over. As stated in the Introduction, I have focused on three research questions related to these homeowners:

(i) Among the socially vulnerable demographic groups above, which were most likely to suffer housing damage at the homeowner level?

(ii) Among those suffering the most housing damage, how did their access to public and private financial assistance differ from other homeowners?

(iii) What role did these differences play in both the relative prevalence and speed of recovery for those suffering the most housing damage?

With respect to question (i), the main finding in Section 3.1 above is that within this AHS study group, Blacks constitute the *only* socially vulnerable subgroup who suffered significant damage from Hurricane Katrina. This result is consistent with the findings of previous social-vulnerability studies involving more aggregate levels of data. For example, the study of Finch et al. (2010) at the census tract level found “extensive flooding” in New Orleans census tracts with “some of the highest levels of social vulnerability” (p.188). In addition, the study of Green et al. (2007) at the neighborhood level found that in the Industrial Canal area of the lower Ninth Ward in New Orleans (which is at least 95% Black), more than half of the houses suffered “heavy structural damage”(p.321). In contrast, the present study focuses on individual homeowners. Moreover, I found not only that Black homeowners were more likely to suffer damage than non-Black homeowners, but also to suffer *more severe* damage (Table 3.4).

With respect to question (ii), the main finding in Section 3.2 is that while Blacks and non-Blacks were about equally likely to receive some form of financial assistance, the nature of this assistance differed dramatically. On the one hand, non-Blacks were far more likely to receive assistance from private Homeowners Insurance (Model 12). This result is consistent with more general findings about the lack of access to Homeowner

Insurance by Blacks (Bolin & Bolton, 1986; Peacock & Girard, 1997). On the other hand, Blacks were more likely to receive assistance from public Road Home Grants (Model 13). With respect to such assistance, however, there is some evidence suggesting monetary discrimination against Blacks in terms of compensation based on pre-storm valuations of housing (Hammer, 2010). Moreover, among those homeowners receiving financial assistance, Blacks were almost twice as likely to perceive a financial gap hindering their recovery process (Model 15).

Turning finally to question (iii), these differences in financial assistance and perceived financial gaps had significant effects on both the prevalence and speed of recovery for Blacks versus non-Blacks. With respect to the prevalence of recovery, Models 3.17 and 3.18 showed that while assistance from private Homeowners Insurance had a significantly positive effect on recovery for both Blacks and non-Blacks, this effect was vastly more significant for non-Blacks. In contrast, while public Road Home Grants had some positive relation to recovery for non-Blacks, they had no significant effect on recovery for Blacks (which may be related to the types of monetary discrimination mentioned above). Finally, with respect to perceived financial gap, the results in Models 3.20 and 3.21 show that even after controlling for the major types of financial assistance, the perception of financial gaps by homeowners was the single most significant predictor of non-recovery for *both* Blacks and non-Blacks. But in spite of its overall significance, the perception of financial gaps provided little information about *differences* in recovery rates between Blacks and non-Blacks.

Perhaps the most important differences between Blacks and non-Blacks found in this study were with respect to speed of recovery, both in terms of starting times and completion times. Here it was found that Blacks took significantly longer *both* to start and to complete their rebuild/repair process of recovery. This is seen most dramatically in the starting and completion survival curves of Figures 3.1(b) and 3.5(b), respectively, together with their corresponding log-rank tests in Tables 3.20 and 3.21 (both with $p < .0005$). For example, while 50% of Blacks took longer than 20 months to complete their rebuild/repair process, only about 25% of non-Blacks took that long. These findings are consistent with the repopulation study of the City of New Orleans done by Fussell, Sastry, and VanLandingham (2010), who found that within the first 14 months after Katrina, "Black residents returned to the city at a much slower rate than white residents" (p.20). Assuming that the rebuilding/repair process for homeowners can only start after returning to the city, this by itself should in part account for the longer starting times found in the present study.

But my findings suggest that there were a number of other key factors influencing starting and completion times, as well as the differences in these times between Blacks and non-Blacks. Here I discuss four key factors based on the results of the nested Cox models for starting and completion times in Tables 3.22 and 3.23, respectively. First it is seen that *damage severity* is a strong predictor of both longer starting times and completion times. The main relevance of this fact for my study purposes is that severe damage is much more prevalent among Blacks than non-Blacks (Table 3.4). A second noteworthy factor is the *number of replacements/renewals*, which is seen to be a strong predictor of completion times. Again, the main relevance of this result for my study purposes is that the number of repairs/renewals is significantly greater among Blacks than non-Blacks (Table 3.25). The third noteworthy factor is *income*, which is seen to have a uniformly significant positive effect on starting times. Once again, the main relevance of this result for my study purposes is the significantly lower incomes of Blacks (Table 3.24), which surely contributed to their longer starting times.[9]

The final set of factors relate to financial assistance and perceived financial gaps. With respect to financial assistance, the single strongest result in Tables 3.22 and 3.23 is the uniformly positive effect of Homeowners Insurance in reducing both starting and completion times. This finding is consistent with Kunreuther (2006), who found that private insurance played an important role in mitigating the losses caused by Hurricane Katrina. But the main relevance of this result in the present context is the significantly greater prevalence of Homeowners Insurance among non-Blacks than Blacks (Table 3.16). In contrast to this private insurance, those homeowners with public Road Home grants tended to take longer both to start and to complete their rebuild/repair processes. While these results are less significant than for Homeowners Insurance, they are uniformly negative and are also consistent with other findings in the literature. For example, Kamel (2012) found that "Applicants who successfully navigated the application process had to wait an average of more than 250 days before receiving Road Home funds" (p.3215). Similarly, with respect to Federal Flood Insurance, the results suggest that homeowners with this insurance also took significantly longer to complete

[9] Here I also note that income had much less effect on completion times. This difference is best understood by noting that while almost all starting times were *before* the financial crisis in 2008, about 22% of homeowners had not completed their rebuild/repair processes by this time. So the financial crisis itself may have led to more uncertainty in completion times relative to stated incomes.

their rebuild/repair processes. However, the reasons here appear to be more related to the types of damage suffered by these homeowners than to Federal Flood Insurance itself. In particular, a logistic regression analysis of those homeowners with Federal Flood Insurance (Table 3.26) shows that they experienced significantly more severe damage, and also required greater numbers of replacements/additions. Both of these factors would appear to have more direct effects on completion times than starting times. In this regard, I also note that a similar logistic regression with respect to Homeowner Insurance (Table 3.26) reveals a very different profile of homeowners with fewer replacements/additions and significantly less severe damage. As above, the main importance of these differences for my study purpose is that Blacks are strongly associated both with more severe damage (Table 3.4) and larger numbers of replacements/additions (Table 3.25). Turning finally to the role of perceived financial gaps, the main finding here was that (as with the prevalence of recovery above) the presence of such gaps was the single most significant predictor of both longer starting and completion times for *all* homeowners. However, in spite of the higher prevalence of such perceived gaps among Blacks, they again provided little information about *differences* in recovery speeds between Blacks and non-Blacks (Tables 3.21 and 3.22).

4.2 Implications

The major implications of these findings can be summarized in terms of their *theoretical*, *methodological*, and *policy* implications. I consider each of these in turn.

4.2.1 Theoretical Implications

From a theoretical perspective, the present results contribute both to the study of *social vulnerability* itself, and to the identification of factors influencing the *resilience* of socially vulnerable groups to environmental disasters.

Social vulnerability. The present study is partly inspired by the work of Cutter et al. (2003) on social vulnerability to environmental hazards, which they defined more explicitly to be "those social factors that influence or shape the susceptibility of various groups to harm and that also govern their ability to respond" (p.243). The groups of interest here include Blacks, Hispanics, female heads of households, and people aged 65 and over within the larger study group of Hurricane Katrina survivors. But as pointed out by Schmidtlein et al. (2008) "…variables that are influential to the vulnerability of individuals or households may not have the same level or type of relationship when examining vulnerability of populations or groups" (p.1101) With this in mind, a major objective of the present study has been to focus on *individual homeowners* within each group, and to examine the impacts of Katrina at the individual level. By doing so, I have been able to relate the degree of damage suffered by individuals to their subsequent processes of recovery. In this way, one can draw more meaningful conclusions about the factors influencing both damage and recovery by individuals within each socially vulnerable group.

A second theoretical characterization of social vulnerability is provided by the work of McEntire (2013), who used the concepts of *capabilities* and *liabilities* to explain social vulnerability. With respect to *recovery capabilities,* including both income and financial assistance contributing to homeowner recovery, I found significant differences between Black and non-Black homeowners. Not only did Blacks have significantly lower income levels, but also had forms of financial assistance (public Road Home Grants versus private Homeowners Insurance) that were significantly less conducive to speedy recovery. With respect to *recovery liabilities*, including damage severity and numbers of replacement/additions required, I also found significant differences: Black homeowners were more likely both to suffer severe damage and to require greater numbers of replacement/additions. These differences in terms of both recovery capabilities and liabilities may help us to understand the slower rates of home recovery by Blacks.

Resilience. In the context of environmental disasters, *housing recovery* has been identified as a critical component of community resilience (Ganapati, Cheng, & Ganapati, 2013) and is therefore recognized as one of the six core recovery support functions in the National Disaster Recovery Framework, according to FEMA (2011). In particular, there is now general agreement [as for example in the R4 Framework of Resilience developed by the Multidisciplinary Center for Earthquake Engineering Research (Tierney & Bruneau, 2007)] that the conceptualization of resilience should incorporate the notion of *rapidity*, or the capacity to restore functionality in a timely manner: “Resilient systems reduce the probability of failure… and the time for recovery” (p. 15). But given difficulties of measuring housing recovery over time (especially in relation to social vulnerability), this aspect of resilience has not been widely studied. To help fill this research gap, the present research has used home recovery data from Katrina to document that Black homeowners were not only more vulnerable to home damage, but were also less resilient to home recovery than their non-Black counterparts.

4.2.2 Methodological Implications

From a methodological perspective, the major contribution of this study has been to introduce more meaningful measures of the real-time duration of recovery, namely *starting times* and *completion times* (rather than simply "before" and "after"). To my knowledge, this is the first study to employ event-history analysis (or survival analysis) as a tool for analyzing housing recovery speed. Although this method has been widely used in the medical and life insurance fields to estimate survival outcomes over time, and in engineering to study failure times, it has not yet been applied to housing recovery. The work most closely related to my present study is that of Fussell et al. (2010), who applied both Kaplan-Meier estimates and Hazard-model regressions[10] to study disparities between Blacks and non-Blacks in their return times to the Orleans Parish after Hurricane Katrina. In a manner similar to my study, they found that severity of housing damage was a significant predictor of longer return times by Blacks than non-Blacks. However, they did not look at either recovery duration or types of financial assistance to Blacks versus non-Blacks.

From a conceptual perspective, it should also be emphasized that my approach implicitly adopts a two-dimensional characterization of recovery in terms of both *prevalence* and *speed* of recovery. Not only does the analysis of each dimension require different tools (multiple and logistic regression verses Kaplan-Meier estimation and Cox regression), but in fact the results of these analyses can produce quite different results. In the present study I found that while there was little difference between Blacks and non-

[10] More specifically, these authors applied a piecewise exponential model to estimate a base hazard-rate function as well as contributions of various homeowner attributes.

Blacks in terms of recovery prevalence, there were indeed dramatic differences with respect to recovery speed, both in terms of starting times and recovery times.

4.2.3 Policy Implications

From a policy perspective, the most relevant findings of the present study are with respect to inequities between Blacks and non-Blacks in terms of financial assistance. Here I found major differences with respect to private versus public assistance.

With respect to *private assistance* (Homeowners Insurance), the results for survivors of Hurricane Katrina support previous findings in the disaster literature suggesting that (i) individual survivors receiving homeowner insurance assistance are more likely to recover, i.e., to rebuild their homes on their original sites after a disaster (Comerio, 1997), and that (ii) Black homeowners are less likely than non-Blacks to receive assistance in the form of Homeowner Insurance following disasters (Zakour & Gillespie, 2013). With respect to hurricanes in particular, Peacock and Girard (1997) found that Black homeowners were less likely than non-Blacks to be covered by Homeowner Insurance after Hurricane Andrew. This of course raises the question as to why Blacks were less likely to be covered by this type of insurance. For the case of New Orleans, Green et al., (2007) has observed that there is “significant insurance redlining in low-income and minority neighborhoods” (p327). From a policy perspective, this suggests (following Peacock and Girard, 1997) that anti-redlining programs be instituted in the NOMSA that will “require insurance companies to file quarterly disclosure reports” on both the “types of policies written” and the “geographic locations of policies issued” (p.189). A second key factor here appears to be Black homeowners’ lack of information regarding the relevant private insurance options that may be available to them. In particular, many researchers (Green et al., 2007; Bolin and Bolton, 1986; Peacock, Morrow, and Gladwin, 1997) have documented that Black homeowners tend to insure through "second tier" regional insurers that have been shown to pay out less, and to do so more slowly in the event of a claim. From a policy perspective, this suggests an information campaign by local government oriented to realtors, banks, unions, and housing-relevant social service agencies, at a minimum, to increase Black awareness about possibly more attractive insurance options. Such an information campaign would necessarily involve multiple local government coalitions who, themselves, would need to learn more about private insurance options for homeowners. Local mayors' offices could take the lead in such campaigns, perhaps using the broad and successful outreach example of the Earned Income Tax Credit (EITC) program as a model (CBPP, 2004). Such an insurance campaign could be broadly useful to Blacks and other groups in generally low-income rural and urban areas such as NOMSA, particularly in the context of a sociological embeddedness perspective, as suggested by Iversen and Armstrong's (2008) ethnographic research. It has also been suggested (Peacock & Girard, 1997) that government provide incentives to private insurance companies to "foster the placement of insurance agencies and agents in minority communities" (p.189).

Turning next to *public assistance* (Road Home Grants), the results for Katrina survivors also support previous findings in the disaster literature suggesting that (i) Blacks are significantly more likely than non-Blacks to rely on public Road Home Grants for financial assistance (Green et al., 2007; Green & Olshansky, 2012) and that (ii) homeowners relying on assistance from Road Home Grants are significantly more likely to experience delays in their recovery process (Kamel, 2012; Rainey, 2016). As noted in Section 4.1 above, Kamel (2012) found that successful applicants for Road Home Grants had to wait an average of more than 250 days before receiving funds. Moreover, with respect to the payment structure of Road Home Grants themselves (as mentioned in the Introduction), Blacks appear to be at a disadvantage in the sense that payments are limited by Road Home's estimated "pre-storm value of the home" (Finger, 2008). In addition, Road Home Grants imposed a 30% penalty on those recipients who lived in a flood plain but did not have either HI or FFI coverage (Spader & Turnham, 2014). So while my flood-plain sample is small (n = 210), the results based on this sample suggest that Blacks are more likely to incur such penalties in Road Home Grants.

These findings raise questions as to why Blacks were more likely to rely on this type of public assistance. Here there appear to be at least two contributing factors. Perhaps most important is the official "Declaration of Purpose" for Road Home Grants, which (as mentioned in the Introduction) states that these grants are "principally for persons of low and moderate income" (Finger, 2008). Since Black homeowners in my study were shown to have significantly lower incomes than non-Blacks, it is reasonable to infer that they were more encouraged to apply for such grants. A second contributing factor is the eligibility requirement of Road Home Grants that the applicant's home be categorized by FEMA as "destroyed or having suffered major damage" (Morris, 2018). Here the results again confirm that Black homeowners were more likely to suffer severe damage than non-Blacks,. Third, Kroll-Smith, Baxter, and Jenkins' (2015) qualitative research provides details about financial inequities in grant awards, noting "the potential discrimination" (p.97) against Blacks in terms of the amount of the Road Home Grant.

Their finding is based on a lawsuit against HUD and Louisiana Housing Recovery Authority (LRA) by five black homeowners with damage after Katrina. It implies that whites are much more likely to have been allocated more RHG money in dollar awards than Blacks (p.59). Their work also suggests that the grant awards in general were allocated in a much less timely manner, described as “the slow dull heave of the will” (p. 97). Although the AHS does not provide information about how much RHG money homeowners received, Kroll-Smith and colleagues’ report that “millions of dollars in disaster relief for survivors of Hurricane Katrina remained unspent” (p. 97).

Given this tendency of Black homeowners to rely on Road Home Grants, the resulting delay-time inequities between Black and non-Black homeowners found in my study essentially adds one more voice to the call for policy reform of this program. As summarized by Finger (2008), “The delay in rebuilding caused by Road Home has made an indelible, detrimental mark on disaster-impacted areas” (p.62).

4.3 Limitations

Any study involving secondary data is necessarily limited by the nature of the data available. Here I focus only on the key issues of *omitted variables* and *missing data*.

4.3.1 Omitted Variables

While the present study could of course be enriched by the addition of many attributes of individual homeowners, the most important limitations for the present results relate to the identification of additional *socially vulnerable* groups among Katrina survivors, and to the *geographic* aspects of this hurricane itself. I consider each of these in turn.

Social-Vulnerability Variables. While the results identify Blacks as the "only" socially vulnerable group of homeowners severely damaged by Katrina, it can be argued that social vulnerability extends well beyond the demographic groups identified in this study. But in order to capture socially vulnerable characteristics on the eve of Hurricane Katrina, it was necessary to restrict my analysis to *time invariant* characteristics. In particular, the only time invariant characteristics of homeowners available in the 2009 AHS data set were Blacks, Hispanics, Female, and 65 and over.

Geographic Variables. With respect to Hurricane Katrina itself, the spatial dimensions of this disaster are of fundamental importance. For example, those homeowners living in the vicinity of the major levee failures resulting from this storm were clearly more likely to suffer flood damage than others. So without such information, it is difficult to gauge either the nature or actual extent of damage suffered by many individual homeowners.

Monetary Variables. While the present categorical variables relating to both damage and financial assistance do allow certain types of analyses, such as estimating the likelihood of "damage" (versus "no damage") or say, the likelihood of "receiving assistance from homeowner insurance", they do not allow any quantitative analyses in terms of actual dollar amounts. Without such information, it is difficult for example to measure the actual financial gaps experienced by homeowners. In addition, it is difficult to establish concrete relations, for example, between the extent of damage costs and time required both to start and to complete the rebuild/repair process.

4.3.2 Missing Data

Of particular importance in the present study is the role played by missing data.

As documented in Section 2.1.3 above, 1811 cases in the Orleans Parish were dropped by the US Census "in order to protect the privacy of these households". This missing data created a number of estimation problems affecting my results. First, while my study group is less than 25% Black, the Orleans Parish is at least 50% Black (US Census, 2005). Moreover, the central city area is all below sea level, and is known to have suffered particularly severe flood damage from Katrina. These facts suggest that my results may underestimate both the severity of damage and the non-recovery rate among Blacks. A second estimation problem is with respect to the effects of Federal Flood Insurance (FFI) on recovery rates. While I found no significant effect, it is widely believed that FFI does indeed facilitate home recovery from flood damage (Kunreuther, 2006). Moreover, it is also known (Green et al., 2007; HUD 2006) that approximately 71% of homeowners in the FEMA-designated lowest risk (100-year flood plain) area of Orleans Parish were covered by FFI. So, assuming that at least this fraction of homeowners had FFI coverage in higher risk areas, this suggests that the inconclusive nature of my FFI results could well be due to this missing data. Finally, while these 1811 samples were replaced by an addition sample of 1844 households in 2009, this data could not be merged with the 2004 AHS data containing all housing characteristics. So, as mentioned in the discussion of Models 3.9 and 3.10 in Chapter 3, my inconclusive results with respect to both *inadequate housing* and *housing location* may largely be due to this same missing data problem.

4.4 Directions for Further Research

The single most pressing task for further research is to address the missing data problems discussed above. The set of 1811 missing samples excluded by the US Census is contained in the AHS Internal Use File and can be accessed under special permission by the US Census. This data is available at all Federal Statistical Research Data Centers, including the newly opened center at the Federal Reserve Bank of Philadelphia. I have already been given permission by the US Census to access this data starting in the Fall of 2018. This will allow me to address many of the limitations outlined above.

A second direction for further research is to extend the definition of “home recovery” to include those Katrina survivors who did *not* return to the NOMSA. Existing literature has shown that there was indeed a substantial population exodus from New Orleans following Hurricane Katrina (Fussell et al., 2010). Moreover, this non-returning population can be expected to include many homeowners with damaged homes. But the question of whether these homeowners received any form of public or private financial assistance for rebuilding has (to my knowledge) not been investigated. For example, the provisions of Road Home Grants allow recipients to either relocate outside of Louisiana (option 2) or even sell their homes (option 3) (Finger 2008; Green & Olshansky, 2012; Gregory, 2013; Hammer, 2011). So to examine the full effectiveness of this funding program, one must determine the extent to which Road Home Grants facilitated the recovery of this group.

Finally, many studies (e.g. Iversen & Armstrong, 2008) have suggested that other socially-based factors can play an important role in both the resilience of disaster victims, the repopulation of disaster areas, and the general health and mental health recovery of survivors. For example, Aldrich (2012) found that *social capital* was “the strongest and most robust predictor of population recovery” after the Kobe earthquake in Japan, especially among socially vulnerable populations. Cohen and Wills (1985) suggested that *social support* contributes to health and mental health resilience, either directly or indirectly, through a stress-buffering effect. Benight and Bandura (2004) suggested that *self-efficacy* contributed to mental health recovery. More recently, Ma and Smith (2017) found that while social cohesion facilitated increased drinking after Hurricane Ike in Galveston, *informal social control* tended to constrain this maladaptive response to the disaster. However, the extent to which housing recovery was associated with any of these social determinants has not yet been explored in the literature. Given that AHS does not contain any of these variables, future studies should combine AHS with other appropriated datasets (including the American Community Survey and National Health Interview Survey) to examine how these social determinants may have contributed to home recovery in the New Orleans MSA, particularly among socially vulnerable groups.

APPENDIX A. TABLES

Table 1.1 Dimensions of housing recovery.

Response to Home Damage	**Home Recovery achieved?**	**Time to initiation of construction**	**Time to completion of construction**
Rebuilt or Repaired	*Yes or No*	*Number of months*	*Number of months*

Table 2.1 Home damage characteristics variables: question, scale and source.

Variable	Questionnaires [i]	Scale	Source
Damaged home	Did any damage occur to this property as a result of Hurricane Katrina?	Dichotomous	2009 AHS
Severely damaged home	Was the damage so severe that the home was levelled, condemned, or had to be demolished?	Dichotomous	2009 AHS

i. The items in this column are quoted directly from the surveys.

Table 2.2 Demographic variables: Scale and source.

Variable	**Scale**	**Source**
Black Homeowner	Dichotomous	AHS 2009
Hispanic Homeowner	Dichotomous	
Female Homeowner	Dichotomous	
Homeowner aged 65 or older	Dichotomous	

Table 2.3 Housing condition variables: Question, scale and source.

Variable	**Questionnaires** [i]	**Scale**	**Source**
Housing Adequacy	A series of questions was used to determine response to physical adequacy of housing at an ordinal level: 1= Adequate housing;2=Moderately inadequate housing, or 3= Extremely inadequate housing [ii].	Ordinal	2004 AHS
Housing age [iii]	In which year this housing unit was built?	Continuous	2009 AHS
Housing location [iv]	Is this property in a flood plain?	Dichotomous	2004 AHS

i. The items in this column are quoted directly from the surveys.

ii. According to AHS Codebook, a severely inadequate housing is defined if any of the following conditions exist:
   - The unit lacks complete plumbing facilities.
   - There were 3 or more heating equipment breakdowns lasting 6 hours or more in the last 90 days.
   - The unit has no electricity.
   - The electrical wiring is not concealed, working wall outlets are not present in every room, and fuses/breakers blew 3 or more times in the last 90 days.
   - 5 or more of the following exist: outside water leaks, inside water leaks, holes in the floor, cracks wider than a dime in the walls, areas of peeling paint or plaster larger than 8 1/2 x 11, rodents seen in the unit recently
   - all 4 of the following exist:
     - no working light fixtures or no light fixtures at all in public hallways, loose, broken,
     - missing steps in common stairways,
     - stair railings not firmly attached or no stair railings on stairs at all,
     - there are 3 or more floors between the unit and the main entrance to the building and there is no elevator

   According to AHS Codebook, a unit is moderately inadequate if it is not severely inadequate and any of the following conditions exist:
   - The unit lacks complete kitchen facilities.
   - There were 3 or more toilet breakdowns lasting 6 hours or more in the last 90 days;
   - An unvented room heater is the main heating equipment;
   - 3 or 4 of the following exist:
     - outside water leaks,
     - inside water leaks,
     - holes in the floor,
     - cracks wider than a dime in the walls,
     - areas of peeling paint or plaster larger than 8 1/2 x 11,
     - rodents seen in the unit recently
   - 3 of the following exist:
     - no working light fixtures or no light fixtures at all in public hallways, loose, broken;
     - missing steps in common stairways;
     - stair railings not firmly attached or no stair railings on stairs at all;
     - there are 3 or more floors between the unit and the main entrance to the building and there is no elevator.

iii. In order to derive the age of the home, the study subtracts the year of the unit built from 2005.

iv. Data from the 2004 AHS is used as a proxy to identify homes located within a flood plain.

Table 2.4 Rebuilt and repaired variables: question, scale and source.

Variables	**Questionnaires** [i]	**Scale**	**Source**
A rebuilt home	Was or will the home be rebuilt/replaced, due to Hurricane Katrina?	Dichotomous	2009 AHS
A repaired home	Have or will repairs be done to the home, due to Hurricane Katrina?	Dichotomous	2009 AHS

i. The questions in this column are quoted directly from the surveys.

Table 2.5 Timing of rebuilding and repair completion.

Variables	**Questionnaires** [i]	**Scale**	**Source**
Start month and year for rebuilding or repairing	a) What was or is the estimated start month [with the optional answers] from January to December b) What was or is the estimated start year [with the optional answers] from 2005 to 2030	Time Variable (Calendar)	AHS 2009
Completion month and year for a rebuilt home or a repaired home	a) What was or is the estimated completion month [with the optional answers] from January to December b) What was or is the estimated completion year [with the optional answers] from 2005 to 2030		

[i.] The questions in this column are quoted directly from the surveys.

Table 2.6 Family income variable, scale and source.

Variable	**Scale**	**Source**
Family Income (sum of all wage incomes)	Continuous	AHS 2009

Table 2.7 Rebuilding/repairing characteristics, question, scale and source.

Variables	**Questionnaires** [i]	**Scale**	**Source**
Number of replacements/ additions	How many replacements/additions were made to the unit as a result of Hurricane Katrina damage?	Continuous	AHS 2009

i. The questions in this column are quoted directly from the surveys.

ii. The study will add up results from the three questions to reflect the total cost for rebuilding, alteration and repairs

Table 2.8 Financial Assistance, question, scale and source.

Variables	**Questionnaires** [i]	**Scale**	**Source**
A homeowner with any financial assistance (AFA)	Did the homeowner receive any form of financial assistance for rebuilding/repairing?	Dichotomous	2009 AHS
A homeowner with Federal flood insurance (FFI)	Did the homeowner receive Federal flood insurance?	Dichotomous	2009 AHS
A homeowner with HI (HI)	Did the homeowner received Homeowner's insurance?	Dichotomous	2009 AHS
A homeowner with RHG	Did the homeowner receive road home grant?	Dichotomous	2009 AHS
A homeowner with other federal (OFA)	Did the homeowner receive other federal assistance?	Dichotomous	2009 AHS
A homeowner with other state assistance (OSA)	Did the homeowner receive other state assistance	Dichotomous	2009 AHS
A homeowner with charitable/private assistance (CPA)	Did the homeowner receive other charitable/ private assistance?	Dichotomous	2009 AHS
A homeowner with any other assistance (AOA)	Did the homeowner receive any other assistance?	Dichotomous	2009 AHS

[i] The questions in this column are quoted directly from the surveys.

Table 2.9 Financial gap variable, question, and scale.

Variables	**Questionnaires** [i]	**Scale**	**Source**
A homeowner experience financial gap	Is the homeowner unable to complete replacing or repairing the home because the owner cannot afford to?	Dichotomous	2009 AHS

[i] The questions in this column are quoted directly from the surveys.

Table 3.1 Weighted summary statistics of homeowner's demographics and housing characteristics.

	Variables	Count	Percent in category	Observation
Black	No	185,928	75%	1,130
	Yes	62,374	25%	395
	Total	248,302	100%	1,525
Ethnicity	Non-Hispanic	231,375	93%	1,419
	Hispanic	16,927	7%	106
	Total	248,302	100%	1,525
Sex	Male	120,676	49%	740
	Female	127,625	51%	785
	Total	248,302	100%	1,525
Age	<65 yr	208,470	84%	1,283
	>=65 yr	39,832	16%	242
	Total	248,302	100%	1,525
Housing Adequacy	Adequate	139,179	97%	841
	Moderately inadequate	2,844	2%	17
	Extreme inadequate	1,510	1%	9
	Total	143,533	100%	867
Home Located in Flood Plain	No	18,742	52%	108
	Yes	16,895	48%	102
	Total	35,030	100%	210
Damaged by Katrina	Not Reported	158	0%	1
	Refused	464	0%	3
	Don't know	4,285	2%	27
	No	50,996	21%	317
	Yes	192,398	77%	1,177
	Total	248,302	100%	1,525
Severely Damaged that had to be demolished	Not reported	158	0%	1
	Refused	464	0%	3
	Don't know	4,285	2%	27
	No	236,022	95%	1,446
	Yes	7,373	3%	48
	Total	248,302	100%	1,525

Table 3.2 Weighted Summary statistics of building age on the eve of Katrina.

Variable	Mean	Standard Deviation	Minimum	25th percentile	Median	75th percentile	Maximum	Observation	Count
Housing Age [a]	33.48	21.94	0	25	35	55	86	1,416	232,303

[a] Unit: year

Table 3.3 Weighted two-way cross-tabulations of the damaged homes on homeowner's demographics and housing Characteristics.

Variables			Damaged by Katrina?		Total	Design - based F-test
			No	Yes		
Black	No	Count	42,267	140,921	183,188	12.45*** [a]
		Percent	23.07%	76.93%	100.00%	
		Observation	261	852	1,113	
	Yes	Count	8,729	51,478	60,207	
		Percent	14.50%	85.50%	100%	
		Observation	56	325	381	
	Total	Count	50,996	192,398	243,395	
		Percent	20.95%	79.05%	100.00%	
		Observation	317	1,177.00	1,494.00	
Ethnicity	Non-Hispanic	Count	47,410	179,934	227,344	0.12
		Percent	20.85%	79.15%	100.00%	
		Observation	295	1,098	1,393	
	Hispanic	Count	3,586	12,464	16,050	
		Percent	22.34%	77.66%	100.00%	
		Observation	22	79	101	
	Total	Count	50,996	192,398	243,395	
		Percent	20.95%	79.05%	100.00%	
		Observation	317	1,177	1,494	
Sex	Male	Count	23,214	94,984	118,198	1.42
		Percent	19.64%	80.36%	100.00%	
		Observation	142	582	724	
	Female	Count	27,782	97,414	125,196	
		Percent	22.19%	77.81%	100.00%	
		Observation	175	595	770	
	Total	Count	50,996	192,398	243,395	
		Percent	20.95%	79.05%	100.00%	
		Observation	317	1,177.00	1,494	
Age	<65 yr	Count	41,255	162,623	203,878	2.27
		Percent	20.24%	79.76%	100.00%	
		Observation	260	994	1,254	
	>=65 yr	Count	9,741	29,775	39,516	
		Percent	24.65%	75.35%	100.00%	
		Observation	57	183	240	
	Total	Count	50,996	192,398	243,395	
		Percent	20.95%	79.05%	100.00%	

		Observation	317	1,177	1,494	
Housing Adequacy	Adequate	Count	29,070	110,109	139,179	0.25
		Percent	20.89%	79.11%	100.00%	
		Observation	169	653	822	
	Moderate Inadequate	Count	389	2,455	2,844	
		Percent	13.66%	86.34%	100.00%	
		Observation	2	14	16	
	Extremely Inadequate	Count	311	1,199	1,510	
		Percent	20.62%	79.38%	100.00%	
		Observation	2	7	9	
	Total	Count	29,769	113,763	143,533	
		Percent	20.74%	79.26%	100%	
		Observation	173	674	847	
Home Located in Flood Plain	No	Count	5,272	13,003	18,275	1.91
		Percent	28.85%	71.15%	100.00%	
		Observation	32	76	108	
	Yes	Count	3,420	13,335	16,755	
		Percent	20.41%	79.59%	100.00%	
		Observation	21	81	102	
	Total	Count	8,692	26,338	35,030	
		Percent	24.81%	75.19%	100.00%	
		Observation	53	157	210	

[a] *** p<0.01, ** p<0.05, * p<0.1.

Table 3.4 Weighted two-way cross-tabulations of the severely damage homes on homeowners' demographics and housing characteristics.

Variable			Severely Damaged by Katrina? No	Severely Damaged by Katrina? Yes	Total	Design - based F-test
Black	No	Count	178,742	4,446	183,188	5.78** [a]
		Percent	97.57%	2.43%	100.00%	
		Observation	1,084	29	1,113	
	Yes	Count	57,279	2,927	60,207	
		Percent	95.14%	4.86%	100%	
		Observation	362	19	381	
	Total	Count	236,022	7,373	243,395	
		Percent	96.97%	3.03%	100.00%	
		Observation	1,446.00	48.00	1,494.00	
Ethnicity	Non-Hispanic	Count	220,630	6,714	227,344	0.41
		Percent	97.05%	2.95%	100.00%	
		Observation	1,349	44	1,393	
	Hispanic	Count	15,391	659	16,050	
		Percent	95.89%	4.11%	100.00%	
		Observation	97	4	101	
	Total	Count	236,022	7,373	243,395	
		Percent	96.97%	3.03%	100.00%	
		Observation	1,446.00	48	1,494	
Sex	Male	Count	113,951	4,248	118,198	1.56
		Percent	96.41%	3.59%	100.00%	
		Observation	696	28	724	
	Female	Count	122,071	3,125	125,196	
		Percent	97.50%	2.50%	100.00%	
		Observation	750	20	770	
	Total	Count	236,022	7,373	243,395	
		Percent	96.97%	3.03%	100.00%	
		Observation	1,446	48	1,494	
Age	<65 yr	Count	198,149	5,730	203,878	1.21
		Percent	97.19%	2.81%	100.00%	
		Observation	1,216.00	38	1,254	
	>=65 yr	Count	37,873	1,643	39,516	
		Percent	95.84%	4.16%	100.00%	
		Observation	230	10	240	
	Total	Count	236,022	7,373	243,395	
		Percent	96.97%	3.03%	100.00%	

		Observation	1,446	48	1,494	
Housing Adequacy	Adequate	Count	136,895	2,284	139,179	0.21
		Percent	98.36%	1.64 %	100.00%	
		Observation	809	13	822	
	Moderately Inadequate	Count	2,844	0	2,844	
		Percent	100%	0%	100.00%	
		Observation	16	0	16	
	Extremely Inadequate	Count	1,510	0	1,510	
		Percent	100%	0%	100.00%	
		Observation	9	0	9	
	Total	Count	141249	2,284	143533	
		Percent	98.41%	1.59%	100%	
		Observation	834	13	847	
Home Located in Flood Plain	No	Count	17,982	293	18,275	4.58**
		Percent	98.40%	1.60%	100.00%	
		Observation	106	2	108	
	Yes	Count	15,510	1,245	16,755	
		Percent	92.57%	7.43%	100.00%	
		Observation	94	8	102	
	Total	Count	33,491	1,538	35,030	
		Percent	95.61%	4.39%	100.00%	
		Observation	200	10	210	

[a] *** p<0.01, ** p<0.05, * p<0.1.

Table 3.5 Weighted logistic regressions to predict a damaged home by the homeowner's demographics (Model 1), and to predict a severely damaged home by the homeowner's demographics (Model 2).

	Model 1	Model 2
VARIABLES	**Damage**	**Severe damage**
Black Yes No^[a]	0.546[b] ***[c] (0.166) [d] {1.727}[e] *** [0.001] [f]	0.768** (0.315)** {2.156}** [0.015]
Age >65 yr <=65 yr^	-0.236 (0.170) {0.789} [0.163]	0.429 (0.370) {1.536} [0.247]
Ethnicity Hispanic Non-Hispanic^	0.048 (0.257) {1.050} [0.851]	0.561 (0.550) {1.753} [0.307]
Sex Female Male^	-0.123 (0.132) {0.884} [0.351]	-0.282 0.307 {0.754} [0.357]
Constant	1.311*** (0.113) [0.000]	-3.702*** (0.272) [0.000]
Observations	1,494	1,494
Design based F-Statistic	3.60***	2.85***

[a] ^ denotes a reference category
[b] beta coefficient
[c] *** p<0.01, ** p<0.05, * p<0.1
[d] (standard error)
[e] {odds ratio}
[f] [p-value]

Table 3.6 Weighted (simple) logistic regressions to predict a damaged home by its building age (Model 3); and to predict a severely damaged home by its building age (Model 4).

VARIABLES	**Model 3 Damage**	**Model 4 Severe Damage**
	β [a]	β
Building age [b]	0.011*** [c] (0.004) [d] [0.003] [e]	0.008 (0.010) [0.449]
Constant	1.072*** (0.147) [0.000]	-4.283*** (0.474) [0.000]
Observations	1,416	1,416
Design based F test	8.65***	0.57

[a] β stands for beta coefficients; log (odds).
[b] Building age here refers to the building age at the year of 2005.
[c] *** $p<0.01$, ** $p<0.05$, * $p<0.1$.
[d] (standard error)
[e] [p-value]

Table 3.7 Weighted linear regression of housing age by homeowners' demographics (Model 5) Weighted ordered logistic regression housing adequacy by homeowners' demographics (Model 6); Weighted logistic regression of housing location by homeowners' demographics (Model 7).

VARIABLES	**Model 5** **Housing age**	**Model 6** **Housing inadequacy**	**Model 7** **Housing location**
Black Yes No^[a]	2.673[b]*[c] (1.366)[d] [0.051][f]	1.118*** (0.453) {3.247}[e]*** [0.009]	0.775 ** (0.368) {2.171}** [0.036]
Age >65 yr <=65 yr^	6.773*** (1.412) [0.000]	-0.373 (0.632) {0.688} [0.554]	-0.938** (0.454) {0.391} [0.040]
Ethnicity Hispanic Non-Hispanic^	-1.787 (2.314) [0.440]	0.332 (0.784) {1.393} [0.672]	0.495 (0.721) {1.641} [0.493]
Sex Female Male^	-0.552 (1.117) [0.639]	-0.293 (0.414) {0.746} [0.479]	0.715 (0.297) {1.074} [0.810]
Constant	37.12*** (1.008) [0.000]	Cut 1 3.563 (0.368) Cut 2 4.651 (0.349)	-0.193 (0.252) [0.445]
Observations R-squared Design based F-Statistic	1416 0.0162 6.76***	847 2.66**	210 2.30*

[a] ^ stands for a reference category
[b] beta coefficient
[c] *** p<0.01, ** p<0.05, * p<0.1
[d] (standard error)
[e] {Odds ratio}
[f] [*p*-value]

Table 3.8 Weighted logistic regression models to predict a housing damage by homeowners' demographics and housing age (Model 8); by homeowners demographics and housing adequacy (Model 9); by homeowner's demographics and housing location (Model 10).

VARIABLES	Model 8 Housing age	Model 9 Housing adequacy	Model 10 Housing location
Black Yes No^[a]	0.650[b]***[c] (0.187)[d] {1.916}[e]*** [0.001][f]	0.085 (0.252) {1.089} [0.735]	1.187** (0. 585) {3.278}** [0.044]
Aging 65 and older Under 65^	-0.402** (0.179) {0.668}** [0.025]	-0.316 (0.215) {0.729} [0.143]	-0.607 (0.468) {0.545} [0.196]
Ethnicity Hispanic Non-Hispanic^	0.132 (0.277) {1.141} [0.633]	-0.011 (0.319) {0.989} [0.973]	-0.695 (0.706) {0.499} [0.326]
Sex Female Male^	-0.039 (0.142) {0.961} [0.783]	0.113 (0.176) {1.119} [0.523]	0.131 (0.345) {1.140} [0.707]
Housing Age[g]	0.011*** (0.004) {1.011}*** [0.003]		
Housing Adequacy Adequate ^ Moderately Inadequate		0.535 (0.761) {1.708} [0.482]	
Extremely Inadequate		-0.103 (0.761) {0.902} [0.900]	
Flood Plain Yes No^			0.305 (0.346) {1.358} [0.377]
Constant	1.005*** (0.184) [0.000]	1.323*** (0.149) [0.000]	0.839*** (.317) [0.009]
Observations	1416	847	210
Design based F-statistic	5.21***	0.63	1.48

[a] ^ stands for a reference category
[b] beta coefficient
[c] *** p<0.01, ** p<0.05, * p<0.1
[d] (standard error)
[e] {odds ratio}
[f] [*p* -value]

Table 3.9 Damage prevalence between Black and Non-black population according to the sample sizes in Models 3.6, 3.7, 3.9, and 3.10.

N=847 (Models 6 & 9)			**Damaged by Katrina?**		**Total**	**Design - based F-test**
			No	Yes		
Black	No	Count	25,740	96,730	122,470	0.63
		Percent	21.02%	78.98%	100%	
		Observation	149	568	717	
	Yes	Count	4,029	17,034	21,063	
		Percent	19.13%	80.87%	100%	
		Observation	24	106	130	
	Total	Count	29,769	113,763	143,533	
		Percent	20.74%	79.26%	100%	
		Observation	173	674	847	
N= 210 (Models 7 & 10)			**Damaged by Katrina?**		**Total**	**Design - based F-test**
			No	Yes		
Black	No	Count	7,966	19,961	27,927	5.56**[a]
		Percent	28.52%	71.48%	100%	
		Observation	49	116	165	
	Yes	Count	726	6,377	7,103	
		Percent	10.23%	89.77%	100%	
		Observation	4	41	45	
	Total	Count	8,692	26,338	35,030	
		Percent	24.81%	75.19%	100.00%	
		Observation	53	157	210	

[a] *** p<0.01, ** p<0.05, * p<0.1.

Table 3.10 An auxiliary continency table of housing adequacy and Black.

Variables			Black No	Black Yes	Total	Design based F-test
Housing Adequacy	Adequate	Count	119,656	19,523	139,179	4.342**[a] [0.013]
		Percent	86	14	100	
		Observation	701	121	822	
	Moderately Inadequate	Count	1,860	983	2,844	
		Percent	65	35	100	
		Observation	10	6	16	
	Severely Adequate	Count	953	557	1,510	
		Percent	63	37	100	
		Observation	6	3	9	
		Count	122,470	21,063	143,533	
		Percent	85	15	100	
		Observation	717	130	847	

[a] *** p<0.01, ** p<0.05, * p<0.1

Table 3.11 Weighted summary statistics of Black, damage characteristics, received financial assistance (including both public and private sources), and perceived financial gap.

Variable		Count	Percent	N
Black	No	140,921	73%	852
	Yes	51,478	27%	325
	Total	192,398	100%	1,177
Severely Damaged	No	7,373	4%	178
	Yes	185,025	96%	975
	Total	192,398	100%	1,177
Received financial assistance in some form	No	28,929	15%	178
	YES	159,619	83%	975
	missing [a]	3,851	2%	24
	Total	192,398	100%	1,177
Received Homeowners Insurance (HI) assistance	No	28,929	15%	178
	Yes	159,619	83%	975
	missing	3,851	2%	24
	Total	192,398	100%	1,177
Received Flood Insurance (FI) assistance	No	146,840	76%	894
	Yes	40,932	21%	254
	missing	4,626	2%	29
	Total	192,398	100%	1,177
Received Road Home Grant program (RHP) assistance	No	147,430	77%	898
	Yes	40,342	21%	250
	missing	4,626	2%	29
	Total	192,398	100%	1,177
Received Other Federal program assistance (OFA)	No	173,754	90%	1,065
	Yes	14,018	7%	83
	missing	4,626	2%	29
	Total	192,398	100%	1,177
Received Other State program assistance (OSA)	No	187,175	97%	1,144
	Yes	598	0%	4
	missing	4,626	2%	29
	Total	192,398	100%	1,177
Received Charitable and Private assistance (CPA)	No	184,882	96%	1,132
	Yes	2,890	2%	16
	missing	4,626	2%	29
	Total	192,398	100%	1,177
	No	184,882	96%	1,132

Received Any Other assistance (AOA)	Yes	2,890	2%	16
	missing	4,626	2%	29
	Total	192,398	100%	1,177
Perceived Financial Gap	Did not receive any financial assistance	28,929	15%	178
	Yes	31,235	16%	193
	No	128,182	67%	781
	missing	4,052	2%	25
	Total	192,398	100%	1,177
Either Rebuilt or Repaired	No	18,277	9%	111
	Yes	174,121	91%	1,066
	Total	192,398	100%	1,177

[a] Missing data

Table 3.12 Weighted two-way cross tabulation of rebuilt/repaired homes on the identified characteristics of social vulnerability, damage characteristics, received financial assistance, and perceived financial gap.

Variables			**Rebuilt / Repaired?** No	Yes	**Total**	**Design based F-test**
Black	No	Count	13,115	127,806	140,921	0.14
		Percent	9.00%	91.00%	100.00%	
		Observation	79	773	852	
	Yes	Count	5,162	46,316	51,478	
		Percent	10.00%	90.00%	100%	
		Observation	32	293	325	
	Total	Count	18,277	174,121	192,398	
		Percent	9.00%	91.00%	100.00%	
		Observation	111	1,066.00	1,177.00	
Home severely damaged	No	Count	17,252	167,773	185,025	1.14
		Percent	9.00%	91.00%	100.00%	
		Observation	104	1,025	1,129	
	Yes	Count	1,025	6,348	7,373	
		Percent	14.00%	86.00%	100.00%	
		Observation	7	41	48	
	Total	Count	18,277	174,121	192,398	
		Percent	9.00%	91.00%	100.00%	
		Observation	111	1,066	1,177	
Insurance or financial assistance in any form	No	Count	6,625	22,303	28,929	46.53*** [a]
		Percent	23.00%	77.00%	100.00%	
		Observation	40	138	178	
	Yes	Count	10,523	149,095	159,619	
		Percent	7.00%	93.00%	100.00%	
		Observation	64	911	975	
	Total	Count	17,149	171,399	188,547	
		Percent	9.00%	91.00%	100.00%	
		Observation	104	1,049.00	1,153	
	No	Count	8,378	39,338	47,717	33.32***
		Percent	18.00%	82.00%	100.00%	

		Observation	51	244	295	
Homeowner Insurance (HI)	Yes	Count	8,615	131,440	140,056	
		Percent	6.00%	94.00%	100.00%	
		Observation	52	801	853	
	Total	Count	16,994	170,779	187,772	
		Percent	9.00%	91.00%	100.00%	
		Observation	103	1,045	1,148	
Flood insurance (NFIP)	No	Count	14,346	132,494	146,840	2.53
		Percent	10.00%	90.00%	100.00%	
		Observation	87	807	894	
	Yes	Count	2,648	38,284	40,932	
		Percent	6.00%	94.00%	100.00%	
		Observation	16	238	254	
	Total	Count	16,993.82	170,779	187,772	
		Percent	9.00%	91.00%	100.00%	
		Observation	103	1,045	1,148	
Road Home Grant (RHP)	No	Count	14,223	133,207	147,430	1.78
		Percent	10.00%	90.00%	100.00%	
		Observation	86	812	898	
	Yes	Count	2,771	37,571	40,342	
		Percent	7.00%	93.00%	100.00%	
		Observation	17	233	250	
	Total	Count	16,994	170,779	187,772	
		Percent	9.00%	91.00%	100.00%	
		Observation	103	1,045	1,148	
Other Federal assistance (OFA)	No	Count	16,540	157,214	173,754	3.93**
		Percent	10.00%	90.00%	100.00%	
		Observation	100	965	1,065	
	Yes	Count	453	13,564	14,018	
		Percent	3.00%	97.00%	100.00%	
		Observation	3	80	83	
	Total	Count	16,994	170,779	187,772	
		Percent	9.00%	91.00%	100.00%	

		Observation	103	1,045	1,148	
Other State assistance (OSA)	No	Count	16,836	170,339	187,175	1.41
		Percent	9.00%	91.00%	100.00%	
		Observation	102	1,042	1,144	
	Yes	Count	158	440	598	
		Percent	26.00%	74.00%	100.00%	
		Observation	1	3	4	
	Total	Count	16,994	170,779	187,772	
		Percent	9.00%	91.00%	100.00%	
		Observation	103	1,045	1,148	
Charitable /Private assistance (CPA)	No	Count	16,830	168,052	184,882	0.24
		Percent	9.00%	91.00%	100.00%	
		Observation	102	1,030	1,132	
	Yes	Count	164	2,726	2,890	
		Percent	6.00%	94.00%	100.00%	
		Observation	1	15	16	
	Total	Count	16,994	170,779	187,772	
		Percent	9.00%	91.00%	100.00%	
		Observation	103	1,045	1,148	
Any other assistance	No	Count	16,630	168,147	184,777	0.19
		Percent	9.00%	91.00%	100.00%	
		Observation	101	1,029	1,130	
	Yes	Count	364	2,631	2,995	
		Percent	12.00%	88.00%	100.00%	
		Observation	2	16	18	
	Total	Count	16,994	170,779	187,772	
		Percent	9.00%	91.00%	100.00%	
		Observation	103	1,045	1,148	
Financial Gap	With-out assistance	Count	6,625	22,303	28,929	39.86***
		Percent	23.00%	77.00%	100.00%	
		Observation	40	138	178	
	Yes	Count	5,326	25,909	31,235	
		Percent	17.00%	83.00%	100.00%	
		Observation	32	161	193	

No	Count	4,996	123,186	128,182
	Percent	4.00%	96.00%	100.00%
	Observation	31	750	781
Total	Count	16,947	171,399	188,346
	Percent	9.00%	91.00%	100.00%
	Observation	103	1,049	1,152

[a] *** p<0.01, ** p<0.05, * p<0.1

Table 3.13 An auxiliary weighted logistic regression model to predict home recovery by major public and private financial assistance among the total population who suffered damaged.

VARIABLES	**Recovery**
HI[a]	1.163[b]***[c]
Yes	(0.211)[d]
No^[e]	{3.199}[f]***
	[0.000][g]
FFI[h]	0.190
Yes	(0.294)
No^	{1.209}
	[0.518]
RHG[i]	0.343
Yes	(0.291)
No^	{1.410}
	[0.239]
Constant	1.456***
	(0.171)
	{4.287}***
	[0.000]
Observations	1,148
Design based F-test	10.29***

[a] Homeowners Insurance
[b] beta coefficient
[c] *** p<0.01, ** p<0.05, * p<0.1
[d] (Standard error)
[e] ^ denotes a reference group
[f] {Odds ratio}
[g] [*p*-value]
[h] Federal Flood Insurance
[i] Road Home Grant

Table 3.14 Weighted (simple/unadjusted) logistic regression to predict a rebuilt or repaired home by each of the covariates.

VARIABLES			β[a]	OR [b]	Constant	N [c]
Black	Yes	No ^ [e]	-.0825 (0.222)[f]	0.921 [0.710][g]	9.745*** [d] (1.167)	1,177
Household Income			0.002 (0.002)	1.002 [0.238]	5.465*** (2.023)	1,177
Severely damaged	Yes	No ^	-0.451 (0.425)	0.637 [0.289]	7.994*** (1.357)	1,177
Number of Replacements/Additions			0.0281 (0.018)	1.028 [0.111]	8.093*** (1.134)	1,177
Any Insurance /Financial Assistance	Yes	No ^	1.437*** (0.224)	4.209*** [0.868]	3.366*** (0.614)	1,153
Homeowners Insurance (HI)	Yes	No ^	1.178*** (0.212)	3.249*** [0.000]	4.695*** (0.734)	1,148
Flood Insurance (NFIP)	Yes	No ^	0.448 (0.283)	1.566 [0.114]	9.235*** (1.057)	1,148
Road Home Grant (RHP)	Yes	No ^	0.369 (0.278)	1.448 [0.184]	9.366*** (1.076)	1,148
Other Federal Assistance (OFA)	Yes	No ^	1.146* (0.610)	3.147* [0.060]	9.505*** (1.010)	1,148
Other State Assistance (OSA)	Yes	No ^	-1.291 (1.160)	0.275 [0.266]	10.12*** (1.066)	1,148
Charitable / Private Assistance (CPA)	Yes	No ^	0.508 (1.039)	1.662 [0.625]	9.986*** (1.063)	1,148
Any other Assistance (AOA)	Yes	No ^	-0.335 (0.764)	0.715 [0.661]	10.11*** (1.068)	1,148
		No ^				

Perceived Financial gap	Without assistance	-1.991*** (0.260)	0.136*** [0.000]	24.655*** (0.856)	1,152
	Yes	-1.623*** (0.269)	0.197*** [0.000]		

[a] β stands for Beta coefficient
[b] OR stands for odds ratio.
[c] Number of Observation.
[d] *** p<0.01, ** p<0.05, * p<0.1.
[e] ^ stands for a reference group.
[f] (standard error)
[g] [*p*-value].

Table 3.15 Prevalence of Financial gap among Blacks and Non-blacks subpopulations.

Variables			Financial gap? No	Financial gap? Yes	Total	Design based F-test
Black	No	Count	98,154	18,591	116,746	22.918***[a] [<0.005]
		Percent	84.08	15.92	100	
		Observation	591	113	704	
	Yes	Count	30,028	12,644	42,672	
		Percent	70.37	29.63	100	
		Observation	190	80	270	
	Total	Count	128,182	31,235	159,417	
		Percent	80.41	19.59	100	
		Observation	781	193	974	

[a] *** p<0.01, ** p<0.05, * p<0.1

Table 3.16 Weighted simple logistic regressions to predict receiving financial assistance in any form, (Model 11), in form of Homeowner Insurance (Model 12), in form of Federal Flood insurance (Model 13), in form of Road Home Grant (Model 14) by the identified social characteristics of social vulnerability; and to predict perceive financial gap by the identified characteristics of social vulnerability (Model 15).

Variables	Model 11	Model 12	Model 13	Model 14	Model 15
	Any Assistance	**Homeowner Insurance**	**Flood Insurance**	**Road Home Grant**	**Financia l Gap**
Black	0.098[b]	-0.361**[c]	0.350**	1.260***	0.799***
Yes	(0.213) [d]	(0.170)	(0.349)	(0.200)	(0.185)
No ^ [a]	{1.102}[e]	{0.697}**	1.418**	3.782***	2.223***
	[0.646] [f]	[0.035]	[0.023]	[0.000]	[0.000]
Constant	5.366***	3.242***	-1.377***	-1.717***	0.190***
	(0.628)	(0.324)	(.097)	(0.0303)	(0.0227)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	1,153	1,148	1,148	1,148	974
Model F-Statistics	0.21	4.47***	69.18***	39.57***	18.61***

---

[a] ^ denotes a reference group
[b] Beta coefficient
[c] *** p<0.01, ** p<0.05, * p<0.1.
[d] (Standard error)
[e] {Odds ratio}
[f] [p-value]

Table 3.17 Weighted logistic regression models to predict home recovery by major public and private financial assistance among subpopulations of black and non-black homeowners.

	Model 17	Model 18
VARIABLES	**Black**	**Non-black**
HI[a]	0.776**	1.321***
Yes	(0.385)	(0.254)
No^[b]	{2.174}**	{3.746}***
	[0.045]	[0.000]
FFI[c]	0.366	0.152
Yes	(0.488)	(0.369)
No^	{1.442}	{1.164}
	[0.454]	[0.681]
RHG[d]	-0.180	1.002**
Yes	(0.403)	(0.498)
No^	{0.835}	{2.724}**
	[0.654]	[0.045]
Constant	1.700***	1.352***
	(0.329)	(0.201)
	{5.472}***	{3.866}***
	[0.000]	[0.000]
Observations	315	833
Design based F-test	1.73	9.69***

[a] Homeowners Insurance
[b] ^ denotes a reference group
[c] Federal Flood Insurance
[d] Road Home Grant

Table 3.18 Weighted logistic regressions to predict a rebuilt/repaired home by perceived financial gap and received major financial assistance among the total (damaged) population and the subpopulations of blacks and non-blacks.

	Black		**Non-Black**	
	Model 18	**Model 20**	**Model 19**	**Model 21**
VARIABLES	**gap**	**gap + assistance**	**gap**	**gap+ assistance**
HI[a] Yes No^[d]		0.229[b] (0.522) [c] 1.257[e] [0.661] [f]		0.485 (0.560) 1.624 [0.386]
FFI[g] Yes No^		0.261 (0.539) 1.298 [0.629]		0.0208 (0.409) 1.021 [0.959]
RHG[h] Yes No^		-0.340 (0.475) 0.712 [0.475]		0.850 (0.531) 2.339 [0.110]
Gap[i] Yes No^	-1.895*** (0.510) 0.150*** [0.000]	-1.873***[j] (0.498) 0.154*** [0.000]	-1.530*** (0.333) 0.217*** [0.000]	-1.590*** (0.351) 0.204*** [0.000]
Constant	3.431*** (0.416) 30.900*** [0.000]	3.327*** (0.590) 27.843*** [0.000]	3.144*** (0.207) 23.206*** [0.000]	2.624*** (0.612) 13.794*** [0.000]
Observations	270	269	704	700
Design based F-tests	13.80***	3.74***	21.16***	6.31***

[a] Homeowners insurance
[b] beta coefficient
[c] (standard error)
[d] ^ denotes a reference group
[e] {odds ratio}
[f] [p value]
[g] Federal Flood Insurance
[h] Road home grant
[i] Financial gap
[j] *** p<0.01, ** p<0.05, * p<0.1

Table 3.19 Contingency table for Black and home recovery among the homeowners who perceived financial gap.

VARIABLES		Rebuilt/repaired		Total	Design based F-test	N
		No	Yes			
Black	No	16.6	83.4	100	0.0397	395
	Yes	17.72	82.28	100		
	Total	17.05	82.95	100		

Table 3.20 Weighted two-way cross tabulation of durations to start to rebuild and repair since the homes were damaged, on the characteristics of Black, family income, damage characteristics, number of replacement and addition, received financial assistance, and perceived financial gap.

VARIABLES		Duration [a] (Survival Time) Percentile 25th	50th	75th	Log-rank test [b]
Total (Months)		2	4	10	
Black	No	2	3	7	18.29***c
	Yes	3	6	16	[< 0.0005]
Family income	Top three quartiles	2	3	8	12.55***
	Bottom quartile	2	5	16	[< 0.0005]
Severely damaged	Not Demolished	2	4	8	22.58***
	Demolished	8	19	31	[< 0.0005]
Number of replacement/ addition	Top three quartiles	2	4	9	1.95
	Bottom quartile	2	3	11	[0.1630]
Any insurance/ financial assistance	No	2	7	33	50.93***
	Yes	2	3	8	[< 0.0005]
Homeowner insurance	No	3	7	32	78.33***
	Yes	2	3	7	[< 0.0005]
Flood Insurance	No	2	3	9	0. 23
	Yes	2	5	11	[0.630]
Road Home Grant	No	2	3	7	11.24***
	Yes	3	6	16	[< 0.0005]
Other Federal Assistance	No	2	4	10	1.37
	Yes	2	4	7	[0.242]
Other State assistance	No	2	4	9	1.88
	Yes	10	11	- d	[0.170]
Charitable Assistance	No	2	4	10	0.11
	Yes	2	4	6	[0. 742]
Any other Assistance	No	2	4	10	0.11
	Yes	2	3	11	[0.738]
Financial gap	Without assistance	2	8	40	91.50***
	Yes	3	6	19	[<0.0005]
	No	2	3	7	
Black (among who perceived financial gap	No	2	5	14	3.25*
	Yes	4	9	21	[0.071]

[a] Unit of analysis: month

---

[b] Log rank tests are employed to test equality of survivor functions for each covariate.
[c] *** p<0.01, ** p<0.05, * p<0.1
[d] Missing data is due to right censoring.

Table 3.21 Weighted two-way cross tabulation of durations to the completion of rebuilding and repairing since the homes were damaged, on the characteristics Black, family income, damage characteristics, number of replacement and additions, received financial assistance, and perceived financial gap.

VARIABLES		Duration [a] (Survival Time) Percentile			Log-rank test [b]
		25th	50th	75th	
Total (Months)		4	12	29	
Black	No	4	10	26	16.38***[c]
	Yes	7	20	40	[< 0.0005]
Family Income	Top three quartiles	4	11	28	10.45***
	Bottom quartile	5	16	40	[0.001]
Severely damaged	No	4	12	28	12.15***
	Yes	21	36	44	[0.0005]
Number of replacement/ addition	Top three quartiles	6	15	32	14.99***
	Bottom quartile	3	6	19	[< 0.0005]
Any insurance/ financial assistance	No	4	16	59	28.48***
	Yes	4	12	28	[< 0.0005]
Homeowner insurance	No	7	22	51	52.29***
	Yes	4	10	25	[< 0.0005]
Flood Insurance	No	4	9	28	11.96***
	Yes	12	20	36	[0.0005]
Road Home Grant	No	4	9	25	27.37***
	Yes	14	25	39	[< 0.0005]
Other Federal Assistance	No	4	12	29	0.35
	Yes	5	12	29	[0.557]
Other State assistance	No	4	12	29	2.31
	Yes	22	47	-[d]	[0.128]
Charitable Assistance	No	4	12	29	1.45
	Yes	9	25	44	[0.228]
Any other Assistance	No	4	12	29	0.13
	Yes	10	14	28	[0.718]
Financial gap	Without assistance	4	16	59	109.81***
	Yes	10	26	57	[< 0.0005]
	No	4	9	21	
Black (among who perceived financial gap)	No	8	26	54	0.66
	Yes	15	28	57	[0.414]

[a] Unit of analysis: month
[b] Log rank tests are employed to test equality of survivor functions for each covariate.
[c] *** p<0.01, ** p<0.05, * p<0.1
[d] Missing data is due to right censoring.

Table 3.22 A sequential weighted Cox regression models to estimate the hazard ratios to start to rebuild or repair a damaged home.

VARIABLES		**Model 22** **Black**	**Model 23** **severe damage**	**Model 24** **number of replace -ment**	**Model 25** **financial assistance**	**Model 26** **financial gap**
Black	Yes No ^[a]	-0.228[b]***[c] (0.065) {0.796}[d]*** [0.001]	-0.217*** (0.066) {0.805}*** [0.001]	-0.208*** (0.072) {0.813}*** [0.004]	-0.176** (0.069) {0.839}** [0.011]	-0.149** (0.066) {0.862}** [0.026]
Income		0.001*** (0.000) {1.001}*** [0.000]	0.001*** (0.000) {1.001}*** [0.000]	0.001*** (0.000) {1.001*** [0.000]	0.001*** (0.000) {1.001}*** [0.001]	0.001*** (0.000) {1.001}*** [0.005]
Severe Damage	Yes No^		-0.662*** (0.102) {0.516}*** [0.000]	-0.666*** (0.102) {0.514}*** [0.000]	-0.635*** (0.133) {0.530}*** [0.000]	-0.602*** (0.140) {0.548}*** [0.000]
Number of replacement/ additions [e]				-0.003 (0.005) {0.997} [0.555]	0.004 (0.006) {1.004} [0.513]	0.004 (0.005) {1.004} [0.414]
HI[f]	Yes No^				0.586*** (0.071) {1.798}*** [0.000]	0.323*** (0.081) {1.381}*** [0.000]
FFI[g]	Yes No^				-0.044 (0.073) {0.957} [0.549]	-0.064 (0.075) {0.938} [0.399]
RHG[h]	Yes No^				-0.137* (0.077) {0.872}* [0.077]	-0.218*** (0.080) {0.804}*** [0.007]
OFA[i]	Yes No^				0.111 (0.119) {1.117} [0.351]	0.039 (0.122) {1.040} [0.746]
OSA[j]	Yes No^				-0.631 (0.664) {0.532} [0.343]	-0.838 (0.626) {0.433} [0.181]

CPA[k]	Yes No^				0.128 (0.161) {1.137} [0.427]	0.243* (0.147) {1.275}* [0.099]
AOA[l]	Yes No^				0.258 (0.269) {1.294} [0.338]	0.136 (0.312) {1.145} [0.664]
Gap	Without assistance					-0.548*** (0.136) {0.578} [0.000]
	Yes					-0.440*** (0.084) {0.644}*** [0.000]
	No^					
Designed Based F-test		17.63***	20.56***	16.18***	12.55***	11.12***
Observations		1,144	1,144	1,144	1,144	1,144

[a] ^ denotes a reference group
[b] Beta coefficient
[c] *** p<0.01, ** p<0.05, * p<0.1
[d] {Hazard ratio}
[e] Cardinal variable
[f] Homeowner Insurance
[g] Federal Flood Insurance
[h] Road Home Grant Program
[i] Other federal assistance
[j] Other state assistance
[k] Charitable/private assistance
[l] Any other assistance

Table 3.23 A sequential weighted Cox regression models to estimate the hazard ratios to complete rebuilding and repairing a damaged home.

VARIABLES		Model 27 Black	Model 28 severe damage	Model 29 number of replace -ment	Model 30 financial assistance	Model 31 financial gap
Black	Yes No ^[a]	-0.242[b]***[c] (0.072) [d] {0.785}[e]*** [0.001] [f]	-0.232*** (0.072) {0.793}*** [0.001]	-0.143* (0.078) {0.867}* [0.067]	-0.094 (0.076) {0.911} [0.217]	-0.027 (0.068) {0.973} [0.691]
Income		0.001* (0.001) {1.001}* [0.070]	0.001* (0.001) {1.001}* [0.088]	0.001 (0.001) {1.001} [0.137]	0.001 (0.001) {1.001} [0.361]	0.000 (0.001) {1.000} [0.770]
Severe damage	Yes No^		-0.506*** (0.109) {0.603}*** [0.000]	-0.587*** (0.114) {0.556}*** [0.000]	-0.518*** (0.133) {0.595}*** [0.000]	-0.481*** (0.154) {0.618}*** [0.002]
Number of replacement/ addition[g]				-0.037*** (0.005) {0.964}*** [0.000]	-0.032*** (0.005) {0.969}*** [0.000]	-0.032*** (0.005) {0.968}*** [0.000]
HI[h]	Yes No^				0.556*** (0.083) {1.743}*** [0.000]	0.290*** (0.090) {1.336}*** [0.001]
FFI [i]	Yes No^				-0.159** (0.069) {0.853}** [0.022]	-0.163** (0.073) {0.849}** [0.025]
RHG[j]	Yes No ^				-0.123 (0.076) {0.884} [0.106]	-0.221*** (0.079) {0.802}*** [0.006]
OFA[k]	Yes No ^				0.154 (0.108) {1.167} [0.155]	0.078 (0.113) {1.081} [0.493]
OSA[l]	Yes No^				-0.394 (0.579) {0.674}	-0.668 (0.594) {0.513}

					[0.496]	[0.262]
CPA[m]	Yes No ^				-0.129 (0.152) {0.879} [0.397]	0.028 (0.119) {1.028} [0.815]
AOA[n]	Yes No^				-0.101 (0.221) {0.904} [0.649]	-0.232 (0.264) {0.793} [0.380]
Gap	Without Assistance					-0.626*** (0.148) {0.535} [0.000]
	Yes					-0.716 *** (0.094) {0.489}*** [0.000]
	No ^					
Design based F-test		9.24***	11.60***	20.66***	10.89***	12.72***
Observations		1,147	1,147	1,147	1,147	1,147

[a] ^ denotes a reference group
[b] Beta coefficient
[c] *** p<0.01, ** p<0.05, * p<0.1
[d] (Standard error)
[e] {Hazard ratio}
[f] [p value]
[g] Cardinal variable
[h] Homeowner Insurance
[i] Federal Flood Insurance
[j] Road Home Grant Program
[k] Other federal assistance
[l] Other state assistance
[m] Charitable/private assistance
[n] Any other assistance

Table 3.24 An auxiliary weighted multiple (linear) regression to estimate family (log) income by the identified characteristics of social vulnerability, damage characteristics, cost for rebuilding and repairing, financial assistance characteristics, and perceived financial gap.

VARIABLES		β [a]
Black	Yes No^ [b]	-0.518*** [c] (0.154) [d] [0.001] [e]
Severely damaged	Yes No ^	-0.570 (0.383) [0.137]
Number of Replacements/ Additions		-0.635 (0.277) [0.845]
Homeowners Insurance	Yes No ^	0.679** (0.296) [0.022]
Flood Insurance	Yes No ^	0.092 (0.208) [0.656]
Road Home Grant	Yes No	0.063 (0.176) [0.721]
Other Federal assistance	Yes No ^	0.093 (0.200) [0.638]
Other State assistance	Yes No ^	0.424 (0.508) [0.404]
Charitable assistance	Yes No ^	0.565 (0.386) [0.143]
Any other assistance	Yes No ^	0.602 (0.236) [0.011]
Financial gap	No ^ Without assistance	0.537 (0 .312) [0.985]
	Yes	-0.452*** (0.150) [0.003]

Constant		10.708*** (0.132)
		[0.000]
Observations		1,119
Design based F-test		5.94***
R-squared		0.058

[a] β stands for beta coefficient, log (odds)
[b] ^ denotes a reference group
[c] *** p<0.01, ** p<0.05, * p<0.1
[d] Standard error in parentheses were calculated with Taylor linearization estimation.
[e] [p-value]

Table 3.25 An auxiliary linear regression to estimate number of replacement/addition by Black, damage characteristics and family income.

VARIABLES		Number of replacement /additions
Black	Yes No^[c]	2.764[a]***[b] (0.653)[d] [0.000][e]
Family income		-0.002 (0.003) [.475]
Demolished2	Yes No^	-0.518 (1.013) [0.610]
Constant		5.689*** (0.534) [0.000]
Observations		1,147
R-squared		0.042
Design based F-test		7.62***

[a] Beta coefficient
[b] *** p<0.01, ** p<0.05, * p<0.1
[c] ^ denotes a reference group
[d] (Standard error)
[e] [p value]

Table 3.26 Two auxiliary logistic regressions to estimate receiving the financial assistance in forms of Federal Flood Insurance and Homeowner Insurance by number of replacement and addition, damage characteristics, income, and race.

VARIABLES		**FFI**[a]	**HI**[b]
# of Replacement/Addition		0.174[c]***[d]	-0.013
		(0.014)[e]	(0.012)
		{1.190}[f]***	{0.987}
		[0.000][g]	[0.254]
Demolished		1.247***	-0.612**
Yes		(0.417)	(0.307)
	No^[h]	{3.480}***	{0.543}**
		[0.003]	[0.046]
Income		0.002*	0.003**
		(0.001)	(0.001)
		{1.002}*	{1.003}**
		[0.072]	[0.035]
Black		-0.065	-0.227
Yes		(0.190)	(0.154)
		{0.937}	{0.797}
	No^	[0.733]	[0.141]
Constant		-2.797***	1.084***
		(0.171)	(0.139)
		{0.061}***	{2.957}***
		[0.000]	[0.000]
Observations		1,148	1,148
Design Based F-test		38.11***	3.77***

[a] Federal Flood Insurance
[b] Homeowner Insurance
[c] Beta coefficient
[d] p<0.01, ** p<0.05, * p<0.1
[e] (Standard error)
[f] {odds ratio)
g [*p* value]
[h] ^ denotes a reference group

APPENDIX B. FIGURES

Figure 1.1 Conceptual framework.

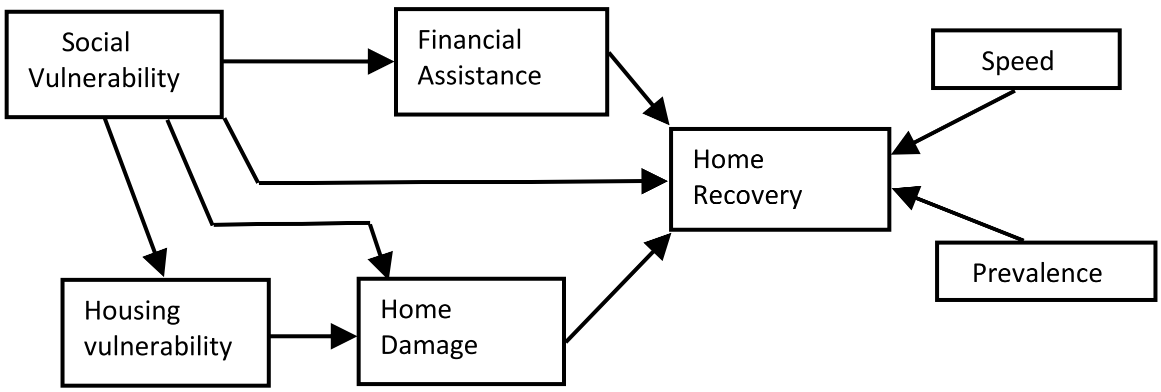


Figure 3.1 Kaplan-Meir estimates of the survivor functions for the event of starting to rebuild and repair, in overall (a), for race (b), income (c), and damage level (d).

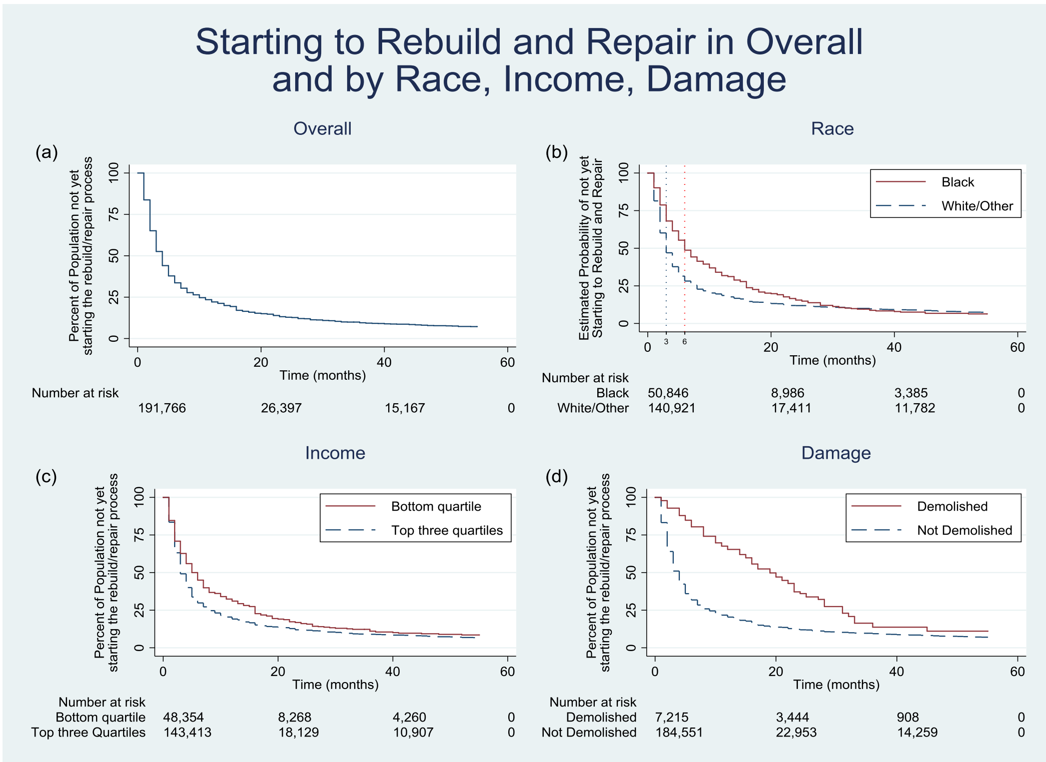


Figure 3.2 Kaplan-Meir estimates of the survivor functions for the event of starting to rebuild and repair, for number of replacement (a), and whether a homeowner received any financial assistance (b).

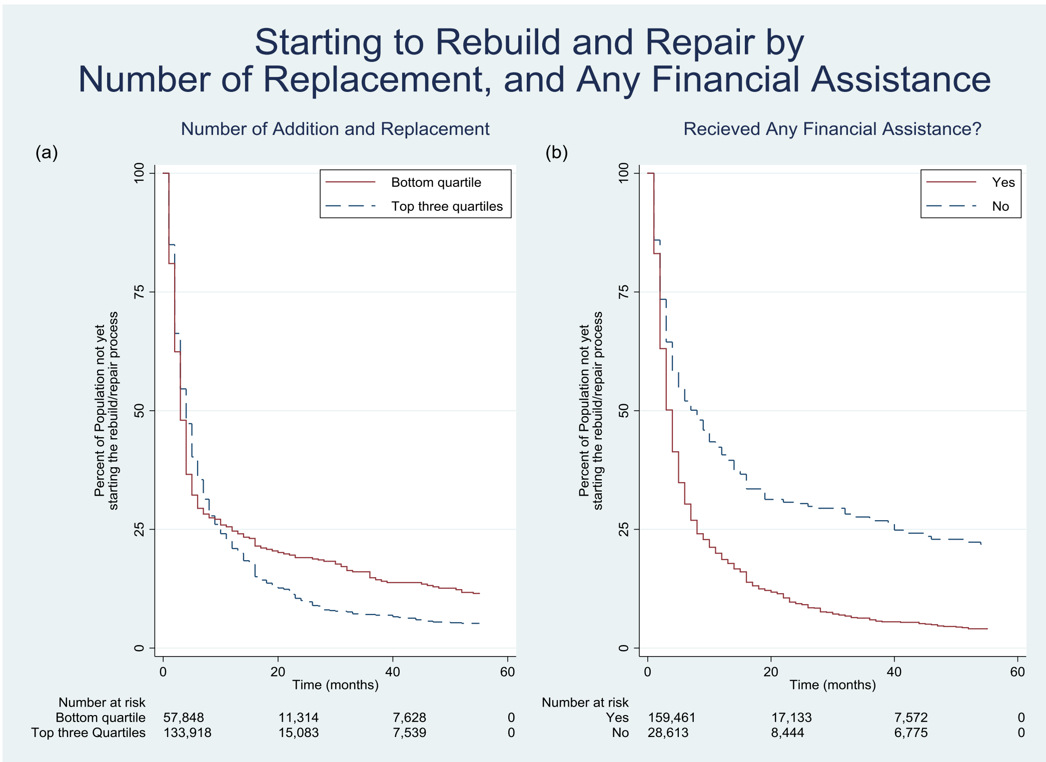


Figure 3.3 Kaplan-Meir estimates of the survivor functions for the event of starting to rebuild and repair, for whether a homeowner received Homeowner Insurance (a), Flood Insurance (b), Road Home Grant (c), and other federal assistance (d).

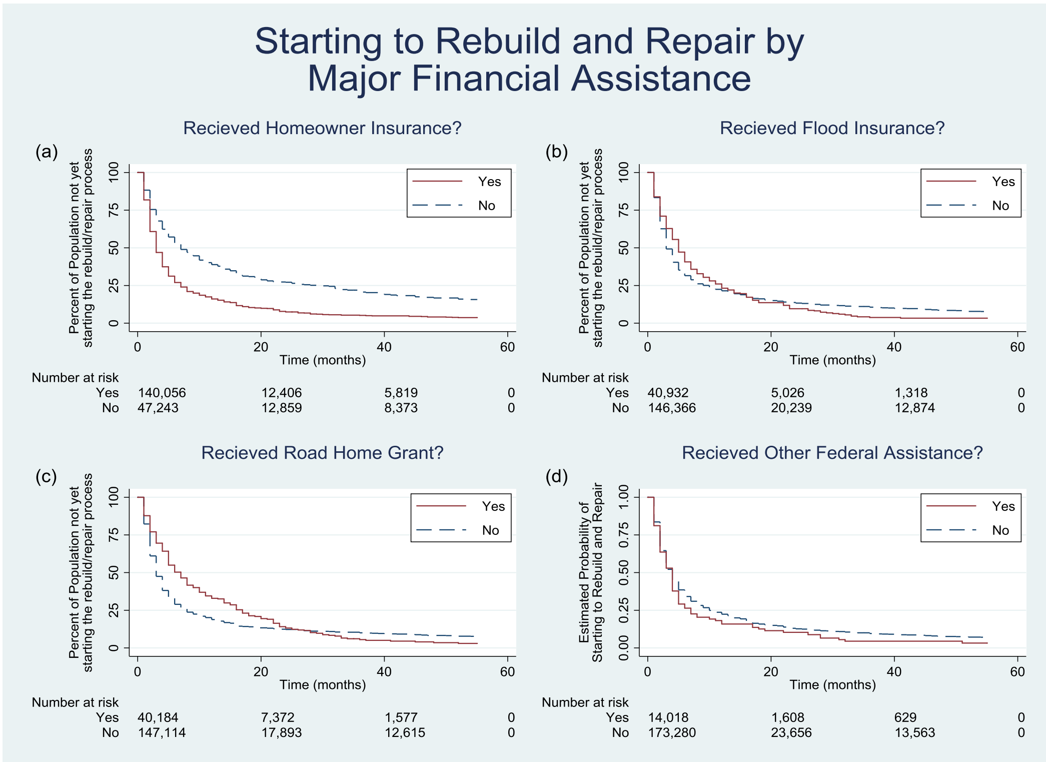


Figure 3.4 Kaplan-Meir estimates of survivor functions for the event of starting to rebuild and repair, for whether a homeowner received other State Assistance (a), charitable assistance (b), any other financial assistance (c), and whether a homeowner perceived financial gap (d).

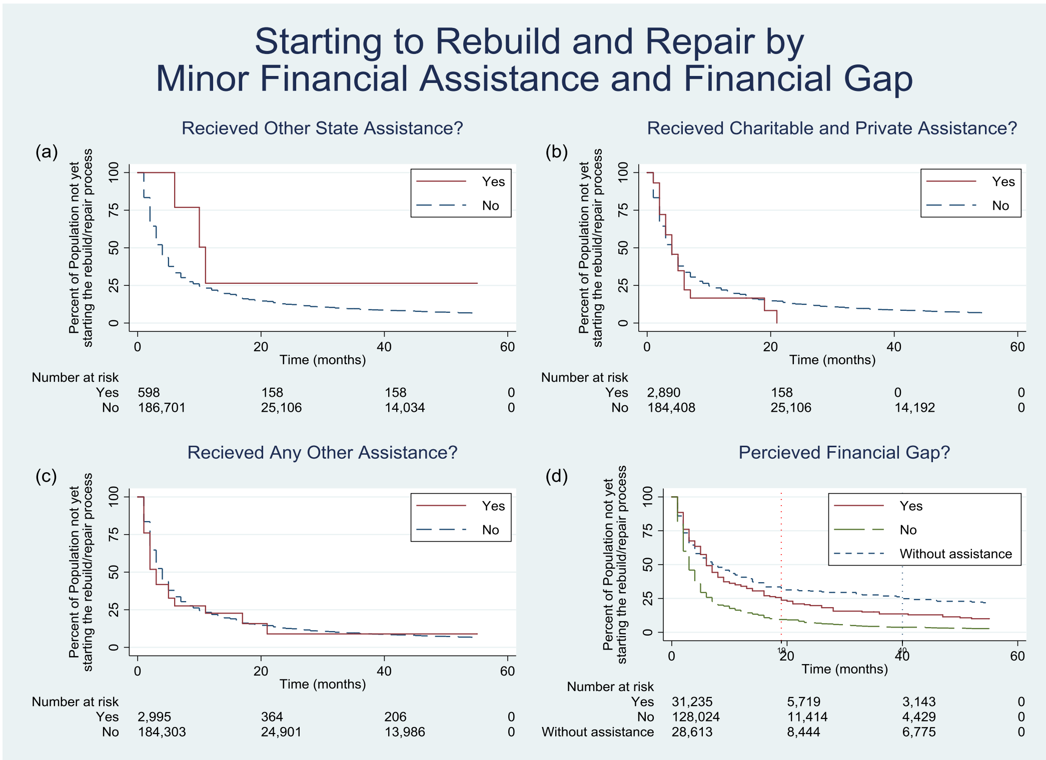


Figure 3.5 Kaplan-Meir estimates of the survivor functions for the event of completion of construction, in overall (a), and for race (b), income (c), and damage level (d).

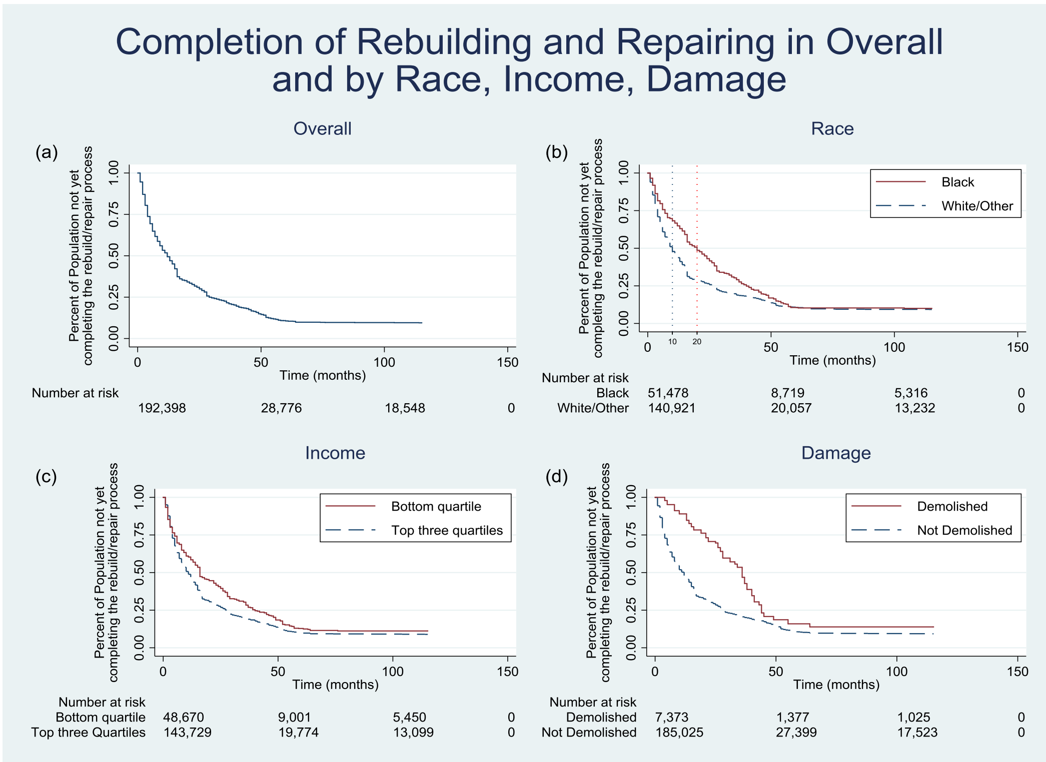


Figure3.6 Kaplan-Meir estimates of the survivor functions for the event of completion of construction, for number of replacement (a), and whether a homeowner received any financial assistance (b).

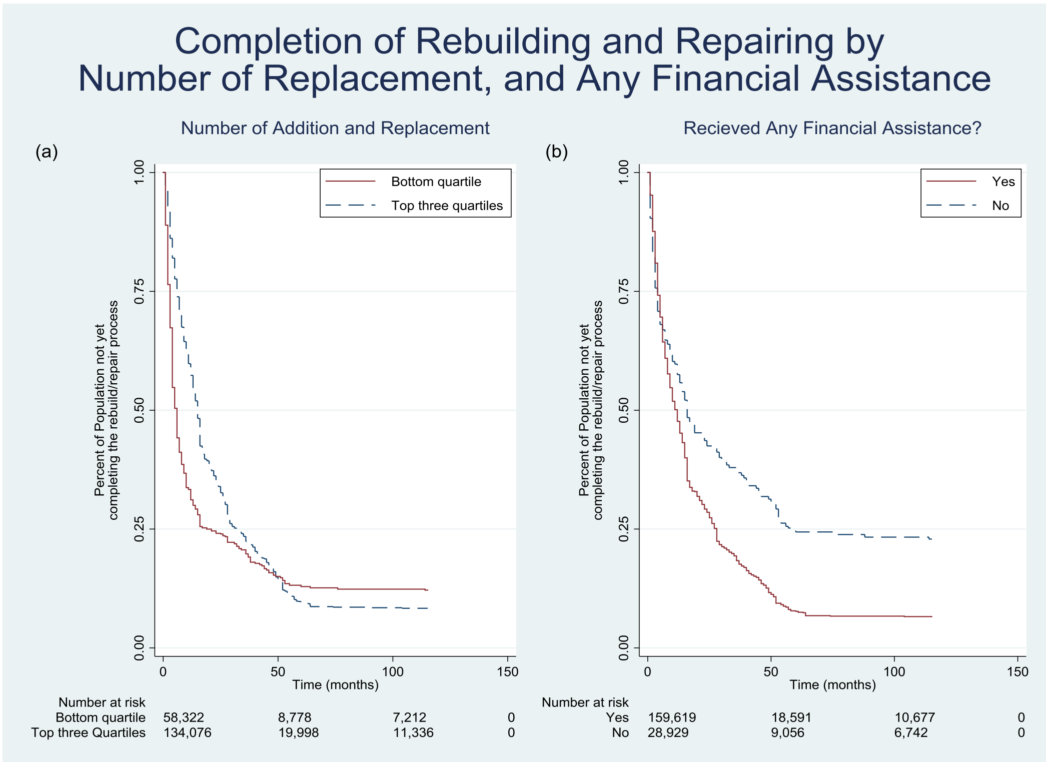


Figure 3.7 Kaplan-Meir estimates of the survivor functions for the event of completion of construction, for whether a homeowner received Homeowner Insurance (a), Flood Insurance (b), Road Home Grant (c), and other federal assistance (d).

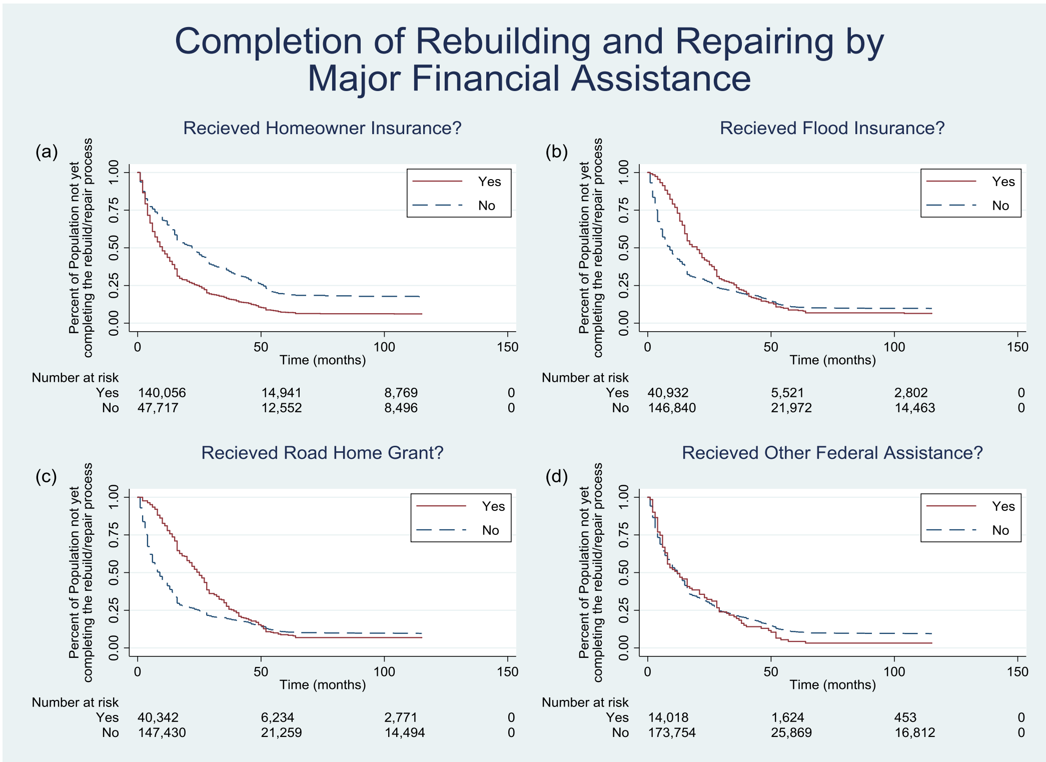


Figure3.8 Kaplan-Meir estimates of the survivor functions for the event of completion of construction, for whether a homeowner received other State Assistance (a), charitable assistance (b), any other financial assistance (c), and whether a homeowner perceived financial gap (d).

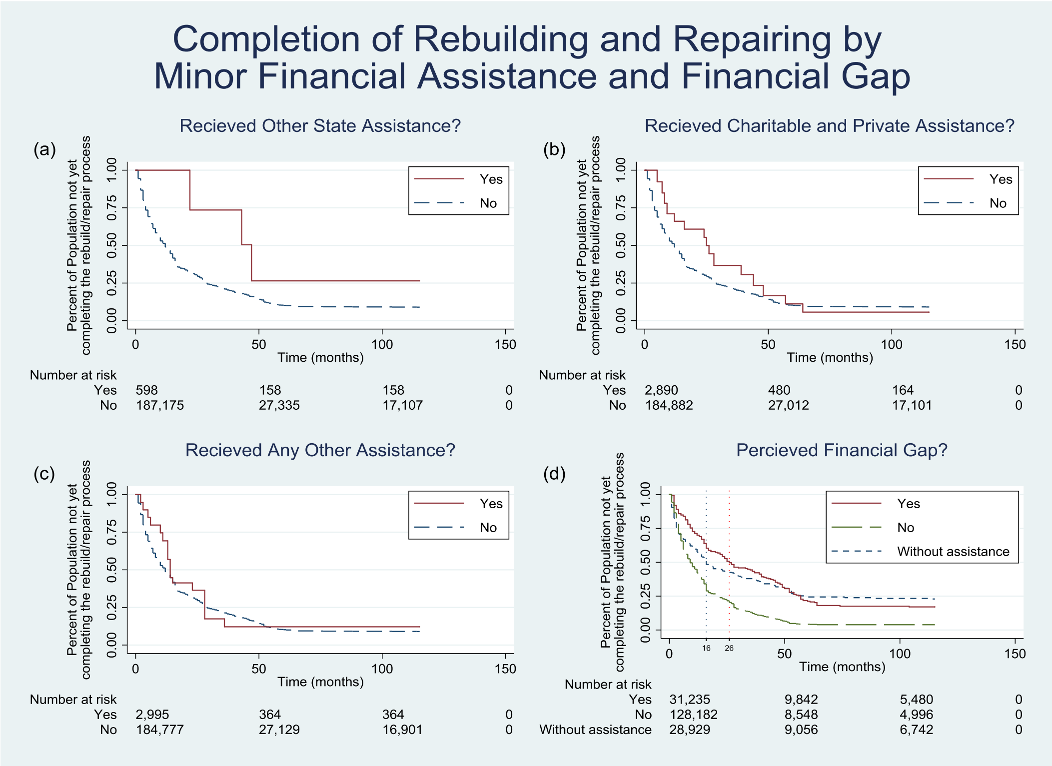


Figure 3.9 Testing Proportional hazard assumption for the starting model (Model 26).

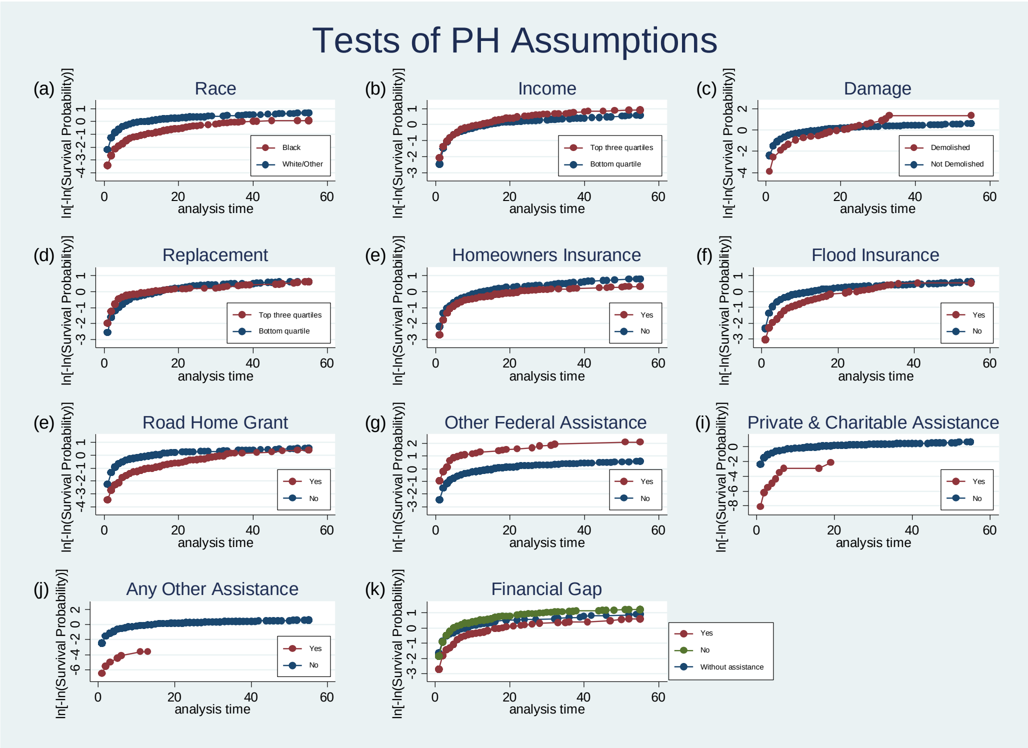
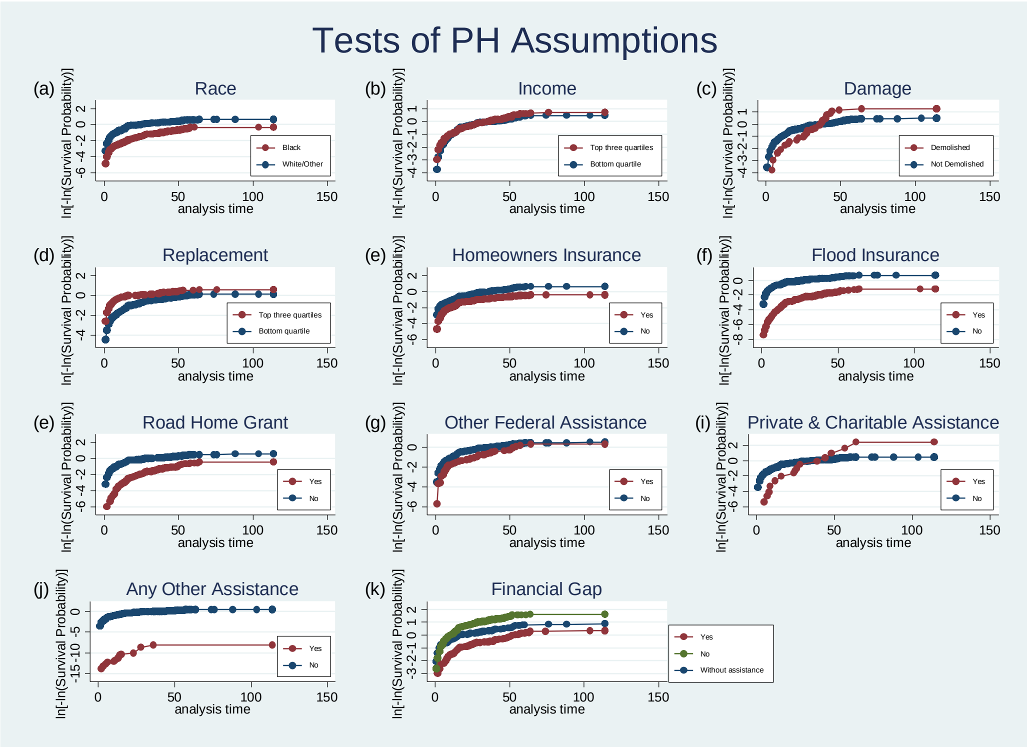


Figure 3.10 Testing proportional hazard assumption for completion model (Model 31).



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