Fleeing the Storm(s):
Evacuations during Florida's 2004 Hurricane Season

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ABSTRACT

The 2004 hurricane season was the worst in Florida's history, with four hurricanes causing at least 47 deaths and some $45 billion in damages. In order to collect information on the demographic impact of those hurricanes, we surveyed households throughout the state and in the local areas sustaining the greatest damage. Using these data, we estimated that one-quarter of Florida's population evacuated prior to at least one of the hurricanes; in some areas, well over half the residents evacuated at least once and many evacuated several times. Most evacuees stayed with family or friends and were away from home for only a few days. In this study, we summarize the results regarding the number of evacuees, types of lodging, and number of days spent away from home for the state and the regions hit hardest by the hurricanes. Using logistic regression analysis, we analyze the factors affecting evacuation decisions. With continued population growth in coastal areas and the apparent increase in hurricane intensity (and perhaps frequency) caused by global warming, the threat posed by hurricanes is increasing as well. We believe the results of the present study will help federal, state, and local officials deal more effectively with this threat.

INTRODUCTION

The years 2004 and 2005 produced two of the most destructive hurricane seasons in the history of the United States. Six hurricanes made landfall each year, compared to an average of 1.8 per year during the preceding century and a half (Blake, Jarrell, and Rappaport, 2006). More than half were category 3 or stronger, classifying them as major hurricanes. Three of the 2004 hurricanes were among the ten costliest since 1900, in terms of the real dollar value of damages (Ibid). Three of the 2005 hurricanes were among the ten most intense ever recorded, based on central pressure (National Weather Service, 2006). Hurricane Katrina—which crossed the southern tip of Florida in August, 2005 as a category 1 storm before strengthening to a category 5 and eventually striking Louisiana and Mississippi as a category 3—was by far the most costly hurricane in U.S. history and one of the five deadliest (Ibid).

The number and intensity of these hurricanes—combined with rapid population growth in coastal areas and concerns about the impact of global warming on future hurricane activity—have focused attention on the importance of dealing effectively with hurricane-related safety issues. One of the most critical issues is the evacuation of residents from vulnerable areas prior to the arrival of a hurricane. Graphic television images and gripping news stories in the aftermath of Hurricane Katrina heightened public awareness of the deadly effects of failing to implement sound evacuation procedures.

The development of such procedures requires a clear understanding of the likely evacuation behavior of people living in hurricane-prone areas and how that behavior varies according to their perceptions of the hurricane threat and their personal and household characteristics. A substantial literature on this topic has emerged over the last

few decades (e.g., Baker, 1979; Drabek, 1986; Fothergill, 1996; Lindell, Lu, and Prater, 2005). In this study, we add to that literature by analyzing evacuation behavior in Florida during the 2004 hurricane season. Using data collected through sample surveys, we estimate the number and characteristics of evacuees, the types of lodging they used, and the length of time they were away from home. For those who did not evacuate, we investigate the reasons why. We use logistic regression analysis to determine the factors affecting evacuation decisions.

The data set analyzed in this study is unique in that it covers the effects of multiple hurricanes striking a variety of locations within a short period of time. We believe our findings not only document evacuation behavior during one of the worst hurricane seasons in history, but also provide information that will help federal, state, and local officials develop more effective evacuation plans for dealing with future hurricanes.

DATA

Four hurricanes blasted through Florida between August 13 and September 25, 2004, with Charley making landfall on the southwest coast near Punta Gorda, Frances on the southeast coast near Stuart, Ivan in the panhandle near Pensacola, and Jeanne nearly retracing the route followed by Frances (see Figure 1). This was the first time in recorded history that four hurricanes had struck Florida in a single year. Most parts of the state were hit by at least one hurricane and some were hit by two or even three. Overall, the storms were directly responsible for at least 47 deaths (National Hurricane Center, 2005) and caused some $45 billion in damages (Blake, et al., 2006).

(Figure 1 about here)

Unfortunately, there are no readily available data sources capable of providing comprehensive information on the demographic and socioeconomic effects of hurricanes and other natural disasters (e.g., Friesema, Caporaso, Goldstein, Lineberry, and McCleary, 1979; Rossi, Wright, Wright, and Webber-Burdin, 1981; Smith and McCarty, 1996). To remedy this problem, the Bureau of Economic and Business Research (BEBR) at the University of Florida conducted a series of household surveys at the state and local levels in Florida. These surveys collected data on evacuations, housing damage, population displacement, reconstruction, and recovery. In this study, we focus on evacuations prior to the arrival of each hurricane.

At the state level, BEBR used list-assisted random-digit dialing to contact approximately 500 households each month between February and May, 2005. Using a database maintained by the Marketing Systems Group/GENESYS of Ft. Washington, Pennsylvania, we identified working telephone banks with at least one residential number (a bank consists of the area code, prefix, and first digit of the suffix). The database excluded banks that had not been assigned or that had been assigned exclusively to commercial or government entities. It also excluded banks associated with cell phone numbers because cell phones typically represent individuals rather than households.

Random digits were added to the partial numbers in the banks and the resulting telephone numbers were called. The household member aged 18 or older who most recently had a birthday was selected to be the survey respondent. Only those who reported that they were permanent residents living in Florida when the first of the hurricanes struck in August, 2004 were included in the sample. This process led to 1,881 completed interviews at the state level.

We do not believe that excluding cell phone numbers had much impact on the representativeness of the sample because most households (including those with cell phone users) have a landline telephone. A recent survey found that households with a cell phone but no landline telephone accounted for less than 4% of all households in the United States in 2003 (Blumberg, Luke, & Cynamon, 2005).

We also conducted surveys in the local areas sustaining the greatest hurricane damage. Using data from the Federal Emergency Management Agency (FEMA), we selected the 13 counties with the highest proportion of housing units sustaining major damage. Samples were drawn at the subcounty level in ten counties and at the county level in three counties, with a target sample size of 400 in each county or subcounty area. For 16 municipalities in the survey area, we used a combination of listed telephone numbers and random-digit dialing; for the three entire counties and all other subcounty areas, we relied solely on random-digit dialing. These surveys were conducted between March and June, 2005 and produced 11,559 completed interviews.

The local surveys were funded by the Florida Legislature and were designed not only to provide information on the demographic impact of the hurricanes, but also to assist in the production of city and county population estimates. In this paper, we combine cities and counties into five geographic regions based on their proximity to the paths followed by the hurricanes (see Table 1). In order to make the sample representative of each region's population, survey data for each city and county were weighted according to their share of the region's households in 2004. We excluded interviews with respondents who were not permanent residents in August, 2004 or who lived in two counties that did not fit into any of the five regions; this reduced the sample

to 9,048 completed interviews. All the results reported in this study have a margin of error of no more than 3% at the state level and 5% at the regional level. For measures that exhibit low levels of variability, the errors are much smaller.

(Table 1 about here)

Table 2 summarizes the demographic characteristics of each region. The Southeast (SE) region has an older population than the state as a whole and has lower proportions black and Hispanic. Its median income is slightly above the state average but its educational level is slightly lower. The Central region is similar to the state in terms of age, race, and ethnicity, but has lower income and educational levels. The Southwest (SW) region is slightly younger than the state as a whole and has a relatively small proportion black, but has a high proportion Hispanic and very low income and educational levels. Charlotte County has a large elderly population and low proportions black and Hispanic. Its income and educational levels are a bit below the state average but its poverty rate is substantially lower. The Northwest (NW) region is slightly younger and has a lower proportion Hispanic than the state as a whole, but is similar to the state on the other characteristics. Mobile homes account for a very large proportion of the housing stock in the Central and SW regions; in the other regions, the proportions are similar to the state average.

(Table 2 about here)

The SE region was affected primarily by Hurricanes Frances and Jeanne. The Central region was affected by Charley, Frances, and Jeanne, but was somewhat protected by its inland location. Charlotte County and the SW region were affected primarily by Charley, but Frances and Jeanne had an impact as well. The NW region was

significantly affected only by Ivan. Charley was a category 4 hurricane when it made landfall, Ivan and Jeanne were category 3, and Frances was category 2 (Blake, et al., 2006).

EVACUATION CHARACTERISTICS

With the advent of the Internet, talk radio, and 24/7 news channels, hurricanes can no longer sneak up on an unwary public. The likely path of a hurricane is known several days prior to its arrival, giving people ample opportunity to evacuate from potentially unsafe locations in search of safer ones. Not all do so, of course. Just over one in four survey respondents at the state level evacuated from their homes prior to at least one hurricane (Table 3). Almost 14% evacuated once, 6% evacuated twice, 2% evacuated three times, and 3% reported that they evacuated prior to all four hurricanes. Given Florida's estimated population of 17.6 million in August, 2004, this implies that almost 4.5 million Floridians evacuated at least once.

(Table 3 about here)

There were substantial variations among the five regions. The SE region had the highest proportion evacuating at least once (53%) and by far the highest proportion evacuating exactly twice (31%). This occurred because the SE region lay directly in the path of two hurricanes (Francis and Jeanne). The Central region had the lowest proportion evacuating at least once (29%), even though it lay in the path of three hurricanes. This most likely occurred because the Central region is comprised of inland counties that are less vulnerable to hurricane damage than coastal counties. Ironically, this region also had a relatively high proportion of residents evacuating three or even four

times. The NW region had 44% evacuating at least once, with very few evacuating more than once. This occurred because only one hurricane directly threatened this region.

The SW region had the highest proportions evacuating three or four times. This region was hit by three hurricanes and sustained especially heavy damages from Charley, the first of the four hurricanes to strike the state. These heavy damages—combined with the large number of hurricanes passing through the region—may have caused residents to be particularly sensitive to hurricane threats.

The results for Charlotte are particularly interesting because this region had a relatively low proportion evacuating at least once (36%) even though it is a coastal county that lay directly in the path of Charley, the strongest of the four hurricanes. We offer an explanation for this finding later in the paper.

It is likely that the type of housing unit people live in influences their evacuation decisions. In particular, people are more likely to evacuate from mobile homes than from single family or multifamily units because of structural differences affecting the safety of the inhabitants. Indeed, many studies have found evacuation rates to be particularly high for residents of mobile homes (e.g., Baker, 1979, 1991; Bateman and Edwards, 2002; Drabek, 1986; Wilmot and Mei, 2004).

Table 4 shows the proportions evacuating at least once by type of housing unit for the state and each region. In every instance, proportions were substantially higher for residents of mobile homes than for residents of other types of housing. Single family units generally had lower proportions evacuating than multi-family and other units, but the differences were generally small.

(Table 4 about here)

We also examined the destinations of evacuees and the number of nights they were away from home (for respondents who evacuated more than once, we treated each evacuation as an independent event). As shown in Table 5, the majority of evacuees stayed with family or friends. This result was found for the state and all five regions, with regional proportions ranging from 57% to 63%. A high proportion staying with family or friends is a common finding in the disaster literature (e.g., Blendon, et al., 2006; Drabek, 1986; Whitehead, Edwards, Van Willigen, Maiolo, Wilson, and Smith, 2000).

(Table 5 about here)

At the state level, the proportions staying in hotels/motels and public shelters were similar to those reported elsewhere (Blendon, et al., 2006; Whitehead, et al., 2000). However, there was substantial variation from one region to another. The SW region had the highest proportion staying in public shelters (11%) and the lowest proportion staying in hotels or motels (7%). This may have been caused by the lack of hotel and motel facilities in this sparsely populated rural area, but a more likely explanation is the low incomes of many of its residents; per capita incomes in this region are among the lowest in the state and poverty rates are among the highest. Conversely, Charlotte had the lowest proportion staying in public shelters (3%) and the highest proportion staying in hotels or motels (25%). Although the median income of this county is slightly lower than for the state as a whole, its poverty rate is substantially lower.

At the state level, more than half of the evacuations lasted only one or two nights, 88% lasted less than a week, 10% lasted for one to two weeks, and 2% lasted for two weeks or more (Table 6). The long stays for some evacuees were due to housing

damages caused by the hurricanes, making it impossible to return to their homes before making extensive repairs. When respondents reporting housing damage were omitted from the sample, 92% were away for less than a week and less than 0.5% were away for two weeks or more (not shown here).

(Table 6 about here)

Length of evacuation varied considerably among the regions. The SE region had the lowest proportion away for only one or two days, most likely because it had a very high proportion evacuating two or more times. It also had a relatively low proportion away for two weeks or more, most likely because of relatively low levels of hurricane damage, compared to other regions. The Central region had the highest proportion with short stays (81% for four days or less) and the lowest proportion with long stays (5% for four 14 days or more). This was most likely due to the relatively low level of damage in the region. The SW, Charlotte, and NW regions had the highest proportions away for two weeks or more. This was most likely caused by the relatively high level of damage in those three regions.

Why did some people evacuate while others did not? To answer this question, we conducted follow-up surveys in Charlotte and Escambia, two counties with relatively heavy damage but relatively low evacuation rates. Charlotte is located on the Gulf Coast some 80 miles south of Tampa; Escambia is located at the western tip of the Florida Panhandle. We called all respondents who reported in the original survey that they did not evacuate before any of the hurricanes. In the follow-up survey, we asked respondents the main reason they did not evacuate. The results are shown in Table 7.

(Table 7 about here)

Over half of the non-evacuees in Escambia reported that they thought they could ride out the hurricane without compromising their safety. This is somewhat surprising, given the strength of Hurricane Ivan and the widespread publicity regarding the damages caused by previous hurricanes. However, it is consistent with the results of numerous studies that have found that the primary reason for not evacuating is the belief that a hurricane is not a serious threat or that the current location is safe (e.g., Perry and Lindell, 1991; Riad, Norris, and Ruback, 1999; Whitehead, et al., 2000). Others did not evacuate because they were concerned about leaving pets behind (8%) and houses unattended (8%). Almost 7% cited job responsibilities and 4% cited medical conditions. The relatively low proportion citing the last four reasons is consistent with the results of previous studies (e.g., Riad, et al., 1999).

In Charlotte, 27% of the respondents did not evacuate because they thought they could ride out the hurricane. Almost as many (26%) believed the storm would hit elsewhere. The high proportion believing the storm would hit elsewhere was most likely due to the fact that the storm had initially been predicted to make landfall near Tampa, well to the north of Charlotte County. A sudden shift in the path of the storm apparently caught many residents by surprise, as 4% of the respondents reported that they did not know the hurricane was coming and 5% reported that they did not have enough time to evacuate. These results help explain the relatively low evacuation rates for Charlotte shown in Tables 3 and 4.

About 6% of the respondents in Charlotte cited concerns about leaving pets and houses unattended, 4% cited medical conditions, and 3% cited job responsibilities. These

results are generally similar to those reported in Escambia, although the proportion citing job responsibilities is lower in Charlotte because of its large number of retirees.

These results illustrate the difficulties emergency management officials face when developing hurricane evacuation plans. Many residents simply do not take hurricanes seriously, even when they are directly in the path of a storm and when severe damages have occurred elsewhere. Others are concerned about pets or leaving homes unattended. Some have jobs or medical conditions that impede their ability to evacuate. Clearly, the development and implementation of a successful evacuation plan requires strategies for dealing effectively with these concerns.

The results for Charlotte also illustrate the importance of providing the public with good information regarding the likely path of a hurricane. A substantial proportion of respondents reported that they thought the storm was going to miss them; when they learned otherwise, they did not have enough time to evacuate. We believe hurricane warnings should emphasize the broad areas that are likely to be affected rather than focusing on exact points of landfall.

It is notable that only a small proportion of respondents reported that they failed to evacuate because they had no transportation or no place to go. This is consistent with some previous research (e.g., Baker, 1991), but stands in contrast to media reports regarding Hurricane Katrina. A recent national survey found that almost 30% of respondents reported that they would be unable to evacuate without assistance if faced with an impending natural disaster; of these, 26% (or 8% of all respondents) cited the lack of transportation as the primary factor (Lui, Dixon, and Leondar-Wright, 2006). Further research on this issue is clearly needed.

The occurrence of multiple hurricanes within a six week period provides an opportunity to observe patterns of evacuation behavior from one hurricane to the next. Although Charlotte was affected primarily by Charley and the NW region solely by Ivan, the other three regions were affected two or even three hurricanes. For each of these regions, we tabulated evacuation behavior for the second hurricane striking the area by evacuation behavior for the first hurricane to do so. The results are shown in Table 8.

(Table 8 about here)

Several patterns stand out. In each region, the majority of those who evacuated for the first hurricane also evacuated for the second, with proportions ranging from 53% in the SW region to 80% in the SE region. Furthermore, very few who failed to evacuate for the first hurricane chose to evacuate for the second, with proportions ranging only from 6% to 12%. Apparently, the characteristics or circumstances that caused people to evacuate (or not evacuate) for the first hurricane generally caused them to repeat their behavior for the second.

We can also observe the effect of damages from one hurricane on evacuation behavior for the second. Table 9 shows evacuation behavior for the second hurricane striking the area by the level of housing damage sustained in the first. In all three regions, evacuation rates for the second hurricane rose with the level of damage sustained in the first. Since the level of housing damage is at least somewhat random among individuals within a given region, these results suggest that damages sustained during one hurricane led to a greater probability of evacuating for the following hurricane, other things being equal.

(Table 9 about here)

FACTORS AFFECTING EVACUATION BEHAVIOR

Evacuation behavior in the face of natural and man-made disasters is determined by the physical risks disasters pose and how people perceive and respond to those risks, given their personal characteristics and circumstances. We have identified a number of variables that the literature suggests may affect evacuation behavior. Three reflect physical risks, four reflect household characteristics, and seven reflect demographic characteristics. Given the limitations of our data set, we do not consider potentially important factors such as transportation difficulties (e.g., Dow and Cutter, 2002), sources of information (e.g., Lindell, Lu, and Prater, 2005), and whether or not official evacuation orders were given (e.g., Wilmot and Mei, 2004).

Physical Risks

The severity of the storm and its location relative to one's place of residence are two of the most important physical risks posed by hurricanes. Not surprisingly, a number of studies have found these factors to be among the most important determinants of evacuation behavior: the stronger the storm and the closer its proximity, the higher the probability of evacuating (e.g., Baker, 1991; Bateman and Edwards, 2002; Dow and Cutter, 2002; Lindell, et al., 2005).

The degree of safety provided by a housing unit also affects physical risks. Due to the nature of their construction, mobile homes are more likely to suffer storm damage than other types of housing units (e.g., Gillespie, 1991; Smith and McCarty, 2006). Table 4 showed residents of mobile homes to be substantially more likely to evacuate than other residents. Many other studies have reported similar results (e.g., Baker, 1979, 1991; Bateman and Edwards, 2002; Drabek, 1986; Wilmot and Mei, 2004).

Household Characteristics

Families tend to evacuate as a unit; typically, all members evacuate or none do (e.g., Drabek, 1986; Perry, 1979; Perry and Lindell, 1991). Consequently, it is easier (i.e., less complicated and less costly) for small households to evacuate than large households. Several empirical studies have found evacuation rates to decline as household size increases (e.g., Gladwin and Peacock, 1997) or as the number of adults in the household increases (e.g., Bateman and Edwards, 2002).

Households with children may be more likely to evacuate because of concerns about child safety and perhaps because women—who are often found to have higher evacuation rates than men—generally play the predominant role in decision making as it relates to children. Some studies have found the presence of children in a household to raise evacuation rates (e.g., Gladwin and Peacock, 1997; Lindell, et al., 2005) but others have not (e.g., Bateman and Edwards, 2002).

Households containing elderly members may be less likely to evacuate because mobility limitations are more common among older persons and perhaps because social isolation makes older persons less knowledgeable about storm threats. Several studies have found the presence of older persons in a household to reduce evacuation rates (e.g., Drabek, 1986; Gladwin and Peacock, 1997; Perry, 1979).

Homeowners may be less likely to evacuate than renters because they have more sunk costs in their homes, making them more concerned about protecting their property against storm damage and looters. Some studies have found empirical evidence supporting this hypothesis (e.g., Riad, et al., 1999) but others have not (e.g., Zhang, et al., 2004).

Personal Characteristics

Many studies have analyzed the impact of personal characteristics on evacuation behavior. The empirical results have been mixed: fairly consistent results have been found for some characteristics but not for others. Age, sex, race, ethnicity, income, education, and experience with previous disasters have been the characteristics most often studied.

A number of studies have found older adults to have lower evacuation rates than younger adults (e.g., Drabek, 1986; Gladwin and Peacock, 1997; Wilmot and Mei, 2004). The most likely explanation for this finding is that physical impairments and medical conditions increase with age and create mobility limitations. It has also been hypothesized that older persons may have less psychological vulnerability to disasters than younger persons because of their greater life experience, previous disaster exposure, and lower level of obligations and responsibilities (Ngo, 2001). Some studies, however, have found no significant differences in evacuation rates by age (e.g., Zhang, et al., 2004).

A number of studies have found evacuation rates to be higher for women than men (e.g., Bateman and Edwards, 2002; Drabek, 1986; Riad, et al., 1999; Whitehead, et al., 2000). Possible explanations include greater vulnerability of women due to social inequality and lack of mobility, a greater awareness of warnings because of wider social networks, and a tendency to perceive disaster events as more serious and risky than men do, especially if they threaten family members (Fothergill, 1996). Again, not all studies have found significant differences in evacuation rates between men and women (e.g., Zhang, et al., 2004).

Reasons for expecting differences in evacuation rates among racial and ethnic groups include differences in feelings of fatalism and risk perception, preparedness behavior (e.g., stocking emergency supplies, planning evacuation routes), language difficulties, social and family networks, the confidence placed in various sources of information, and the economic resources needed to evacuate successfully (Fothergill, Maestas, and Darlington, 1999). These factors would generally tend to reduce evacuation rates for racial and ethnic minorities. However, the empirical evidence on this effect has been mixed. Some studies have found lower evacuation rates for racial and ethnic minorities (e.g., Gladwin and Peacock, 1997), some have found lower rates for some minorities but not for others (e.g., Riad, et al., 1999), and some have found no significant differences (e.g., Bateman and Edwards, 2004).

A number of studies have investigated differences in evacuation rates by income and education. Higher incomes might be expected to raise the probability of evacuating by providing the resources needed to do so and higher educational levels might be expected to raise the probability of evacuating by improving the ability to gather relevant information and formulate effective evacuation plans. However, empirical studies have generally found the effects of these two variables to be small and/or statistically insignificant (e.g., Bateman and Edwards, 2002; Gladwin and Peacock, 1997; Whitehead, et al., 2000).

A final characteristic that might affect evacuation behavior is one's personal experience with previous hurricanes. However, it is not clear what the impact of personal experience might be. It may make some people more likely to evacuate by raising their awareness of hurricane risks and the nature of the evacuation process; it may make others

less likely to evacuate by imparting a sense of security from having made it safely through previous hurricanes. The empirical evidence for this variable is mixed: some studies have reported positive effects; some, negative effects; and some, no effect at all (e.g., Baker, 1991; Riad, et al., 1999; Gladwin and Peacock, 1997).

LOGISTIC REGRESSION ANALYSES

We used logistic regression analysis to investigate the determinants of evacuation behavior in Florida. This technique is well-suited for this purpose because of the dichotomous nature of the evacuation process (see DeMaris, 2004, for a discussion of binary dependent variables and the use of logistic regression models). Logistic regression models have been used to analyze hurricane evacuation behavior by Bateman and Edwards (2002), Gladwin and Peacock (1997), Whitehead, et al. (2000), Wilmot and Mei (2004), and others.

Choice of Variables

The dependent variable in our initial set of regressions was coded 1 if the respondent evacuated at least once during the 2004 hurricane season and 0 otherwise. We developed a number of explanatory variables based on the literature cited above.

The severity and location of the storm are two of the most important measures of the physical risks posed by hurricanes. We constructed a variable combining these two measures using information on the intensity and location of each hurricane passing through Florida in 2004. This variable ("storm strength") was coded 0-4 based on the severity of the strongest storm hitting each respondent's county of residence and the distance of that county from the point of landfall. We expect storm strength to have a positive impact on the probability of evacuating.

Some places were largely unaffected by any of the hurricanes striking Florida in 2004, while others were affected by two or even three. Using the information shown in Figure 1, we constructed a variable measuring the number of hurricanes passing through each county in 2004. This variable was coded 0-3 for each respondent, depending on the number of hurricanes passing through their county of residence. We expect the number of hurricanes to have a positive impact on the probability of evacuating at least once. The classification of counties regarding storm strength and number of hurricanes is shown in Appendix A.

Many studies have found living in a mobile home to substantially raise the probability of evacuating. We expect the same will be true in the present study.

We developed four measures of household characteristics. Household size is the number of residents living in the household at the time of the hurricanes. Two are 0-1 variables coded 1 if a household contained a member younger than age 18 or age 65 and older, respectively. The final household variable was coded 1 if the housing unit was owner-occupied and 0 otherwise. We expect the presence of children younger than age 18 to have a positive effect on the probability of evacuating and the other three variables to have negative effects.

We included six measures of personal characteristics. Three were coded 1 if the respondent was female, black, or Hispanic, respectively, and 0 otherwise. Income (measured in thousands of dollars) and education (measured in years of school completed) were coded according to numerical responses. We did not include age as an explanatory variable because two of the household variables picked up age effects. Based on theoretical considerations and our survey of the literature, we expect black and

Hispanic to have negative effects on the probability of evacuating and female, income, and education to have positive effects. Given the results of previous studies, however, there is a good chance all these effects except female will be statistically insignificant.

Finally, we used years lived in Florida as a proxy for previous hurricane experience. We hypothesize that this variable will have a negative effect on the probability of evacuating. Again, given the empirical evidence (e.g., Baker, 1991; Riad, et al., 1999; Zhang, et al., 2004), we are not confident that this effect will be statistically significant.

State Level Analyses

We began by analyzing evacuation behavior at the state level. We ran a series of bivariate logistic regression models in order to investigate the uncontrolled relationship between each explanatory variable and the probability of evacuating at least once during the 2004 hurricane season. The results are shown in Table 10. The odds ratio shows the proportion by which the probability of evacuating increases (or declines) with a one unit increase in the value of the explanatory variable. Ratios above one reflect increases and ratios below one reflect declines.

(Table 10 about here)

The strength and number of hurricanes each had a strong positive effect on the probability of evacuating. Living in a mobile home had an even stronger positive effect. Household size and being a homeowner had the expected negative effects, but only household size was significant. Neither of the two age variables was significant, but women were found to be significantly more likely to evacuate than men. Blacks and Hispanics were less likely to evacuate than non-Hispanic whites, but the effect was

significant only for Hispanics. Contrary to expectations, income and education had negative effects on the probability of evacuating, but they were small and were statistically significant only for income. Years lived in Florida had a negative but insignificant effect.

Bivariate regressions do not account for interactions among the independent variables, of course. Consequently, some of the statistical relationships shown in Table 10 may be spurious, leading to false inferences regarding the determinants of evacuation behavior. To deal with this problem, we constructed a multivariate model using the same explanatory variables. The results are shown in Table 11.

(Table 11 about here)

Both the strength and number of hurricanes retained their positive signs, but only strength remained statistically significant. It appears that it is the severity and proximity of hurricanes, rather than their frequency, which has the larger impact on the probability of evacuating. Housing type had a significant and substantial impact on evacuation behavior: other things being equal, people living in mobile homes were six times more likely to evacuate than people living in other types of housing. Household size and homeownership had marginally significant negative effects on evacuation rates. The presence of a person less than age 18 significantly raised the probability of evacuating, while the presence of a person age 65 and older had a negative but insignificant effect. Women were more likely to evacuate than men and Hispanics were less likely to evacuate than non-Hispanics, but all the other demographic variables had insignificant effects.

Table 11 highlights the variables that had significant effects on the probability of evacuating at least once during the 2004 hurricane season. Another important aspect of evacuation behavior is the destination to which people travel when they evacuate. It is likely that some variables have effects that differ according to the destination of the evacuation. We don't expect physical risk factors such as the strength and number of hurricanes to affect the choice of destination, but household and personal characteristics could play a significant role.

Table 12 shows the logistic regression results for models with dependent variables reflecting three different evacuation destinations: family or friends, public shelters, and hotels or motels. All are coded 1 for evacuations to that destination and 0 otherwise. The sample covered all respondents who evacuated at least once; each evacuation was treated as an independent observation.

(Table 12 about here)

As expected, the strength and number of hurricanes did not have significant effects on evacuation destinations, but housing type and home ownership did. People living in mobile homes were significantly more likely to go to a public shelter and less likely to go to a hotel or motel than others, whereas homeowners were significantly more likely to go to a hotel or motel. We believe these variables are picking up the effects of socioeconomic differences (e.g., availability of resources) not accounted for by the other explanatory variables. Income had a negative effect on the probability of going to a public shelter and a positive effect on the probability of going to a hotel or motel, but the coefficient was statistically significant only for the former.

Household size had a significant negative effect on the probability of moving in with family or friends and positive but insignificant effects on the probability of going to other types of lodging. Apparently, families and friends find it difficult to accommodate large numbers of visitors, forcing large households to find other accommodations.

Years lived in Florida had a significant positive effect on the probability of moving in with family or friends and significant negative effects on the other two types of lodging. We believe this reflects the broader social networks, closer relationships with friends and neighbors, and greater probability of having family members living nearby for long-term than short-term residents.

Most of the other variables had insignificant effects on evacuation destinations. The only exception was that women were more likely than men to move in with family or friends.

Regional Analyses

Results at the state level show some clear evacuation patterns: the probability of evacuating increases with the severity and proximity of the hurricane and declines with increases in household size. Residents of mobile homes, members of households with children less than age 18, and women are more likely to evacuate than others, while homeowners and Hispanics are less likely. Do these patterns hold when we look at each region individually?

We made several adjustments to the multivariate model before running the regressions for each of the five regions. Variables measuring the presence of a person younger than age 18 or age 65 and older in a household were not included because those

data were not collected in the small-area surveys. Instead, we included a variable for the age of the respondent.

Since all respondents within a given region were similar (or identical) on our measures of the strength and number of hurricanes, we omitted those two variables from the model. To replace those measures of physical risk, we added a variable reflecting the housing damage sustained by each respondent. This variable was coded 0-4 based on the severity of damages, with 0 indicating no damage and 4 indicating the complete destruction of the housing unit. If respondents had a fairly clear idea of risk given their location and the severity of the hurricane—and if those risks were borne out by subsequent damage—then higher risk as measured by housing damage should be associated with a greater probability of evacuating. Similar measures have been used previously as proxies for physical risk (e.g., Riad, et al., 1999).

Most of the patterns observed for the state as a whole were found in each of the five regions (Table 13). The hypotheses regarding the impact of physical risk on evacuation rates were strongly supported: Damage and living in a mobile home had positive effects in all five regions; all were statistically significant except the mobile home variable in Charlotte County (perhaps because of a relatively small sample size). Homeownership had a significant negative effect in all five regions, but household size had no significant effects. Age had a marginally significant negative effect in two regions, whereas female had a positive effect in all five regions, statistically significant in all but one. Black, Hispanic, and years lived in Florida had inconsistent and mostly insignificant effects. Income and education also displayed inconsistent results, sometimes having positive effects and sometimes negative effects. Even when

significant, the effects of income and education as measured by odds ratios were quite small (not shown here).

(Table 13 about here)

CONCLUSIONS

A number of studies have concluded that the physical risks posed by hurricanes are a major determinant—perhaps *the* major determinant—of evacuation behavior (e.g., Baker, 1991; Bateman and Edwards, 2002; Dow and Cutter, 2002; Lindell, et al., 2005). The present study supports this conclusion. Hurricane intensity and proximity had a significant positive effect on evacuations at the state level and hurricane damage had significant positive effects in four of the five regions. The vulnerability of the housing unit, as measured by living in a mobile home, had a significant positive effect at the state level and in four of the five regions. According to the odds ratios, the impact of these variables was larger than for any other variable in almost every instance.

Several other factors were important as well. At the state level, homeownership and household size reduced the probability of evacuating. Women and households with children less than age 18 were more likely to evacuate than others, whereas Hispanics were less likely. At the regional level, homeownership had a significant negative effect on evacuations but household size did not. Women were more likely to evacuate than men in four of the five regions, but the other demographic variables had inconsistent and mostly insignificant effects. These results are consistent with the findings of many (but not all) previous studies (e.g., Bateman and Edwards, 2002; Drabek, 1986; Gladwin and Peacock, 1997; Lindell, et al., 2005; Perry, 1979).

Although hypothetical choices of evacuation destinations have been modeled before (Whitehead, et al., 2000), to our knowledge this is the first study to model actual choices of evacuation destinations. Several interesting results were found. Women were more likely than men to stay with family or friends, whereas large households were less likely to do so. The availability of resources—as reflected by income and homeownership—raised the probability of going to a hotel or motel and lowered the probability of going to a public shelter. Living in a mobile home—associated with a *lack* of resources—had the opposite effects. Clearly, hotels and motels are preferred over public shelters by those who can afford them. Perhaps most interesting, the number of years lived in Florida had a significant positive effect on the probability of staying with family and friends and a significant negative effect on the probability of going to a public shelter or a hotel or motel. We believe this reflects the presence of social and family networks that residents build up over time. These results suggest that when government officials make decisions regarding the location and size of public shelters, they should consider not only on the number of persons residing in an area but their socioeconomic and demographic characteristics as well.

Our analysis of the reasons people did not evacuate showed that many residents believed they were safe, given their location and the severity of the hurricane. Some were concerned about caring for pets or leaving homes unattended. Others had jobs or medical conditions that hindered their ability to evacuate. A few cited transportation problems or the lack of a place to go. These results illustrate the complex issues that must be confronted by individuals when developing and implementing their personal

evacuation plans and by public officials when attempting to develop and implement effective plans for the population as a whole.

There is evidence that the intensity (and perhaps the frequency) of hurricanes has increased in recent years as a result of rising sea surface temperatures; these rising temperatures are generally attributed to global warming caused by the production of greenhouse gases (e.g., Hoyos, Agudelo, Webster, and Curry, 2006; Santer, Wigley, Gleckler, Bonfils, Wehner, AchutaRao, Barnett, Boyle, Gruggemann, Fiorino, Gillett, Hansen, Jones, Klein, Meehl, Raper, Reynolds, Taylor, and Washington, 2006; Trenberth, 2005). Combined with rapid population growth in coastal areas, this represents a growing threat to larger and larger numbers of people. We hope the results of this and similar studies will help decision makers improve their policies and procedures as they develop evacuation plans related to future hurricanes.

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Figure 1. Paths Followed by the 2004 Florida Hurricanes.

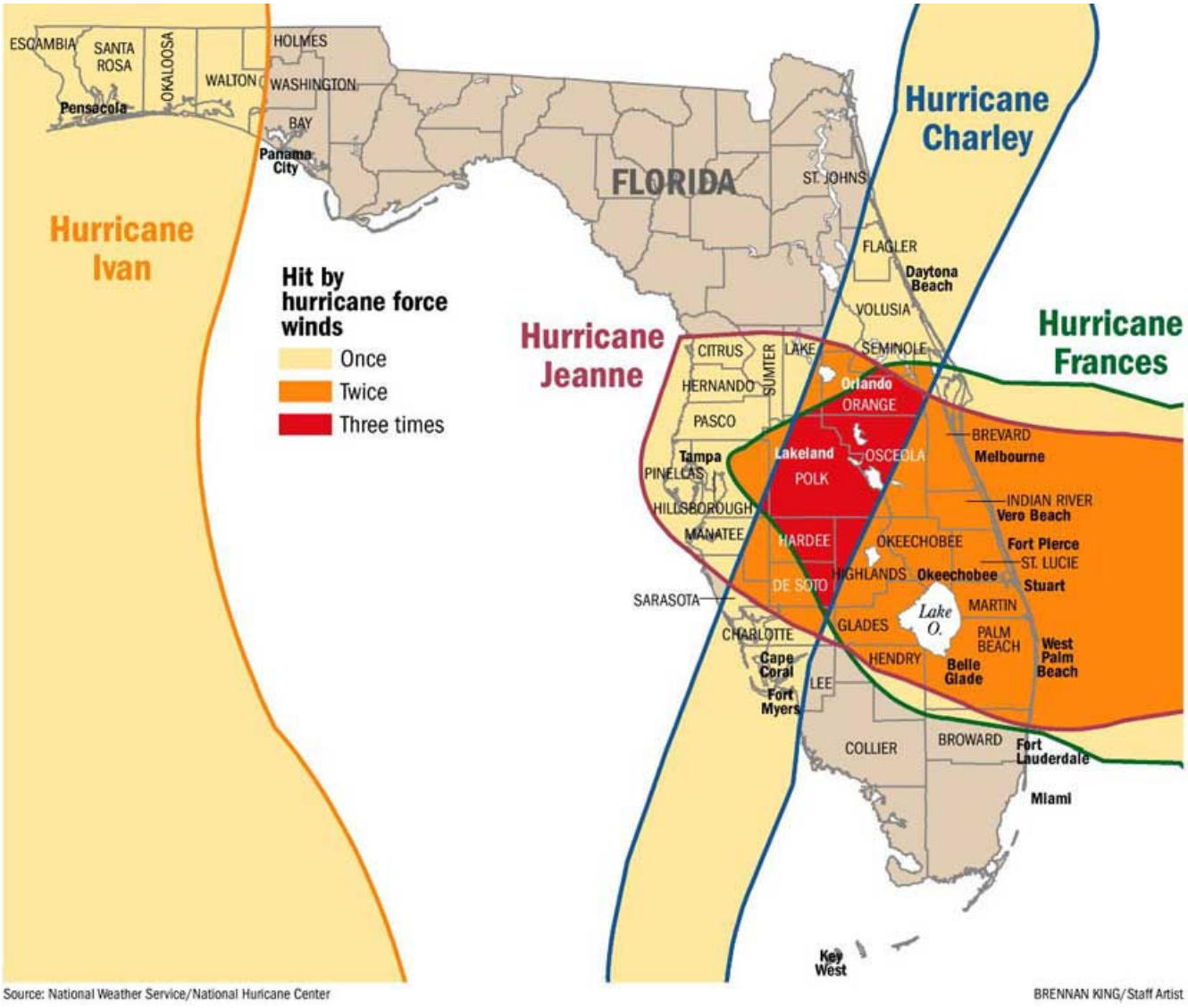

Table 1. Regions and Sample Size

Region	**Counties**	**N**
Southeast	Indian River, Martin, St. Lucie	2,739
Central	Highlands, Osceola, Polk	1,711
Southwest	DeSoto, Hardee	2,105
Charlotte	Charlotte	568
Northwest	Escambia, Santa Rosa	1,925
Total		9,048

Table 2. Demographic Characteristics

Characteristic*	SE	Central	SW	Charlotte	NW	Florida
Median age	48.1	39.6	35.2	54.3	36.4	39.6
% 65+	25.6	18.3	17.0	34.3	13.3	17.4
% Black	11.1	12.8	11.7	5.2	16.9	15.2
% Hispanic	9.2	18.3	31.9	3.8	2.9	18.5
Median Income	39,199	35,857	30,490	36,379	37,225	38,819
% Poverty	11.0	12.8	24.0	8.2	13.7	12.5
% College Grad.	20.5	14.9	8.4	17.6	21.6	22.4
% Mobile Homes	12.1	25.3	34.0	14.6	12.0	11.6

* Data for age, race, and Hispanic origin refer to 2004, whereas data for income, poverty, education, and mobile homes refer to 2000.

Sources:
Data for 2000 – U.S. Census Bureau.
Data for 2004 – Bureau of Economic and Business Research, University of Florida.

Table 3. Number of Times Each Respondent Evacuated (percent distribution)

Region	Zero	One	Two	Three	Four
SE	47.3	20.1	30.5	1.0	1.1
Central	70.7	10.0	6.3	7.2	5.8
SW	58.8	17.6	7.7	7.7	8.2
Charlotte	64.1	26.0	4.9	1.8	3.2
NW	56.2	43.0	0.1	0.3	0.4
Florida	74.8	13.5	6.3	2.1	3.3

Table 4. Percent Evacuating at Least Once, by Type of Housing Unit

Region	Mobile Home	Single Family	Multi-Family	Other	Total
SE	95.0	49.3	57.7	57.9	52.7
Central	71.9	18.2	40.8	39.9	29.3
SW	77.7	27.8	31.2	30.4	41.2
Charlotte	74.0	32.2	25.3	49.0	35.9
NW	72.3	40.8	40.3	46.6	43.8
Florida	62.8	20.6	25.8	30.3	25.2

Table 5. Type of Lodging during Evacuation (percent distribution)

Region	Family/ Friends	Public Shelter	Hotel/ Motel	Other
SE	58.0	6.6	20.4	15.0
Central	62.6	5.8	14.3	17.3
SW	63.3	11.3	7.3	18.0
Charlotte	56.5	3.3	25.3	14.9
NW	57.6	7.1	22.3	13.0
Florida	65.2	5.7	15.3	13.8

Table 6. Number of Nights Away from Home during Evacuation (percent distribution)

Region	**1-2**	**3-4**	**5-6**	**7-13**	**14+**
SE	20.0	33.8	16.8	20.5	9.0
Central	53.5	27.3	6.8	7.9	4.5
SW	57.1	17.5	4.4	6.5	14.5
Charlotte	46.1	17.8	10.5	9.5	16.0
NW	26.5	23.9	16.3	15.9	17.4
Florida	51.3	27.6	9.0	9.7	2.4

Table 7. Primary Reason for Failing to Evacuate: Escambia and Charlotte Counties (percent distribution)

Reason	Escambia	Charlotte
Thought I could ride it out	53.6	27.2
Storm was predicted to hit elsewhere	1.8	25.6
Was not aware hurricane was coming	0.0	4.1
Concerned about leaving pets	8.3	6.1
Concerned about leaving house unattended	8.3	5.7
Had no place to go	1.8	2.0
Had no transportation	1.2	1.2
Medical condition prevented evacuation	4.2	3.7
Job did not permit leaving	6.8	2.9
Did not have enough time	0.0	4.9
Other	14.0	16.6

Table 8. Percent Evacuating in Consecutive Hurricanes

Evacuated for First Hurricane

Evacuated for Second Hurricane	**Yes**	**No**
SE Region		
Yes	63.9	12.1
No	36.1	87.9
Central Region		
Yes	79.9	9.3
No	20.1	90.7
SW Region		
Yes	53.3	6.5
No	46.7	93.5

Table 9. Percent Evacuating for Second Hurricane, by Extent of Housing Damage in First Hurricane

	Damage in First Hurricane		
Evacuated for Second Hurricane	**Major**	**Minor**	**None**
SE Region			
Yes	63.6	51.5	42.2
No	36.4	48.5	57.8
Central Region			
Yes	34.1	30.2	24.7
No	65.9	69.8	75.3
SW Region			
Yes	47.6	35.3	33.4
No	52.4	64.7	66.6

Table 10. Bivariate Regression Results

Variable	**N**	**Coefficient**	**Odds Ratio**
Strength	1,844	0.2890***	1.335
Number	1,844	0.3291***	1.390
Mobile Home	1,870	1.7871***	5.972
HH Size	1,867	-0.0715*	0.931
Homeowner	1,868	-0.1701	0.844
< Age 18	1,867	-0.0217	0.979
Age 65+	1,855	0.0123	1.012
Female	1,876	0.3268***	1.387
Black	1,844	-0.3033	0.738
Hispanic	1,860	-0.4181**	0.658
Income	1,592	-0.0030***	0.997
Education	1,876	-0.0094	0.991
Years in FL	1,876	-0.0151	0.985

*** $p < .01$
** $p < .05$
* $p < .10$

Table 11. Multivariate Regression Results

Variable	**Coefficient**	**Odds Ratio**
Strength	0.2730***	1.314
Number	0.0520	1.053
Mobile Home	1.8427***	6.313
HH Size	-0.1140*	0.892
Homeowner	-0.2954*	0.744
< Age 18	0.4234**	1.527
Age 65+	-0.1216	0.885
Female	0.2978**	1.347
Black	-0.2725	0.761
Hispanic	-0.3839*	0.681
Income	-0.0016	0.998
Education	0.0340	1.035
Years in FL	-0.0053	0.995
N	1,524	
Model X^2	155.49***	

*** p < .01
** p < .05
* p < .10

Table 12. Multivariate Regression Coefficients, by Destination

Variable	Family/Friends	Public Shelter	Hotel/Motel
Strength	-0.0274	-0.0740	-0.0460
Number	0.2116	0.3504	-0.1116
Mobile Home	0.1662	0.8674**	-0.5818**
HH Size	-0.2910***	0.2348	0.1149
Homeowner	-0.3143	-0.5777	0.6446**
< Age 18	0.3849	-0.6019	0.3058
Age 65+	0.1249	0.0655	-0.4105
Female	0.3694**	-0.4295	-0.0319
Black	0.2686	-0.3866	-0.1755
Hispanic	0.2363	0.5054	-0.3883
Income	0.0005	-0.0140*	0.0020
Education	-0.0188	-0.0314	0.0457
Years in FL	0.0813***	-0.0840**	-0.0620***
N	681	681	681
Model X^2	42.56***	42.63***	40.66***

*** p < .01
** p < .05
* p < .10

Table 13. Multivariate Regression Coefficients, by Region

Variable	Southeast	Central	Southwest	Charlotte	Northwest
Damage	0.3067 ***	0.1626**	0.2752***	0.4294***	0.3251***
Mobile Home	2.4169 ***	2.5197***	2.3111***	0.6696	1.3427***
HH Size	0.0132	-0.0455	-0.0085	-0.0500	0.0221
Homeowner	-0.5945 ***	-0.4225 **	-0.3117*	-0.6269*	-0.3854**
Age	-0.0054	-0.0090 *	-0.0072*	-0.0098	0.0013
Female	0.4050 ***	0.3883 **	0.0709	0.3608*	0.4407***
Black	-0.8832 ***	-0.1470	0.2644	-1.7203	-0.3408
Hispanic	-0.0622	0.2173	0.2639	0.7212	0.1943
Income	0.0028 ***	-0.0024	-0.0053 ***	0.0026	0.0048***
Education	0.0583 ***	-0.0740 ***	-0.0196	-0.3858	0.0343
Years in FL	-0.0068	0.0064	0.0052	-0.0123	-0.0491***
N	2,085	1,299	1,708	426	1,488
Model X^2	212.90***	231.07***	430.69***	35.63***	129.46***

*** p < .01
** p < .05
* p < .10

Appendix A: Classification of Counties by STRENGTH and NUMBER

STRENGTH:

4 – Charlotte, DeSoto, Sarasota.
3 – Brevard, Escambia, Indian River, Martin, Okaloosa, Palm Beach, Santa Rosa, St. Lucie, Walton.
2 – Hardee, Hendry, Highlands, Okeechobee, Orange, Osceola, Polk.
1 – Citrus, Hernando, Hillsborough, Lake, Manatee, Pasco, Pinellas, Sumter.
0 – All others.

NUMBER:

4 – None.
3 – DeSoto, Hardee, Orange, Osceola, Polk.
2 – Brevard, Charlotte, Glades, Highlands, Hendry, Indian River, Martin, Okeechobee, Palm Beach, Sarasota, St. Lucie.
1 – Citrus, Escambia, Flagler, Hernando, Hillsborough, Lake, Lee, Manatee, Okaloosa, Pasco, Pinellas, Santa Rosa, Seminole, Sumter, Volusia, Walton.
0 – All others.