Fleeing the Storm(s):
An Examination of Evacuation Behavior 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. We estimate that one-quarter of Florida's population evacuated prior to at least one hurricane; 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. Using logistic regression analysis, we found the strength of the hurricane and the vulnerability of the housing unit had the greatest impact on evacuation behavior; several demographic variables had significant effects on the probability of evacuating and the choice of evacuation lodging (family/friends, public shelters, or hotels/motels). With continued population growth in coastal areas and the apparent increase in hurricane activity caused by global warming, the threats posed by hurricanes are rising in the United States and throughout the world. We believe the present study will help government officials plan more effectively for future hurricanes evacuations.

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 devastated Louisiana and Mississippi in 2005, 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 have elevated 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 personal and household characteristics and their perceptions of the hurricane threat. A substantial literature on this topic has emerged over the last several decades (e.g., Baker 1979, 1991; Dash and Gladwin 2007; Drabek 1986; Zhang, Prater, and Lindell 2004). In this study, we analyze evacuation behavior in Florida during the 2004 hurricane season using survey data collected at the state and local levels.

We start by describing our data set and discussing the selection of survey areas, the survey procedures followed, and the aggregation of local areas into five geographic regions. For the state and each region, we develop estimates of the proportion evacuating, the type of lodging used, and the length of time away from home. Using a sample of those who did not evacuate, we investigate the reasons why. We review the determinants of evacuation behavior, summarize the empirical evidence reported in previous studies, and use logistic regression analysis to estimate the impact of several risk factors and demographic variables on evacuation behavior. We close by drawing several conclusions regarding the determinants of evacuation behavior.

We have four primary objectives. First is to document evacuation behavior in Florida in 2004. Second is to examine the impact of several determinants of that behavior. Third is to investigate factors affecting the choice of evacuation lodging (family or friends, hotel or motel, public shelter). Fourth is to compare evacuation characteristics across regions. We believe this study documents several important aspects of evacuation behavior during one of the worst hurricane seasons in history and provides information that will help federal, state, and local officials plan more effectively for future hurricane evacuations.

DATA

Four hurricanes blasted through Florida between August 13 and September 25, 2004, with Charley making landfall on the southwest coast, Frances on the southeast coast, Ivan in the panhandle, 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. Many counties 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 data sources capable of providing comprehensive, reliable information on the demographic and socioeconomic effects of hurricanes and other natural disasters (e.g., Friesema et al. 1979; Rossi et al. 1981; Smith and McCarty 1996). To remedy this problem, we conducted a series of household surveys at the state and local levels. These surveys were funded by the Florida Legislature and were designed primarily to collect data related to changes in occupancy rates and average household size in the cities and counties sustaining the greatest hurricane damage; these data form a crucial part of the population estimation methods used in Florida. Although they were not designed specifically for studying evacuation behavior—and have several shortcomings in that regard—these surveys reached a large number of households and collected a substantial amount of data on the impact of the hurricanes, making them very useful for analytical purposes.

At the state level, we used list-assisted random-digit dialing to contact approximately 500 households each month between February and May, 2005. These surveys covered the entire state, including some areas with heavy hurricane damage and others with little or no damage. 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. We do not believe 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 phone. A recent survey found that households with a cell phone but no landline phone accounted for less than 4% of all households in the United States (Blumberg, Luke, and Cynamon 2005).

Random digits were added to the partial numbers in the banks and the resulting numbers were called. The household member age 18 or older who most recently had a birthday was selected as the survey respondent. Only those who reported that they were permanent residents of Florida in August, 2004 were included in the sample. Each number was called up to ten times before it was dropped from the sample. This process led to 1,881 completed interviews. The response rate—calculated as the number of completed interviews as a percentage of eligible numbers called—was 24.5%. This calculation was based on the most conservative formula (RR1) sanctioned by the American Association of Public Opinion Research. Response rates can be calculated in a variety of ways, leading to widely varying estimates (e.g., Bourque, Shoaf, and Nguyen, 1997; Dow and Cutter 1998; Zhang et al. 2004).

We also conducted surveys in the local areas sustaining the greatest hurricane damage. Using data from the Federal Emergency Management Agency (FEMA), we identified the 13 counties with the highest proportion of housing units sustaining major damage. In the ten counties with the greatest damage, samples were drawn for 16 cities and the balance of each county. In the other three counties, samples were drawn for the

county as a whole. For the 16 cities, we used a combination of listed numbers and random-digit dialing; for the three full counties and ten county balances, we relied solely on random-digit dialing. These surveys were conducted between March and June, 2005 and produced 11,559 completed interviews. Again, each number was called up to ten times before being dropped from the sample. The aggregate response rate for these surveys was 33.3% using the RR1 formula.

Although data for each city and county were essential for the production of local population estimates, our focus in this study is on larger geographic areas. We therefore combined the 29 local areas into five 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, data for each city, balance of county, and county were weighted according to their share of the region's households in 2004. We excluded 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 less than 3% at the state level and less than 5% at the regional level.

(Table 1 about here)

Table 2 summarizes the demographic and damage characteristics for 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 other characteristics. Mobile homes account for a very large proportion of the housing stock in the Central and SW regions.

(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 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). Of the five regions surveyed, Charlotte County and the SW region sustained the heaviest damages, with about half the housing units suffering major damage and only 12-18% avoiding damage completely. The Central region had the lightest damages, with 25% of the units suffering major damage and 34% sustaining no damage at all.

EVACUATION CHARACTERISTICS IN FLORIDA

With the advent of the Internet, talk radio, and 24/7 television news channels, hurricanes can no longer sneak up on an unwary public. Although the future path of a hurricane cannot be perfectly predicted, people generally receive several days advance warning when a hurricane threatens their area, giving them ample opportunity to leave

potentially unsafe locations. Not all do so, of course. Just over one in four survey respondents in Florida evacuated prior to at least one hurricane in 2004 (Table 3). Almost 14% evacuated once; 6%, twice; 2%, three times; and 3% reported that they evacuated for 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 differences among the five regions. The SE region had the highest proportion evacuating at least once (53%) and by far the highest proportion evacuating twice (31%). This most likely occurred because the SE region lay directly in the paths of two hurricanes. Although it was struck by three hurricanes, the Central region had the lowest proportion evacuating at least once (29%). This most likely occurred because this region is comprised of inland counties that are less vulnerable to hurricane damage than coastal counties. The NW region had 44% evacuating at least once, with very few evacuating more than once. This occurred because only one hurricane directly threatened the region.

The SW region had the highest proportion evacuating three or four times. This region was hit by three hurricanes and sustained especially heavy damages from Charley, the first hurricane striking 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 noteworthy 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 article.

The second panel of Table 3 shows the proportions evacuating at least once by type of housing unit. In every region, proportions were substantially higher for residents of mobile homes than for residents of other types of housing. This is consistent with the results of many previous studies (e.g., Baker 1979, 1991; Bateman and Edwards 2002; Drabek 1986; Wilmot and Mei 2004). Single family units generally had lower proportions evacuating than multi-family units, but the differences were relatively small.

The third panel of Table 3 shows the type of lodging used by evacuees (for respondents who evacuated more than once, we treated each evacuation as an independent event). The majority stayed with family or friends, with regional proportions ranging from 57% to 63%. A high proportion staying with family or friends is a common finding in the literature (e.g., Blendon et al. 2006; Drabek 1986; Whitehead et al. 2000).

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). For regions, however, these proportions varied substantially. 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 rooms in this sparsely populated rural area, but a more likely explanation is the low incomes of many 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 Charlotte's median income is below the state average, its poverty rate is very low. We analyze evacuation lodging at the household level later in the article.

More than half the evacuations at the state level 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 (bottom panel of Table 3). The long stays for some evacuees were due to storm damages that made it impossible to return home immediately. When respondents reporting housing damage were omitted from the sample, 92% of evacuees were away for less than a week and less than 1% were away for two weeks or more (not shown here).

Length of evacuation varied considerably among the regions. The SE region had the highest proportion away for three or more nights, probably because so many respondents evacuated at least twice. Due its relatively low damage levels, it also had a relatively low proportion away for two weeks or more. The Central region had the highest proportion with stays of four nights or less and the lowest proportion with stays of two weeks or more. This region had the lowest level of hurricane damage. The SW, Charlotte, and NW regions had the highest proportions away for two weeks or more, most likely because high levels of hurricane damage prevented many residents from returning home until repairs could be completed.

To deepen our understanding of why some people chose not to evacuate, we conducted follow-up surveys in Charlotte and Escambia, two counties with heavy damages that were affected primarily (or solely) by a single hurricane. 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 4.

(Table 4 about here)

Over half the non-evacuees in Escambia reported they thought they could ride out the hurricane without compromising their safety. This is consistent with the results of numerous studies finding the main reason for not evacuating is the belief that a hurricane is not a serious threat or the current location is safe (e.g., Perry and Lindell 1991; Riad et al. 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 proportions citing the last four reasons is consistent with previous studies (e.g., Riad, et al. 1999). Only 3% cited lack of transportation or a place to go; this too is consistent with previous research (e.g., Baker 1991)

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 is unusual and 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 they did not know the hurricane was coming and 5% reported they did not have enough time to evacuate. These results explain the relatively low evacuation rates for Charlotte shown in Table 3.

About 6% of the respondents in Charlotte cited concerns about leaving pets and houses unattended, 4% cited medical conditions, 3% cited lack of transportation or a place to go, and 3% cited job responsibilities. These results are similar to those reported

in Escambia, but the proportion citing job responsibilities was a bit lower in Charlotte because of its high proportion of retirees.

FACTORS AFFECTING EVACUATION BEHAVIOR

Evacuation behavior in the face of natural and man-made disasters is determined by the physical risks posed by disasters and by how people perceive and respond to those risks. Based on our review of the literature, we have identified a number of factors we believe help explain evacuation behavior in Florida in 2004. Given the limitations of our data set, we do not consider potentially important factors such as transportation issues (e.g., Dow and Cutter 2002), communication of relevant information (e.g., Lindell, Prater, and Peacock 2007), how evacuation decisions are made (e.g., Gladwin, Gladwin, and Peacock 2001), and whether or not official evacuation orders were given (e.g., Wilmot and Mei 2004). Rather, we focus on factors reflecting physical risks and demographic characteristics.

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 greater the probability of evacuating (e.g., Baker 1991; Bateman and Edwards 2002; Dow and Cutter 2002; Lindell, Lu, and Prater 2005).

The degree of protection provided by a housing unit is also important. 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). It is not

surprising that many studies have found residents of mobile homes to be more likely to evacuate than residents of other types of housing (e.g., Baker 1979, 1991; Bateman and Edwards 2002; Drabek 1986; Wilmot and Mei 2004).

Demographic 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). Since they face fewer logistical constraints, it might be expected that small households would be more likely 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 than other households due to 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 making decisions affecting children. Several studies have found the presence of children to raise evacuation rates (e.g., Gladwin and Peacock 1997; Lindell et al. 2005) but others have not (e.g., Bateman and Edwards 2002).

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 common explanation for this finding is that physical impairments and medical conditions limit the mobility of older persons and social isolation makes them less knowledgeable about storm threats. Some studies, however, have found no significant differences in evacuation rates by age (e.g., Zhang et al. 2004).

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

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

It has been hypothesized that evacuation rates for racial and ethnic minorities will be lower than for other groups because of differences in feelings of fatalism and risk perception, preparedness behavior, language difficulties, social and family networks, the confidence placed in various sources of information, and the economic resources needed to evacuate (Fothergill, Maestas, and Darlington 1999). The empirical evidence, however, is 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).

Higher income and educational levels might be expected to raise evacuation rates by providing the resources needed to evacuate and by improving the ability to gather relevant information and formulate effective evacuation plans. The empirical evidence,

however, is weak. Most studies have found income and education to have small and/or statistically insignificant effects on evacuation rates (e.g., Bateman and Edwards 2002; Gladwin and Peacock 1997; Whitehead et al. 2000).

A final demographic characteristic that might affect evacuation behavior is previous hurricane experience. Some analysts believe previous experience makes people more likely to evacuate by raising their understanding of hurricane risks and the evacuation process; others believe it makes them less likely to evacuate by imparting a sense of security from having made it safely through previous hurricanes. Again, the empirical evidence is mixed: some studies have found a significant positive effect (e.g., Riad et al. 2000), some have found a significant negative effect (e.g., Gladwin and Peacock 1997), and some have found no significant effect (e.g., Lindell et al. 2005).

LOGISTIC REGRESSION ANALYSIS

We used logistic regression analysis to examine the determinants of evacuation behavior in Florida (see DeMaris 2004 for a description of logistic regression models). This technique is well-suited for our purposes because we are concerned with a dichotomous final outcome (evacuating or not evacuating) rather than with the various stages of the decision-making process. 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.

State Level Analyses

Choice of Variables. We began by analyzing evacuation behavior at the state level. 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.

The choice of independent variables was based on our review of the literature and the availability of relevant data. Some variables measured physical risks and others measured demographic characteristics. Our expectations regarding the effect of each variable on evacuation behavior were based on theoretical considerations and the empirical evidence discussed previously.

The severity and location of the storm are two of the most important measures of hurricane risk. We constructed an independent variable combining these two measures using information on the intensity and location of each hurricane. This variable ("storm strength") was coded 0-4 based on the severity of the strongest storm hitting each county and the distance of each county from the point of landfall. If the county was on the coast, it was assigned a score equal to the Saffir-Simpson category at the point of landfall; for the hurricanes striking Florida in 2004, these categories ranged from 2 to 4. If the county was inside the hurricane area shown in Figure 1 but was not on the coast, its Saffir-Simpson score was reduced according to the county's distance from the coast. If the county was not inside the area shown in Figure 1, it was assigned a score of 0. The classification of counties regarding storm strength is shown in Appendix A. Although this measure is somewhat subjective, we believe it provides a reasonable approximation of the strength of the strongest storm hitting each county. We expect storm strength to have a positive effect on the probability of evacuating.

Some places were unaffected by any of the hurricanes striking Florida 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 (Appendix A). Because an increase in the number of hurricanes raised the number of

opportunities to evacuate, we expect this variable to have a positive effect on the probability of evacuating at least once.

Living in a mobile home poses a substantial physical risk when a hurricane strikes an area. We coded a variable 1 if the respondent lived in a mobile home and 0 otherwise. We expect this variable to have a positive effect on the probability of evacuating.

Several independent variables were based on household characteristics. Owning a home, having a household member younger than age 18, and having a household member age 65 or older were coded 1 if the household had that characteristic and 0 otherwise. Household size was measured by the number of persons living in the household at the time the hurricanes struck. We expect the presence of a household member younger than age 18 to have a positive effect on the probability of evacuating and the other three variables to have negative effects.

Several independent variables were based on 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 expect race (black) and ethnicity (Hispanic) to have negative effects on the probability of evacuating and gender (female), income, and education to have positive effects. Given the results reported in previous studies, however, there is a good chance that—except for gender—all these effects will be statistically insignificant.

Finally, we used years lived in Florida as a proxy for previous hurricane experience: the larger the number of years lived in Florida, the greater the likelihood of having experienced a hurricane prior to 2004. We hypothesize that this variable will

have a negative effect on the probability of evacuating. Again, given the empirical evidence reported in previous studies, it is unlikely that this effect will be significant.

Bivariate Regressions. We ran a series of bivariate logistic regressions to investigate the uncontrolled relationship between each independent variable and the probability of evacuating at least once. The results are shown in Table 5. The odds ratios show the proportion by which the probability of evacuating increases (or declines) with a one unit increase in the value of each independent variable. Ratios above one reflect increases and ratios below one reflect declines.

(Table 5 about here)

As expected, storm strength, number of hurricanes, and living in a mobile home had significant positive effects on the probability of evacuating. Household size had the expected negative effect but was significant only at the 10% level. Neither homeownership nor the two age variables were significant, but women were 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 the effects were small and were significant only for income. Years lived in Florida had a small insignificant negative effect.

Multivariate Regressions. Bivariate regressions do not account for interactions among the independent variables. Consequently, some of the statistical relationships shown in Table 5 may be spurious, leading to false inferences regarding the factors affecting evacuation behavior. To deal with this problem, we constructed a multivariate

regression model using the same set of independent variables. The results are shown in Table 6 and a matrix of correlation coefficients is shown in Appendix B.

(Table 6 about here)

Many results were about the same in the multivariate regression as they were in the bivariate regressions. Hurricane strength, living in a mobile home, and gender had the same signs and were statistically significant in both sets of regressions; in fact, the coefficients themselves did not vary substantially from one set to the other. Household size, homeownership, and ethnicity had the same signs in both sets of regressions but were significant only at the 10% level in the multivariate regression. Having a household member age 65 or older, race, education, and years lived in Florida were insignificant in both sets of regressions.

Several results changed. Perhaps the most dramatic was the change for the number of hurricanes, which had a large significant effect in the bivariate regression but a small insignificant effect in the multivariate regression. It appears that the bivariate results for this variable were spurious, having been caused by a strong correlation between the number and strength of hurricanes.

We believe the number of hurricanes had a large significant effect in the bivariate regression because that variable reflected the occurrence of at least one hurricane. The multivariate results, however, suggest that increases in the number of hurricanes beyond one have no further impact of the probability of evacuating. We tested for this possibility by rerunning the regressions using a data set that included only respondents who lived in counties hit by at least one hurricane (not shown here). In the bivariate regression, the coefficient for number of hurricanes was small and statistically insignificant; it was

actually *negative* (albeit insignificant) in the multivariate regression. In contrast, the coefficient for hurricane strength was positive and highly significant in both the bivariate and multivariate regressions. We conclude that hurricane strength had a significant positive effect on the probability of evacuating at least once during the 2004 hurricane season, but the number of hurricanes (beyond one) did not.

Several other results changed as well. Income had a small but significant effect on the probability of evacuating in the bivariate regression, but lost its significance when the effects of the other independent variables were accounted for. Having a household member less than age 18 had a small insignificant effect in the bivariate regression but the effect was much larger and statistically significant in the multivariate regression. We believe this variable was insignificant in the bivariate regression because it is strongly correlated with race and ethnicity. Having a household member younger than age 18 is much more common for blacks and Hispanics than for non-Hispanic whites; both of these groups are associated with relatively low evacuation rates. This variable became significant in the multivariate regression because the effects of blacks and Hispanics were accounted for.

The multivariate analysis thus supported some but not all of our hypotheses. Hypotheses regarding storm strength, living in a mobile home, having a household member younger than age 18, and gender were strongly supported. Hypotheses regarding household size, homeownership, and ethnicity were marginally supported (i.e., at the 10% level). Hypotheses regarding number of hurricanes, household members age 65 or older, race, income, education, and years lived in Florida were not supported.

Type of Lodging. It is likely that differences in demographic characteristics affect the type of lodging people choose when evacuating. Specifically, we hypothesize that: 1) Greater access to economic resources will raise the probability of going to a hotel or motel and lower the probability of going to a public shelter, and 2) The more extensive the family and social network within a feasible evacuation distance, the greater the probability of staying with family and friends and the lower the probability of going to a public shelter or a hotel or motel.

To test these hypotheses, we constructed models with dependent variables measuring three types of lodging: family or friends, public shelters, and hotels or motels. All were coded 1 for evacuations to that type of lodging and 0 otherwise. The sample covered all respondents who evacuated at least once; each evacuation was treated as an independent observation. The independent variables were those used previously. The results are shown in Table 7.

(Table 7 about here)

We consider income, homeownership, and living in a mobile home to be measures of economic resources, with the first two variables positively associated with the availability of resources and the third, negatively associated. Income had the expected negative effect on the probability of going to a public shelter and the expected positive effect on the probability of going to a hotel or motel, but the effects were only marginally significant for the former and insignificant for the latter. Residents of mobile homes were significantly more likely to go to a public shelter and less likely to go to a hotel or motel, however, and homeowners were significantly more likely to go to a hotel or motel. These results provide support for our first hypothesis and are consistent with

previous studies finding socioeconomic status to be negatively associated with the likelihood of going to a public shelter (e.g., Drabek 1986; Mileti, Sorensen, and O'Brien 1992).

We do not have a direct measure of family and social networks within a feasible evacuation distance, but length of residence in Florida may provide a reasonable proxy measure. This measure will not be valid, however, if most evacuees go to locations outside the state. To investigate this possibility, we conducted a follow-up survey of respondents who reported they evacuated prior to at least one hurricane. We found that 49% of evacuees went to a location within the same county, 30% went to another county in Florida, and only 21% left the state. We believe the high proportions remaining in the state validate the use of length of residence in Florida as a proxy measure for family and social networks within a feasible evacuation distance.

Table 7 shows length of residence in Florida to have a significant positive effect on the probability of staying with family or friends and significant negative effects on the probabilities of going to a public shelter and a hotel or motel. These results strongly support our second hypothesis.

We also found household size to have a significant negative effect on the probability of moving in with family or friends and positive but insignificant effects on the probabilities of going to other types of lodging. We believe these results imply that families and friends find it difficult to accommodate large numbers of visitors, forcing large households to find other accommodations. Most of the other variables had insignificant effects. The only exception was that women were more likely than men to stay with family or friends.

Personal and household characteristics thus have several significant effects on the type of lodging people choose when evacuating. These effects have received little attention in the literature but have potentially important implications for public policy.

Regional Analyses

State-level analyses show several significant effects of risk factors and demographic variables on the probability of evacuating. Do these effects hold when looking at each region individually? To answer this question, we ran multivariate regressions for each of the five regions.

Choice of Variables. The dependent variable was the same as that used in the initial set of regressions (coded 1 if the respondent evacuated at least once and 0 otherwise) but two changes were made to the independent variables. First, variables measuring the presence of a household member younger than age 18 or older than age 65 were not included because those data were not collected in the local surveys. Instead, we added the age of the respondent as an independent variable. Given results cited in previous studies, we expect age to have a negative effect on the probability of evacuating.

Second, since all respondents within a given region had similar (or identical) scores on variables measuring the strength and number of hurricanes as defined in Appendix A, we omitted those variables from the model. In their place, we added a variable measuring housing damage sustained by each respondent as a result of the hurricanes. 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 unit. We used the severity of damage as an indicator of storm strength. Damage estimates have been used in other studies to reflect physical risks posed by hurricanes (e.g., Riad et al. 1999). As

before, we expect storm strength to have a positive effect on the probability of evacuating. All the other independent variables were the same as those used in the state-level analysis.

Regression Results. Four of the major findings in the state-level analysis were replicated at the regional level (Table 8). Storm strength, living in a mobile home, and gender had positive effects on the probability of evacuating in all five regions. These effects were statistically significant at least at the 10% level in all five regions for storm strength and in four of the five for living in a mobile home and gender. Homeownership had a negative effect that was significant at least at the 10% level in all five regions. The consistency of these results across regions strengthens their reliability.

(Table 8 about here)

Most of the results for the other demographic variables were inconsistent and/or statistically insignificant. Household size and ethnicity had no significant effects on the probability of evacuating in any of the five regions. Race and years lived in Florida were insignificant in all regions but one. Age had the expected negative effect in four of the five regions, but those effects were insignificant in two regions and only marginally significant in the other two. Income and education had effects that were sometimes significant and positive, sometimes significant and negative, and sometimes insignificant.

We do not have a ready explanation for results that differed from one region to another. They may represent true regional differences or may have been caused by sampling variability. Also, they may have been affected by regional differences in the geographic distribution of households with particular characteristics relative to the paths

followed by the hurricanes. Given the inconsistent empirical results reported in previous studies, finding regional differences in the present analysis is not surprising.

CONCLUSIONS

Many 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). This study supports that conclusion. Storm strength had a significant positive effect on the probability of evacuating at the state level and in all 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. In most instances, these two variables had a greater impact on evacuation behavior than any other variable.

Several demographic variables were important as well. Women were found to be significantly more likely to evacuate than men at the state level and in four of the five regions. Households with children less than age 18 size were significantly more likely to evacuate than other households in the state-level multivariate analysis, but lack of data prevented us from evaluating this variable at the regional level. Homeownership had at least a marginally significant negative effect on the probability of evacuating in all five regions and at the state level. The other demographic variables had inconsistent or mostly insignificant effects in both the state and regional analyses. These results are consistent with those reported in most previous studies (e.g., Bateman and Edwards 2002; Drabek 1986; Gladwin and Peacock 1997; Lindell et al. 2005; Perry 1979).

This study found that many people did not evacuate even when faced with an imminent hurricane threat. Some doubted the severity of the threat or believed their

current locations were safe. Others were concerned about pets or leaving homes unattended. Some had job responsibilities or medical conditions that impeded their ability to evacuate and others had no transportation or no place to go. These findings illustrate the difficulties emergency management officials face as they attempt to develop effective hurricane evacuation plans.

Although hypothetical choices of evacuation lodging have been modeled before (Whitehead et al. 2000), to our knowledge this is the first study to model a variety of actual lodging choices. Several interesting results were found. The availability of economic resources—as reflected by income and homeownership—lowered the probability of going to a public shelter and raised the probability of going to a hotel or motel, respectively. Living in a mobile home—associated with a *lack* of resources—lowered the probability of going to a hotel or motel and raised the probability of going to a public shelter. Clearly, hotels and motels are preferred over public shelters by those who can afford them.

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, hotel, or motel. We believe this variable reflects the prevalence of in-state family and social networks. These lodging results suggest that when government officials make decisions regarding the location and size of public shelters, they should consider not only the number of persons residing in an area but their socioeconomic and demographic characteristics as well.

This study has several limitations. The survey instrument did not ask questions about several potentially important topics, limiting the number of research issues that

could be addressed. The measure of hurricane strength used for the state-level analysis was somewhat subjective and the measure used for the regional analyses was a proxy rather than a direct measure. The data set contained no explicit information on family and social networks, requiring the use of a proxy for this variable as well. Post-hurricane surveys themselves are subject to imperfect recall on the part of respondents and miss people who leave the area following a hurricane and do not return.

If designed properly, however, post-hurricane surveys are capable of providing accurate and useful information (Bourque et al. 1997). The present study provides extensive documentation of evacuation patterns during one of the most active hurricane seasons in history, confirms a number of findings reported in previous studies, and presents several new findings. We believe it adds to our understanding of evacuation behavior.

Many aspects of evacuation behavior require further research, such as how hurricane warnings can best be communicated to the public, how people assess the validity of the warnings they receive, how they balance the costs and benefits of evacuating, how they formulate and implement evacuation plans, how traffic and lodging issues affect evacuation decisions, and how the most vulnerable residents can best be assisted. Clearly, much remains to be done. Gladwin et al. 2007; Lindell, Prater, and Peacock 2007; and Phillips and Morrow 2007 provide excellent discussions of future research needs.

Why does this matter? 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 (e.g., Hoyos et al. 2006; Saunders and Lea 2008); these rising temperatures

are often attributed to global warming caused by the production of greenhouse gases (e.g., Santer et al. 2006; Trenberth 2005). Combined with rapid population growth in coastal areas, greater hurricane activity represents a growing threat to larger and larger numbers of people in the United States and throughout the world. We believe further research on the determinants of evacuation behavior will deepen our understanding of this increasingly important topic and help officials at all levels of government develop and implement safer, more efficient, and less stressful evacuation plans.

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Figure 1. Paths Followed by the 2004 Florida Hurricanes

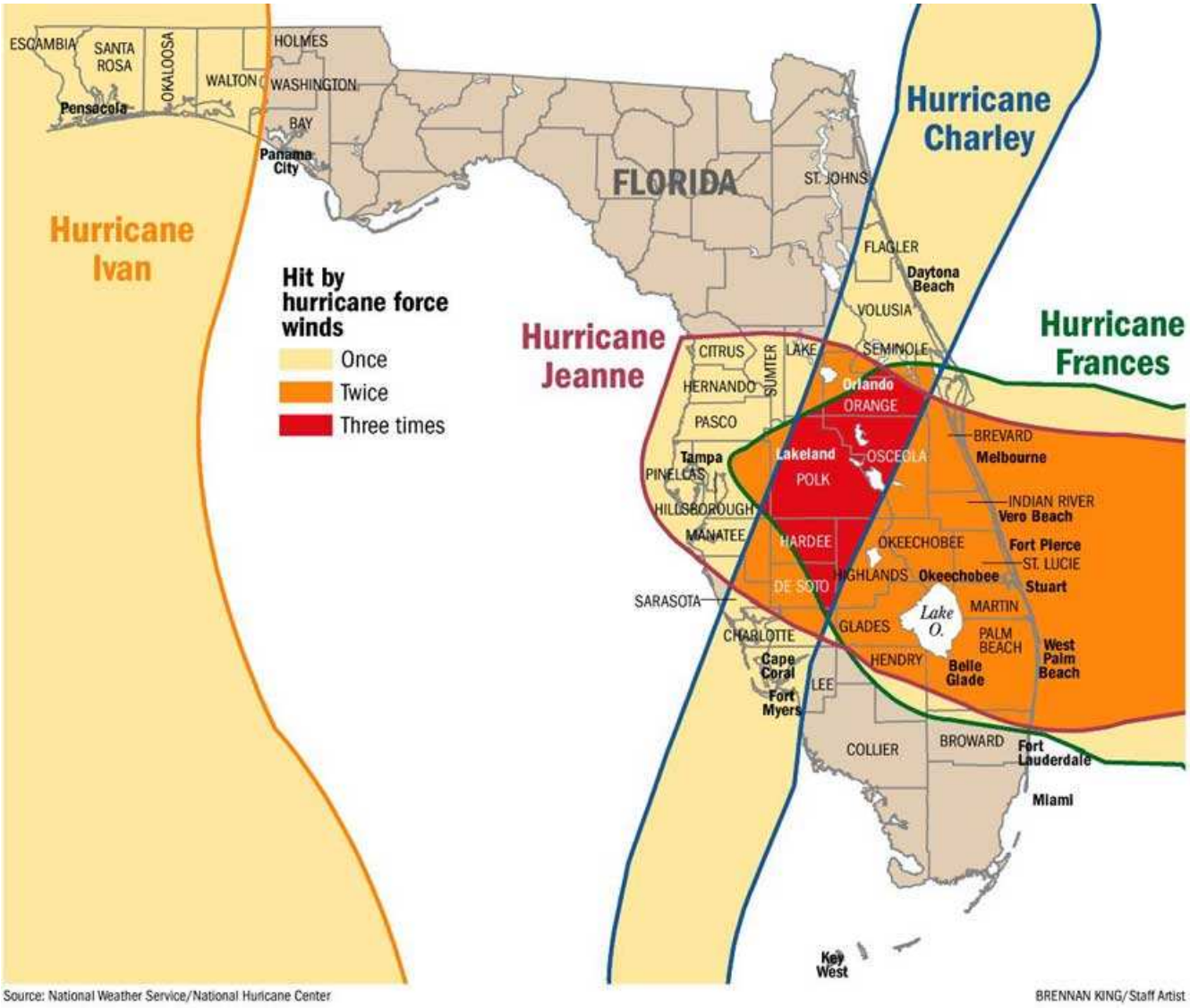

Table 1. Regions and Sample Size

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 and Damage 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
% Major Damage	35.5	25.0	50.2	49.0	40.6	8.5
% Minor Damage	42.0	41.3	38.2	32.6	38.9	23.7
% No Damage	22.5	33.7	11.6	18.4	20.5	67.8

Note: Data for age, race, Hispanic origin, and hurricane damage refer to 2004 and data for income, poverty, education, and mobile homes refer to 2000.

Sources: U.S. Census Bureau (2000 data) and Bureau of Economic and Business Research, University of Florida (2004 data).

Table 3. Evacuation Characteristics

Number of Times Each Respondent Evacuated (percent distribution)

Region	Zero	One	Two	Three	Four	Total
SE	47.3	20.1	30.5	1.0	1.1	100.0
Central	70.7	10.0	6.3	7.2	5.8	100.0
SW	58.8	17.6	7.7	7.7	8.2	100.0
Charlotte	64.1	26.0	4.9	1.8	3.2	100.0
NW	56.2	43.0	0.1	0.3	0.4	100.0
Florida	74.8	13.5	6.3	2.1	3.3	100.0

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

Type of Lodging (percent distribution)

Region	Family/ Friends	Public Shelter	Hotel/ Motel	Other	Total
SE	58.0	6.6	20.4	15.0	100.0
Central	62.6	5.8	14.3	17.3	100.0
SW	63.3	11.3	7.3	18.0	100.0
Charlotte	56.5	3.3	25.3	14.9	100.0
NW	57.6	7.1	22.3	13.0	100.0
Florida	65.2	5.7	15.3	13.8	100.0

Table 3. Evacuation Characteristics (continued)

Number of Nights Away from Home (percent distribution)

Region	1-2	3-4	5-6	7-13	14+	Total
SE	20.0	33.8	16.8	20.5	9.0	100.0
Central	53.5	27.3	6.8	7.9	4.5	100.0
SW	57.1	17.5	4.4	6.5	14.5	100.0
Charlotte	46.1	17.8	10.5	9.5	16.0	100.0
NW	26.5	23.9	16.3	15.9	17.4	100.0
Florida	51.3	27.6	9.0	9.7	2.4	100.0

Table 4. 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 5. Evacuation Determinants: Bivariate Regressions

Variable	N	Coefficient	Odds Ratio
Strength	1,844	0.289***	1.335
Number	1,844	0.329***	1.390
Mobile Home	1,870	1.787***	5.972
HH Size	1,867	-0.071†	0.931
Homeowner	1,868	-0.170	0.844
< Age 18	1,867	-0.022	0.979
Age 65+	1,855	0.012	1.012
Female	1,876	0.327**	1.387
Black	1,844	-0.303	0.738
Hispanic	1,860	-0.418*	0.658
Income	1,592	-0.003**	0.997
Education	1,876	-0.009	0.991
Years in FL	1,876	-0.015	0.985

*** $p < .001$
** $p < .01$
* $p < .05$
† $p < .10$

Table 6. Evacuation Determinants: Multivariate Regressions

Variable	Coefficient	Odds Ratio
Strength	0.273***	1.314
Number	0.052	1.053
Mobile Home	1.843***	6.313
HH Size	-0.114†	0.892
Homeowner	-0.295†	0.744
< Age 18	0.423*	1.527
Age 65+	-0.122	0.885
Female	0.298*	1.347
Black	-0.272	0.761
Hispanic	-0.384†	0.681
Income	-0.002	0.998
Education	0.034	1.035
Years in FL	-0.005	0.995
N	1,524	
Model X^2	155.49***	

*** p < .001
** p < .01
* p < .05
† p < .10

Table 7. Evacuation Determinants by Type of Lodging

Variable	Family/Friends	Public Shelter	Hotel/Motel
Strength	-0.027	-0.074	-0.046
Number	0.212	0.350	-0.112
Mobile Home	0.166	0.867*	-0.582*
HH Size	-0.291***	0.235	0.115
Homeowner	-0.314	-0.578	0.645*
< Age 18	0.385	-0.602	0.306
Age 65+	0.125	0.066	-0.410
Female	0.369*	-0.429	-0.032
Black	0.269	-0.387	-0.176
Hispanic	0.236	0.505	-0.388
Income	0.001	-0.014†	0.002
Education	-0.019	-0.031	0.046
Years in FL	0.081***	-0.084*	-0.062**
N	681	681	681
Model X^2	42.56***	42.63***	40.66***

*** p < .001
** p < .01
* p < .05
† p < .10

Table 8. Evacuation Determinants by Region

Variable	Southeast	Central	Southwest	Charlotte	Northwest
Strength	0.307***	0.163*	0.275***	0.429***	0.325***
Mobile Home	2.417***	2.520***	2.311***	0.670	1.343***
HH Size	0.013	-0.045	-0.008	-0.050	0.022
Homeowner	-0.595***	-0.423*	-0.312†	-0.627†	-0.385*
Age	-0.005	-0.009†	-0.007†	-0.010	0.001
Female	0.405***	0.388**	0.071	0.361†	0.441***
Black	-0.883***	-0.147	0.264	-1.720	-0.341
Hispanic	-0.062	0.217	0.264	0.721	0.194
Income	0.003**	-0.002	-0.005**	0.003	0.005***
Education	0.058**	-0.074**	-0.020	-0.386	0.034
Years in FL	-0.007	0.006	0.005	-0.012	-0.049***
N	2,085	1,299	1,708	426	1,488
Model X^2	212.90***	231.07***	430.69***	35.63***	129.46***

*** p < .001
** p < .01
* p < .05
† p < .10

Appendix A: Classification of Counties by Strength and Number of Hurricanes

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.

Appendix B. Pearson Correlation Coefficients (Probability > r)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1-Evacuation	1.000													
2-Strength	0.168	1.000												
	(0.001)													
3-Number	0.140	0.786	1.000											
	(0.001)	(0.001)												
4-Mobile Home	0.264	-0.006	-0.012	1.000										
	(0.001)	(0.806)	(0.608)											
5-HH Size	-0.042	-0.053	-0.034	-0.032	1.000									
	(0.070)	(0.023)	(0.148)	(0.166)										
6-Homeowner	-0.030	0.052	0.039	0.038	0.022	1.000								
	(0.193)	(0.026)	(0.095)	(0.101)	(0.352)									
7-HH < Age 18	-0.004	-0.050	-0.010	-0.017	0.714	-0.060	1.000							
	(0.847)	(0.031)	(0.661)	(0.463)	(0.001)	(0.010)								
8-HH Age 65+	0.002	0.059	0.026	0.045	-0.238	0.157	-0.320	1.000						
	(0.916)	(0.012)	(0.264)	(0.051)	(0.001)	(0.001)	(0.001)							
9-Female	0.070	0.008	-0.013	0.028	0.040	-0.028	0.072	-0.006	1.000					
	(0.002)	(0.724)	(0.569)	(0.218)	(0.083)	(0.224)	(0.002)	(0.808)						
10-Black	-0.034	-0.087	-0.056	-0.045	0.110	-0.198	0.104	-0.082	0.065	1.000				
	(0.140)	(0.001)	(0.016)	(0.051)	(0.001)	(0.001)	(0.001)	(0.001)	(0.005)					
11-Hispanic	-0.056	-0.129	-0.112	-0.026	0.151	-0.105	0.114	-0.012	-0.002	-0.115	1.000			
	(0.016)	(0.001)	(0.001)	(0.260)	(0.001)	(0.001)	(0.001)	(0.612)	(0.935)	(0.001)				
12-Income	-0.068	-0.009	-0.032	-0.156	0.116	0.273	0.063	-0.187	-0.100	-0.125	-0.081	1.000		
	(0.007)	(0.715)	(0.206)	(0.001)	(0.001)	(0.001)	(0.012)	(0.001)	(0.001)	(0.001)	(0.001)			
13-Education	-0.011	0.023	0.009	-0.164	-0.077	0.108	-0.070	-0.073	-0.036	-0.074	-0.100	0.315	1.000	
	(0.644)	(0.327)	(0.688)	(0.001)	(0.001)	(0.001)	(0.003)	(0.002)	(0.116)	(0.002)	(0.001)	(0.001)		
14-Years in FL	-0.031	-0.054	-0.020	0.001	-0.014	0.152	-0.044	0.055	0.029	0.058	-0.027	-0.023	-0.107	1.000
	(0.185)	(0.020)	(0.399)	(0.975)	(0.554)	(0.001)	(0.058)	(0.017)	(0.214)	(0.014)	(0.246)	(0.368)	(0.001)	