HOUSEHOLDS' EVACUATION DECISION IN RESPONSE TO HURRICANES KATRINA AND RITA

A Dissertation

by

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ABSTRACT

Although evacuation has been recognized as an effective protective action in responding to a hurricane emergency, it is still not clear why some people leave but others do not. In order to better understand this issue, this study began with a statistical meta-analysis (SMA), which is a procedure that has never been conducted previously in the field of disaster studies. The SMA indicates that homeownership, official warning, risk area, seeing peers evacuating, expected hydrological impacts, and expected wind impacts have strong and consistent effects on evacuation decisions whereas female gender, black ethnicity, presence of children in the home, reliance on news media for storm information, reliance on peers for storm information, and hurricane intensity have weaker effects that might be due to mediation through psychological variables. Next, this study collected data from the Hurricane Katrina and Rita evacuations and extended the results of the SMA by testing the Huang et al. (2012) abbreviated protective action decision model (PADM). The results show that (1) a household's evacuation decision, as predicted, is determined most directly by expected wind impacts and expected evacuation impediments. In turn, expected wind impacts and expected hydrological impacts are primarily determined by expected storm threat and expected rapid onset. Finally, expected storm threat, expected rapid onset, and expected evacuation impediments are determined by households' personal characteristics, their reception of hurricane information, and their observations of social and environmental cues. (2) Surprisingly, expected hydrological impacts did not have as much of an impact on evacuation decisions as wind impacts—which are associated with expected injuries, job disruption, and service disruption. (3) Official warnings and risk area also had direct effects on households' evacuation decisions, which can be explained as the peripheral route to persuasion that bypasses messages about the personal impacts hurricane impact (Petty & Cacioppo, 1986). (4) Unlike other hurricane evacuation studies, this one found that expected rapid onset had a significant effect on households' evacuation decisions, perhaps because both Hurricanes Katrina and Rita had late-changing tracks that might have caused residents to be concerned being caught on the road by a rapidly approaching storm. (5) Supplemental information, such as environmental cues, risk area, and hurricane experience, have effects on individuals' expectations of storm threat, wind impacts, and hydrological impacts that are similar to those of National Weather Service information that is disseminated through multiple information channels (e.g., news media and official warnings). This implies that households used other sources to place the National Weather Service's hurricane information into an appropriate context. Nonetheless, some of the results conflict with the model presented by Huang et al. (2012), so further research is needed to determine whether the conflicting results can be replicated and, consequently, require revision of the model.

DEDICATION

To my lovely family:

Grandparents,

Parents,

Sister, Winnie,

And

Fiancée, Catherine

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NOMENCLATURE

b / β	Regression Coefficients
BusClos	Observing Business Closing
CDT	Central Daylight Time
CI	Confidence Interval
CV	Credibility Interval
Edu	Education
EM	Expectation-Maximization Algorithm
EnvCues	Observed Environmental Cues
EvacExp	Expected Evacuation Expenses
EvaDec	Evacuation Decisions
ExEvacImp	Expected Evacuation Impediments
ExHydroImp	Expected Hydrological Impacts
Exper	Previous Experiences
ExRapOnset	Expected Rapid Onset
ExStmThreat	Expected Storm Threats
ExWindImp	Expected Wind Impacts
GSA	Galveston-Houston Study Area
HearWarn	Hearing Hurricane Watch or Warning
HHSize	Household Size
HmOwn	Homeownership

HrrExp	Previous Hurricane Experience
HRRC	Texas A&M University Hazard Reduction & Recovery Center
JobDrpt	Expected Job Disruptions
K	Number of Studies
LD	Listwise Deletion
LocAuth	Frequency of Consulting Local Authorities
LocNews	Frequency of Consulting Local News Media
M	Mean
MAR	Missing at Random
MCAR	Missing Completely at Random
NatNews	Frequency of Consulting National News Media
NearbyLand	Expected Nearby Landfall
n	Sample Size
NHC	National Hurricane Center
OffOrder	Receiving Official Evacuation Order
OffWarn	Observed Official Warnings
OR	Odd Ratios
PADM	Protective Action Decision Model
PD	Pairwise Deletion
Peers	Frequency of Consulting Peers
PeerEvac	Observing Peers Evacuating
ProtLoot	Property Protection from Looters

ProtStm	Property Protection from Storm
RQ	Research Question
RH	Research Hypothesis
r	Pearson Correlation Coefficients
$\bar{r}$	Effect Sizes
r_{WG}^{*}	Interrater agreement
ServDrpt	Expected Service Disruptions
SD	Stand Deviation
SMA	Statistical Meta-Analysis
SocCues	Observed Social Cues
SSA	Lake Sabine Study Area
TrafRisk	Expected Traffic Risk
UnnecEvac	Unnecessary Evacuation Experience
Var	Variables

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CHAPTER I

INTRODUCTION

During the 2005 hurricane season, the Texas Gulf Coast was repeatedly struck by major hurricanes. First, the deadliest and costliest U.S. hurricane in the past century, Katrina, struck the New Orleans metropolitan area with 1,833 deaths and $108 billion in economic loss. One month later, another Category 5 hurricane, Rita, severely disrupted residents' lives in the upper Texas coast (Huang et al., 2012, 2013). Even though evacuation has been recognized as an effective protective action (Lindell et al., 2004, 2007b), both hurricanes revealed severe evacuation problems in this region. Specifically, population growth in coastal surge zones had increased evacuation demand and traffic (Wu et al., 2012, 2013). Moreover, population growth in inland areas such as Harris County, which is on the evacuation route for Galveston residents, is also important because shadow evacuation from this area could mire coastal evacuees in the surge zone area and prevent them from reaching safety before hurricane onset (Baker, 1991; Lindell et al., 2007b; Huang et al., 2012, 2013). The solution to these hurricane evacuation issues is substantially determined by answers to the questions—"Who evacuates?" and "Why do they decide to leave?"

These questions have been addressed in many previous studies reviewed by Baker (1991) and Dash and Gladwin (2007) that have identified variables predicting households' hurricane evacuation decisions. However, the conclusions about the significance of these predictors have varied from one study to another. One possible reason for the inconsistent results is the lack of a comprehensive conceptual model based upon systematic examination of the literature on households' evacuation decisions (Huang et al., 2013). To address this deficiency, this study aims to provide a better understanding of the cause-and-effect relationship between each predictor and households' evacuation decisions by achieving three objectives. First, this study systematically reviews previous hurricane evacuation studies and assesses the impact of each predictor on households' evacuation decisions. Second, it modifies a conceptual model of protective action decisions (PADM, see Lindell & Perry 1992, 2004, 2012). Finally, it tests the model using data from households' actual responses to Hurricanes Rita and Katrina.

CHAPTER II

LITERATURE REVIEW

Baker (1991) summarized 15 empirical studies conducted from 1960 to 1990 that covered 12 hurricanes and concluded that the risk level of the area (e.g., low-lying sites close to water or shoreline and barrier islands), official notices, mobile home residence, personal risk perceptions, storm severity, and some social cues (such as business closing and peers evacuating), were generally good predictors of evacuation behavior. Other variables were sometime statistically significant, but varied from study to study. In the 20 years since Baker's (1991) review, researchers have conducted many hurricane evacuation studies but none of them has provided a definitive summary of the field. One important reason is the lack of a systematic statistical meta-analysis (SMA) summarizing results across hurricane evacuation studies.

To address this deficiency, this study begins with an SMA that will draw general conclusions about the results of previous hurricane evacuation studies. Leedy and Ormrod (2010, also see Field & Gillett, 2010) described three steps for a SMA: (1) conduct an extensive search for relevant studies; (2) decide which studies and variables to include; and (3) convert the results from each study into a common statistical effect size and analyze these effect sizes. The results of the SMA will be compared to the conceptual model in Huang et al. (2012) and yield research hypotheses for this study.

2.1 Statistical Meta-Analysis

2.1.1 Selection of Variables and Articles for Household Evacuation Decisions

After Baker's (1991) summary, Sorensen (2000) reviewed progress in forecasting, warning integration, warning dissemination, and public responses in the years since Mileti, Drabek, and Haas' (1975) review of hazard warning systems. He summarized the evidence supporting the impact of 32 different factors affecting warning response. Later, Sorensen and Sorensen (2007) summarized the findings of research on individuals' responses to emergency warnings for a broad range of hazards. Recently, Huang et al. (2012) summarized research findings and organized variables into nine categories—information sources, demographic characteristics, geographic location, personal experience, official warnings, social and environmental cues, perceived storm characteristics, expected personal impacts, and perceived evacuation impediments. In order to test the conclusions from these reviews, an SMA should select variables those studies have identified.

The present review has searched the psychological and sociological abstracts to identify 30 English-language empirical studies published between 1991 and 2012 that correlated households' evacuation decisions with the variables Baker (1991) and Sorensen (2001) identified. Among 30 articles, there are two kinds of studies: (1) those examining households' evacuation decisions after actual hurricane strikes; and (2) those examining respondents' evacuation intentions in response to hypothetical hurricanes or approaching hurricanes. Those 30 articles reported data from 46 independent studies—35 actual hurricane studies and 11 hypothetical evacuation studies (see Appendixes A and B).

2.1.2 SMA Methodology

Field and Gillett (2010) indicated that calculating effect sizes ($\bar{r}$, Pearson correlation coefficients) is an effective way to convert results from each study into a common statistical index. The analyst can then compute the weighted average correlation coefficient across the relevant studies to estimate the true effect of that variable. One problem is that studies vary in the statistical results they report; some present correlation coefficients (r), whereas the others only report regression coefficients (b), odd ratios (OR), or even just test statistics such as χ^2 values or significance levels (i.e., p values). However, these statistics can be transformed into a common effect size, so the first step of the SMA is to convert other statistical coefficients into correlation coefficients. Field and Gillett (2010) reported two important conversion equations.

$$r = \sqrt{\frac{\chi^2}{n}} \tag{2.1}$$

$$r = \frac{\sqrt{OR} - 1}{\sqrt{OR} + 1} \tag{2.2}$$

Next, the analyst can process the effect sizes using the Hunter and Schmidt (2004) method, which emphasizes the need to identify and eliminate sources of error, such as sampling error, variance restriction, and unreliability (Field & Gillett, 2010; Overstreet et al., 2013). First, the average effect size is estimated as the weighted mean of the correlations (r) from all studies, where the correlation from each study is weighted by the sample size (n) from that that study.

$$\bar{r} = \frac{\sum_{i=1}^{k} n_i r_i}{\sum_{i=1}^{k} n_i} \tag{2.3}$$

The variance of sample effect sizes (σ_r^2) is the frequency-weighted average squared error (see equation 2.4):

$$\hat{\sigma}_r^2 = \frac{\sum_{i=1}^{k} n_i (r_i - \bar{r})^2}{\sum_{i=1}^{k} n_i} \tag{2.4}$$

Next, the sampling error variance (σ_e^2), and the sampling error variance from the variance in sample correlations (σ_ρ^2) can be computed by Equations 2.5 and 2.6:

$$\hat{\sigma}_e^2 = \frac{(1 - \bar{r}^2)^2}{\bar{N} - 1} \tag{2.5}$$

$$\hat{\sigma}_\rho^2 = \hat{\sigma}_r^2 - \hat{\sigma}_e^2 \tag{2.6}$$

Then, the analyst can estimate the 95% confidence interval and 80% credibility interval of the effect size using Equations 2.7 and 2.8.

$$95\%CI = \bar{r} \pm 1.96\sqrt{\hat{\sigma}_e^2} \tag{2.7}$$

$$80\%CV = \bar{r} \pm 1.28\sqrt{\hat{\sigma}_\rho^2} \tag{2.8}$$

Finally, a χ^2 statistic in Equation 2.9 is used to measure the homogeneity of effect sizes.

$$\chi^2 = \sum_{i=1}^{k} \frac{(n_i - 1)(r_i - \bar{r})^2}{(1 - \bar{r}^2)^2} \tag{2.9}$$

2.1.3 SMA Criteria

Before proceeding with the results of the SMA for household evacuation decisions, there are some limitations that need to be identified. First, even though Field and Gillett (2010) suggested correcting for unreliability and variance restriction, the present review omits this stage because these data are generally unavailable in evacuation studies. Specifically, evacuation decision is measured as a single dichotomous item whose population variance is unknown (thus preventing correction for variance restriction) and whose reliability is also unknown but assumed to be high. Among the predictor variables, many are also measured as single items whose population variances are unknown and whose reliabilities cannot be estimated. Some psychological variables are measured by multi-item scales whose reliability can be estimated. However, reliability estimates for these variables are not often reported. Moreover, the psychological variables have unknown population variances. Demographic variables, like evacuation decisions, are typically measured by single items whose reliability is unknown but assumed to be high. In principle, population variances for the demographic variables can be estimated from census data, but the demographic composition of an evacuation zone is likely to differ—perhaps substantially—from that of the most readily available census units (e.g., a city or county).

Second, Nisbett and Wilson (1977) argued that people have poor insight into the causes of their behavior, which could cause studies of hypothetical scenarios to produce different results from studies of actual evacuations. Thus, the present SMA calculates separate effect sizes for actual hurricane evacuations and hypothetical evacuation studies. Moreover, some actual evacuation studies reported correlations whereas others reported regression coefficients or odds ratios. Even though odd ratios can be converted into correlations (see Equation 2.2), mixing studies with different statistical methods might result in systematic errors because regression coefficients control for the effects of other variables whereas correlation coefficients do not. Thus, the SMA begins by reporting each variable's estimated effect size separately for correlation and regression studies. Then, the SMA compares whether there is a significant difference between these two types of estimates of effect sizes. Since the hypothetical evacuation studies only reported regression coefficients, the distinction between correlation and regression studies is quite similar to the distinction between actual and hypothetical evacuation decisions.

Third, rather than reporting correlation and regression coefficients, some other studies reported respondents' ratings (dichotomous or continuous) of the importance of different variables in determining their decisions to evacuate. Mean ratings of variable importance present two problems for this SMA, the first of which is the question of accurate insight into the causes of one's own behavior. The second problem is that there is rarely enough information to calculate effect sizes from the reported data. Specifically, studies to date have generally reported the mean ratings of reasons for not evacuating only for those who did not evacuate and the reasons for evacuating only for those who did evacuate. Thus, it is impossible to compare the mean ratings for evacuees with those of non-evacuees to see if they are different from each other. Moreover, the lack of information about the sample standard deviation for each variable is a further impediment to the computation of an effect size. Thus, data on self-reported decision variable importance have been excluded from the SMA, but the results from these mean ratings of importance will be examined to see if they support or conflict with the results of the SMA for the correlation and regression coefficients.

Fourth, some variables were infrequently studied in previous research, which affects the SMA's ability to draw meaningful conclusions because of insufficient sample sizes. This review adopted the criterion proposed by Sanchez-Meca and Marin-Martinez (1997), whose Monte Carlo simulation of study homogeneity suggested that the number of studies (*K*) should be greater than or equal to six.

This review uses the 95% confidence interval (95% CI) as the standard for determining whether the effect sizes are significantly different from zero or significantly different from one another. In addition, the SMA, following Cohen (1988, 1992; see also Field & Gillett, 2010), identifies a variable having a small effect size if the average effect size $r = .1$, medium if $r = .3$, and large if $r = .5$.

This review also assesses the consistency of the results for each variable in terms of whether a result is repeatedly found among all published studies. In this SMA, consistency is described by the percentage of significant positive and negative results, respectively, and is classified into three categories—"Low (0% to 33%)," "Moderate (34% to 66%)," and "High (67% to 100%)."

Finally, this SMA compares the level of difference of effect sizes between actual hurricane studies and hypothetical evacuation studies by calculating the overlap of the 95% confidence intervals. Although this index has no rigorous statistical foundation, it can roughly describe the degree of the difference in the results of these two types of studies. This index is classified into three categories—"Low (0% to 33%)," "Moderate (34% to 66%)," and "High (67% to 100%)."

2.1.4 SMA Results

Information Sources

Lindell and Perry's (1992, 2004, 2012) PADM proposes that individual's protective action decision process begins with receiving information from different categories of sources. Many studies (e.g., Lindell et al., 2005; Solís et al., 2009; Meyer et al., 2013) examined this hypothesis and generally concluded that coastal residents rely more on local news media, somewhat less on national news media, then authorities' notices, and finally peers as information sources.

Reliance on authorities has been studied in 6 actual evacuation studies, which reported 1 (17%) positive correlation and 5 (83%) nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged $r = -.03$ to .21 with a nonsignificant weighted average $\bar{r} = .02$ (95% CI: $-.06 \leq r \leq .11$). A series of studies of North and South Carolina residents supports this result, with about 10% of coastal residents reporting that they relied on the advice of authorities in their evacuation decisions (Dow & Cutter, 1998, 2000; Cutter et al., 2011).

Reliance on news media has been studied in 13 actual evacuation studies that reported 6 (46%) positive correlations, 2 negative correlations (15%), and 5 (39%) nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged $r = -.23$ to .28 with a nonsignificant weighted average $\bar{r} = .03$ (95% CI: $-.06 \leq r \leq .13$). Dow and Cutter (1998, 2000) also reported that the percentage of residents' relying on the news media varied from 13% to 27% across hurricanes.

Reliance on peers has been studied in 9 actual evacuation studies. The studies reported 2 (22%) positive correlations and 7 (78%) nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged $r = .00$ to .25 with a significant weighted average $\bar{r} = .11$ (95% CI: $.05 \leq r \leq .17$). This finding conflicts with the results from the studies of self-rated importance, which report that most respondents do not rely on peer information in making their evacuation decisions (Dow & Cutter, 1998, 2000; Hasan et al., 2011; Meyer et al., 2013).

Demographic Characteristics

Baker (1991) concluded that demographic characteristics are typically not associated with hurricane evacuation. Nevertheless, 23 subsequent articles (comprising 29 actual evacuation studies and 8 hypothetical evacuation studies) examined the impact of demographic variables — age, female gender, ethnicity, marital status, household size, presence of children in the home, education, income, and homeownership.

Age has been studied in 22 actual evacuation studies and 2 hypothetical evacuation studies. Among the actual evacuation studies, 5 (23%) reported significant negative correlations, and 17 (77%) reported nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged $r = -.15$ to .12 with a nonsignificant weighted average $\bar{r} = -.01$ (95% CI: $-.08 \leq r \leq .06$). This result is also supported by the results from the hypothetical evacuation studies, which reported 1 (50%) significant negative correlations, and 1 (50%) nonsignificant correlations with a nonsignificant weighted average $\bar{r}$ = .00 (95% CI: -.11 ≤ r ≤ .10). Over all studies, age had low consistency (25%) with a nonsignificant $\bar{r}$ = -.01 (95% CI: -.08 ≤ r ≤ .06).

Female gender has been studied in 21 actual evacuation studies and 8 hypothetical evacuation studies[1]. Among the actual evacuation studies, 10 (48%) reported significant positive correlations, and 11 (52%) reported nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged r = -.08 to .21 with a significant weighted average $\bar{r}$ = .08 (95% CI: .01 ≤ r ≤ .14). This result conflicts with the results from the hypothetical evacuation studies, which reported 3 (38%) significant positive correlations, 2 (25%) significant negative correlations, and 3 (38%) nonsignificant correlations. The correlations for the hypothetical scenarios ranged r = -.10 to .14 with a nonsignificant weighted average $\bar{r}$ = -.02 (95% CI: -.09 ≤ r ≤ .04). Over all studies, female gender had moderate consistency (45%) with a nonsignificant weighted average $\bar{r}$ = .05 (95% CI: -.08 ≤ r ≤ .06).

White ethnicity has been studied in 13 actual evacuation studies and 4 hypothetical evacuation studies. Among the actual evacuation studies, 1 (8%) reported a significant positive correlation and 12 (92%) reported nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged r = -.10 to .23 with a nonsignificant weighted average $\bar{r}$ = .01 (95% CI: -.08 ≤ r ≤ .10). This result is consistent with the results from the hypothetical evacuation studies, which reported 4 (100%) nonsignificant correlations with a weighted average $\bar{r}$ = -.04 (95% CI: -.12 ≤ r ≤ .04). Over all studies,

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[1] Lindell et al. (2001) and Cassasco (2009) only reported the results of the significance tests instead of providing correlations.

white ethnicity had low consistency (6%) with a nonsignificant $\bar{r} = .00$ (95% CI: $-.09 \le r \le .09$).

Black ethnicity has been studied in 10 actual evacuation studies and 1 hypothetical evacuation study. Among the actual evacuation studies, 1 (10%) reported a significant positive correlation, 1 (10%) reported a significant negative correlation, and 8 (80%) reported nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged $r = -.41$ to .18 with a nonsignificant weighted average $\bar{r} = -.08$ (95% CI: $-.13 \le r \le -.03$). The only hypothetical evacuation study reported a contrary result—a significant $r = .20$ (Bhattacharjee et al., 2009). Over all studies, black ethnicity had low consistency (6%) and a nonsignificant effect size $\bar{r} = -.08$ (95% CI: $-.13 \le r \le .02$).

Hispanic ethnicity has been studied in 12 actual evacuation studies and 1 hypothetical evacuation study[1]. The actual evacuation studies reported 1 (8%) significant positive correlation, 1 (8%) significant negative correlation, and 10 (83%) nonsignificant correlations. The correlations for the actual evacuation studies ranged $r = -.21$ to .29 with a nonsignificant weighted average $\bar{r} = .00$ (95% CI: $-.05 \le r \le .05$).

Marital status has been studied in 8 actual evacuation studies[2] that reported 2 (25%) negative correlations and 6 (75%) nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged $r = -.16$ to .09 with a nonsignificant weighted average $\bar{r} = -.04$ (95% CI: $-.12 \le r \le .05$).

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[2] Lindell et al. (2005) only reported the results of the significance tests instead of providing correlations.

Household Size has been studied in 19 actual evacuation studies[2] and 2 hypothetical evacuation studies. Among the actual evacuation studies, 3 (16%) reported significant negative correlations and 16 (84%) reported nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged r = -.13 to .11 with a nonsignificant weighted average $\bar{r}$ = -.01 (95% CI: -.07 ≤ r ≤ .05). Even though the hypothetical evacuation studies reported only 1 (50%) significant positive correlation and 1 (50%) nonsignificant correlation, the results for the hypothetical studies are consistent with those of the actual evacuation studies with a nonsignificant weighted average $\bar{r}$ = .00 (95% CI: -.10 ≤ r ≤ .10). Over all studies, household size had low consistency (14%) with a nonsignificant effect size $\bar{r}$ = -.01 (95% CI: -.07 ≤ r ≤ .05).

Presence of children in the home has been studied in 23 actual evacuation studies that reported 8 (35%) significant positive correlations, 1 (4%) significant negative correlation, and 14 (61%) nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged r = -.24 to .45 with a nonsignificant weighted average $\bar{r}$ = .07 (95% CI: -.01 ≤ r ≤ .14).

Education has been studied in 18 actual evacuation studies[2] and 8 hypothetical hurricane studies[3]. Among the actual evacuation studies, 3 (17%) reported significant positive correlations, 1 (6%) reported a significant negative correlation, and 14 (77%) reported nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged r = -.10 to .17 with a nonsignificant weighted average $\bar{r}$ = .02 (95% CI:

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[3] Cassasco (2009) only reported the results of the significance tests instead of providing correlations.

$-.03 \leq r \leq .08$). This result is consistent with the results from the hypothetical evacuation studies, which reported 3 (38%) significant positive correlations, 1 (13%) significant negative correlation, and 4 (50%) nonsignificant correlations. Overall, the correlations for the hypothetical evacuation studies ranged $r = -.02$ to $.11$ with a nonsignificant weighted average $\bar{r} = .05$ (95% CI: $-.01 \leq r \leq .12$). Over all studies, education had low consistency (23%) with a nonsignificant $\bar{r} = .03$ (95% CI: $-.03 \leq r \leq .09$). One interesting finding is that all of the six studies reporting significant positive correlations were published after 2009, which suggests the impact of education on evacuation decisions might be increasing over time.

Income has been studied in 29 actual evacuation studies[4] and 7 hypothetical evacuation studies. Among the actual evacuation studies, 4 (14%) reported significant positive correlations, 6 (21%) reported significant negative correlations, and 19 (65%) reported nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged $r = -.21$ to $.33$ with a nonsignificant weighted average $\bar{r} = .01$ (95% CI: $-.05 \leq r \leq .07$). This result is consistent with the results from the hypothetical evacuation studies, which reported 1 (14%) significant negative correlation and 6 (86%) nonsignificant correlations. Overall, the correlations for the hypothetical evacuation studies ranged $r = -.02$ to $.01$ with a nonsignificant weighted average $\bar{r} = .00$ (95% CI:

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[4] Van Willigen et al. (2002) and Lindell et al. (2005) only reported the results of the significance tests instead of providing correlations.

$-.09 \leq r \leq .08$). Over all studies, income had low consistency (19%) with a nonsignificant $\bar{r} = .01$ (95% CI: $-.06 \leq r \leq .07$).

Homeownership has been studied in 25 actual evacuation studies[2] and 3 hypothetical evacuation studies. Among the actual evacuation studies, 13 (52%) reported significant negative correlations and 12 (48%) reported nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged $r = -.46$ to .04 with a significant weighted average $\bar{r} = -.10$ (95% CI: $-.16 \leq r \leq -.04$). This result conflicts with the results from the hypothetical evacuation studies, which reported 1 (33%) significant positive correlation and 2 (67%) nonsignificant correlations with a nonsignificant weighted average $\bar{r} = .06$ (95% CI: $-.04 \leq r \leq .16$). Over all studies, homeownership had moderate consistency (46%) with a nonsignificant $\bar{r} = -.09$ (95% CI: $-.16 \leq r \leq .03$).

Geographic Location

Researchers believe that physical danger resulting from hazard exposure and physical vulnerability is associated with households' evacuation (Mileti & O'Brien, 1992). Thus, people who live in a risk-prone area would be more likely to leave when a hurricane threatens. This SMA collected 23 published articles examining the impact of *Risk area*, which has been studied in 19 actual evacuation studies[5] and 4 hypothetical evacuation studies[3]. Among the actual evacuation studies, 16 (84%) reported significant positive correlations and 3 (16%) reported nonsignificant correlations. Overall, the correlations for

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[5] Vu (2009) only reported the results of the significance tests instead of providing correlations.

the actual evacuation studies ranged r = -.02 to .49 with a significant weighted average $\bar{r}$ = .17 (95% CI: .09 ≤ r ≤ .24). This result is consistent with the results from the hypothetical evacuation studies, which reported 3 (75%) significant positive correlations and 1 (25%) nonsignificant correlation with a significant weighted average $\bar{r}$ = .20 (95% CI: .15 ≤ r ≤ .25). In addition, a South Carolina hypothetical evacuation study found about 75% to 85% of risk area residents would evacuate from a major hurricane, which is higher than the 69% of inland residents who would do so (Cutter et al., 2011). Over all studies, risk area had high consistency (79%) with a significant effect size $\bar{r}$ = .17 (95% CI: .10 ≤ r ≤ .24).

Personal Experience

Lindell and Perry (2004) concluded that previous hurricane experience can help residents understand their physical risk and motivate them to evacuate. However, Baker (1991) and Gladwin and Peacock (1997) concluded that, even though one would expect households' evacuation behavior to be affected by their previous experience, the impact of hurricane experience reported by previous studies varies greatly. The present SMA collected 14 previous articles studying in evacuation experience and "unnecessary" evacuation experience (evacuation from an area that was not subsequently struck by a hurricane).

Previous Experience has been studied in 17 actual evacuation studies and 2 hypothetical evacuation studies. Among the actual evacuation studies, 4 (24%) reported significant positive correlations, 1 (6%) reported a significant negative correlation, and 12

(70%) reported nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged $r = -.12$ to $.30$ with a nonsignificant weighted average $\bar{r} = .02$ (95% CI: $-.06 \leq r \leq .09$). This result is consistent with the results from the hypothetical evacuation studies, which reported 1 (50%) significant negative correlation and 1 (50%) nonsignificant correlation with a nonsignificant weighted average $\bar{r} = -.06$ (95% CI: $-.17 \leq r \leq .04$). In addition, Dow and Cutter (1998; 2000) reported that less than 15% of households reported depending on their previous experience as a reason for evacuating whereas Brommer and Senkbeil (2010) found that 83% of households' reported relying on previous experience. Over all studies, previous experience had low consistency (21%) and a nonsignificant $\bar{r} = .01$ (95% CI: $-.07 \leq r \leq .09$).

"Unnecessary" Evacuation Experience has been studied in 5 actual evacuation studies that reported 4 (80%) negative correlations and 1 (20%) nonsignificant correlation. Overall, the correlations for the actual evacuation studies ranged $r = -.16$ to $.15$ with a nonsignificant weighted average $\bar{r} = -.06$ (95% CI: $-.15 \leq r \leq .04$).

Official Warning

Baker (1991) indicated that an official warning—whether it was a National Hurricane Center hurricane watch or warning, a local official's recommendation, a voluntary evacuation order, or a mandatory evacuation order—is the strongest predictor of household evacuation decisions and subsequent research examined the effect of this variable in 16 actual evacuation studies and 4 hypothetical evacuation studies. Among the actual evacuation studies, 14 (88%) reported significant positive correlations and 2 (12%)

reported nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged $r = -.04$ to .64 with a significant weighted average $\bar{r} = .36$ (95% CI: $.31 \leq r \leq .42$). Although the correlations provided by hypothetical evacuation studies are generally lower than actual evacuation studies with a significant weighted average $\bar{r} = .15$ (95% CI: $.07 \leq r \leq .23$), all four hypothetical evacuation studies reported significant positive effects that are consistent with actual evacuation studies. Dow and Cutter (1998, 2000) supported this result by reporting that about 20% of North and South Carolina coastal residents reported relying on official warnings in their evacuation decisions. Over all studies, official warning had high consistency (90%) with a significant $\bar{r} = .34$ (95% CI: $.28 \leq r \leq .39$).

Observed Social and Environmental Cues

Social and environmental cues can be powerful motivating factors for evacuation if warnings are weak or unavailable (Lindell & Perry, 2004). These social and environmental cues include observations of storm conditions, peers' evacuating, and business closing. Eleven articles examined how social and environmental cues affect households' evacuation decisions.

Storm Conditions has been studied in 2 actual evacuation studies and 4 hypothetical evacuation studies. Both of the actual evacuation studies reported significant positive correlations that ranged $r = .12$ to .22 with a weighted average $\bar{r} = .17$ (95% CI: $.09 \leq r \leq .25$). This result is consistent with the results from the hypothetical evacuation studies, which reported 2 (50%) significant positive correlations and 2 (50%)

nonsignificant correlations with a weighted average $\bar{r}$ = .17 (95% CI: $.09 \leq r \leq .25$). Over all studies, storm conditions had high consistency (67%) with a significant effect size $\bar{r}$ = .17 (95% CI: $.09 \leq r \leq .25$).

Peers Evacuating has been studied in 8 actual evacuation studies, all of which reported significant positive correlations that ranged r = .24 to .49 with a significant weighted average $\bar{r}$ = .32 (95% CI: $.24 \leq r \leq .40$). Cutter et al.'s (2011) evacuation intention study confirmed this result by reporting that 52% of respondents would be likely to evacuate when they see peers leaving.

Businesses Closing has been studied in 2 actual evacuation studies, both of which reported significant positive correlations that ranged r = .16 to .24 with a significant weighted average $\bar{r}$ = .20 (95% CI: $.12 \leq r \leq .28$).

Perceived Storm Characteristics

Baker (1991) concluded that when a hurricane approaches, coastal residents obtain information about its location intensity, size, forward movement speed, and likely landfall. Eleven published articles assessed the impact of perceived storm characteristics on evacuation decisions:

Intensity has been studied in 8 actual evacuation studies and 2 hypothetical evacuation studies, all of which reported significant positive correlations that ranged r = .04 to .11 with a weighted average $\bar{r}$ = .07 (95% CI: $.02 \leq r \leq .12$). However, the correlations in hypothetical evacuation studies, which have a weighted average $\bar{r}$ = .31 (95% CI: $.24 \leq r \leq .39$), are much higher than those in actual evacuation studies. Moreover, Dow and her colleagues (Dow & Cutter, 1998, 2000; Cutter et al. 2011) reported that 24-32% of respondents reported their decisions were affected by hurricane intensity. Over all studies, intensity had perfect consistency (100%) with a significant effect size $\bar{r} = .09$ (95% CI: $.04 \leq r \leq .14$).

Nearby Landfall has only been studied in 1 actual evacuation study and 1 hypothetical evacuation study. The actual evacuation study reported a nonsignificant result with $r = .04$ (95% CI: $-.04 \leq r \leq .12$) as did the hypothetical evacuation study — $r = .00$ (95% CI: $-.08 \leq r \leq .09$). Even though few studies provided statistical results, many studies (e.g., Dow & Cutter, 1998; 2000; Lindell et al., 2005; Smith et al., 2009; Cutter et al. 2011) found that evacuation rate was higher when residents believed their homes would be directly hit by a hurricane.

Rapid Onset has been studied in 3 actual evacuation studies and 2 hypothetical evacuation studies. Among the actual evacuation studies, 2 (67%) reported significant negative correlations and 1 (33%) reported a nonsignificant correlation. Overall, the correlations for the actual evacuation studies ranged $r = -.03$ to .00 with a weighted average $\bar{r} = -.01$ (95% CI: $-.08 \leq r \leq .05$). This result is consistent with the results from the hypothetical evacuation studies, which reported 2 (100%) significant negative correlations with a weighted average $\bar{r} = -.03$ (95% CI: $-.11 \leq r \leq .06$). Other studies (e.g., Riad et al., 1999; Smith et al., 2009) reported that about 5% of respondents rated ”not having enough time” as their reason for not evacuating. Over all studies, rapid onset had high consistency (80%) with a nonsignificant effect size $\bar{r} = -.01$ (95% CI: $-.09 \leq r \leq .06$).

Expected Personal Impacts

Baker (1991) concluded that expectation of personal impacts, rather than other storm characteristics, is a better explanation of residents' evacuation decisions. These impacts have been characterized as death or serious injury to an individual, damage or destruction to personal property (Gladwin et al., 2001; Huang et al., 2012; Lindell et al., 2005). A more recent study defined expectations of personal impact by six variables—property damage by storm surge, flood, or wind; personal casualties (death or injury to self or loved ones), job disruption, and service disruption (Huang et al., 2012). This SMA examined the findings for expected personal impact in 20 articles.

Surge Damage Risk has been studied in 5 actual evacuation studies and 1 hypothetical evacuation study. Among the actual evacuation studies, 3 (60%) reported significant positive correlations and 2 (40%) reported nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged $r = -.01$ to .35 with a significant weighted average $\bar{r} = .22$ (95% CI: $.11 \leq r \leq .32$). Although Fu's (2004) hypothetical evacuation study also provided a significant positive result, the correlation was much lower than in the actual evacuation studies and nonsignificant — $r = .06$ (95% CI: $-.02 \leq r \leq .14$). Over all studies, surge risk had high consistency (67%) with a significant $\bar{r} = .17$ (95% CI: $.08 \leq r \leq .27$).

Flood Damage Risk has been studied in 11 actual evacuation studies and 3 hypothetical evacuation studies. Among the actual evacuation studies, 7 (64%) reported significant positive correlations and 3 (36%) reported nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged $r = -.05$ to .32 with a significant weighted average $\bar{r}$ = .13 (95% CI: $.05 \le r \le .22$). This result is consistent with the results from the hypothetical evacuation studies, which reported 1 (33%) significant positive correlation and 2 (67%) nonsignificant correlations with a significant weighted average $\bar{r}$ = .12 (95% CI: $.04 \le r \le .19$). Over all studies, flood risk had moderate consistency (57%) with a significant $\bar{r}$ = .13 (95% CI: $.04 \le r \le .21$).

Wind Damage Risk has been studied in 8 actual evacuation studies and 4 hypothetical evacuation studies. Among the actual evacuation studies, 6 (75%) reported significant positive correlations and 2 (25%) reported nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged r = .06 to .29 with a significant weighted average $\bar{r}$ = .14 (95% CI: $.05 \le r \le .22$). This result conflicts with the results from the hypothetical evacuation studies, which reported 1 (25%) significant positive correlation, 1 (25%) significant negative correlation, and 2 (50%) nonsignificant correlations with a nonsignificant weighted average $\bar{r}$ = -.01 (95% CI: $-.09 \le r \le .07$). Over all studies, wind risk had moderate consistency (58%) but a nonsignificant with a weighted average $\bar{r}$ = .08 (95% CI: $.00 \le r \le .17$).

Personal casualties has been studied in 6 actual evacuation studies that reported 3 (50%) significant positive correlations and 3 (50%) nonsignificant correlations. Overall, the correlations ranged r = -.06 to .46 with a significant weighted average $\bar{r}$ = .22 (95% CI: $.11 \le r \le .32$).

Job Disruption has been studied in 3 actual evacuation studies and 1 hypothetical evacuation study. Among the actual evacuation studies, 1 (33%) reported a significant negative correlation and 2 (67%) reported nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged $r = -.15$ to $.02$ with a significant weighted average $\bar{r} = -.07$ (95% CI: $-.12 \leq r \leq -.02$). The Bhattacharjee et al. (2009) hypothetical evacuation study supported this result with $r = -.10$ (95% CI: $-.18 \leq r \leq -.01$). In addition, some studies (e.g., Dow & Cutter, 1998, 2000; Smith et al., 2009) also reported job disruption was the reason for about 7-10% of residents refusing to leave. Over all studies, job disruption had high consistency (75%) with a significant $\bar{r} = -.07$ (95% CI: $-.12 \leq r \leq -.01$).

Service Disruption has only been studied in 1 actual evacuation study that reported a nonsignificant $r = .07$ (95% CI: $-.01 \leq r \leq .15$).

Perceived Evacuation Impediments

Baker (1991) indicated that it is as important to identify residents' reasons for refusing to evacuate as to understand their reasons for evacuation (also see Riad et al., 1999; Dow and Cutter, 2000). Huang et al. (2012) summarized previous studies and classified evacuation impediments into four categories of concerns—looters, property protection from the storm, evacuation expenses, and traffic jams. This SMA examined 12 articles addressing these issues.

Looting Concerns has been studied in 2 actual evacuation studies that reported 1 (50%) significant negative correlation and 1 (50%) nonsignificant correlation. Overall, the correlations for the actual evacuation studies ranged $r = -.08$ to $-.04$ with a nonsignificant weighted average $\bar{r} = -.06$ (95% CI: $-.15 \leq r \leq .02$).

Property Protection from the Storm has been studied in 3 actual evacuation studies and 1 hypothetical evacuation study. Among the actual evacuation studies, 1 (33%) reported a significant negative correlation and 2 (67%) reported nonsignificant correlations. Overall, the correlations for the actual evacuation studies ranged r = -.22 to .05 with a nonsignificant weighted average $\bar{r}$ = -.05 (95% CI: -.14 ≤ r ≤ .03). Consistent with this finding, the Lazo et al. (2010) hypothetical evacuation study found a nonsignificant result with r = -.16 (95% CI: -.26 ≤ r ≤ .07). Over all studies, property protection had low consistency (25%) with a nonsignificant $\bar{r}$ = -.08 (95% CI: -.17 ≤ r ≤ .01).

Evacuation Expense has been examined in 2 actual evacuation studies that reported 1 (50%) significant positive correlation and 1 (50%) nonsignificant correlation. Overall, these correlations ranged r = .02 to .14 with a nonsignificant weighted average $\bar{r}$ = .08 (95% CI: -.01 ≤ r ≤ .16).

Traffic Jams has been studied in 4 actual evacuation studies and 1 hypothetical evacuation study. The actual evacuation studies reported nonsignificant correlations that ranged r = .01 to .17 with a nonsignificant weighted average $\bar{r}$ = .05 (95% CI: -.05 ≤ r ≤ .15). This result is consistent with the Lazo et al. (2010) hypothetical evacuation study that reported a nonsignificant r = .10 (95% CI: .00 ≤ r ≤ .20). Over all studies, traffic jams had low consistency (0%) with a nonsignificant $\bar{r}$ = .06 (95% CI: -.04 ≤ r ≤ .16).

2.1.5 Summary

Table 2.1 summarizes the relationships of independent variables to evacuation decision by actual studies and hypothetical scenarios, respectively. These results reveal that the effect sizes from the correlational analyses are generally consistent with those from the regression analyses. After combining the correlations from these two sets of studies, the results from the actual hurricane studies indicate that an individual who relies on peers' advice; is female; lives in a hurricane risk area; receives an official warning; observes storm conditions, sees peers evacuating or business closing; perceives a high storm intensity a high risk of damage from storm surge, inland flooding, or wind, or risk of personal casualties would be more likely to evacuate. By contrast, an individual who is Black, a homeowner, or who expects job disruption would be less likely to evacuate.

Figure 2.1 extends the data in Table 2.1 by cross-plotting consistency by effect size and splitting variables into four groups based upon the four quadrants of the figure. First, the results indicate that official warnings, observations of peers evacuating, expected casualties, risk area, wind damage risk, flood damage risk, homeownership, surge damage risk, observation of businesses closing, and storm conditions are strong and consistent predictors of households' evacuation decisions. Next, there are other variables—hurricane intensity, female gender, children in the home, reliance on news media, expected evacuation expenses, expected job disruption, expected service disruption, unnecessary evacuation experience, looting concerns, property protection concerns, and rapid storm onset—that might be useful predictor variables because they had high consistency even though they had low correlations. Third, reliance on peers and Black ethnicity, which had low consistency but sometimes had high impact, might also be useful predictor variables. Finally, consistent with Baker's (1991) conclusions, the remaining demographic variables, hurricane experience, expected nearby landfall, and traffic jams have no significant impact on hurricane evacuation.

This review also compares whether studies of evacuation from actual hurricanes differ from those of expected evacuation from hypothetical scenarios, even though the hypothetical scenarios only examined 15 of 34 variables. As Table 2.2 indicates, these two types of studies produced identical signs of the correlations on 8 of 15 variables. Moreover, the 95% CIs had high overlap for five variables (age, income, observation of storm conditions, rapid onset, and flood damage risk), medium overlap for five (White ethnicity, household size, education, risk area, and hurricane experience), and low overlap for five (female gender, homeownership, official warning, hurricane intensity, and wind damage risk). Respondents in hypothetical scenarios had lower average effect sizes than those facing actual hurricanes for official warnings and wind damage risk but higher average effect sizes for hurricane intensity.

Table 2.1 Relationship of Independent Variables to Evacuation Decision by Actual and Hypothetical Studies

		K_corr	N_corr	r_corr	K_corr+reg	N_corr+reg	r_corr+reg	% of PS	% of NS	SD	SE	$95\%CI^-$	$95\%CI^+$	$80\%CV^-$	$80\%CV^+$	χ^2
Authority	A	1	507	.21¥	6	3,217	0.02	17%	0%	.08	.04	-.06	.11	-.07	.11	21.96**
	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
News Media	A	5	1,986	.08	13	5,668	0.03	46%	15%	.12	.05	-.06	.13	-.11	.17	81.26**
	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peer	A	2	2,502	.13	9	8,338	0.11*	22%	0%	.09	.03	.05	.17	.00	.22	71.97**
	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Age	A	8	3,210	-.04	22	16,742	-0.01	0%	23%	.05	.04	-.08	.06	-.05	.02	34.82**
	H	-	-	-	2	710	0.00	0%	50%	.01	.05	-.11	.10	-	-	0.09**
Female Gender	A	7	4,550	.08	21	20,317	0.08*	48%	0%	.05	.03	.01	.14	.02	.13	61.46**
	H	-	-	-	6	5,649	-0.02	38%	25%	.09	.03	-.09	.04	-.13	.09	46.56**
White	A	6	2,272	-.03	13	6,370	0.01	8%	0%	.10	.05	-.08	.10	-.10	.12	58.18**
	H	-	-	-	4	2,362	-0.04	0%	0%	.06	.04	-.12	.04	-.09	.02	8.56**
Black	A	1	1,881	-.08	10	15,102	-0.08*	10%	10%	.11	.03	-.13	-.03	-.22	.05	190.51**
	H	-	-	-	1	532	0.20*	100%	0%	.00	.04	.12	.28	-	-	0.00
Hispanic	A	2	2,193	-.10¥	12	15,654	0.00	8%	8%	.11	.02	-.05	.05	-.14	.14	195.49**
	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marital Status	A	4	1,850	.01	7	3,729	-0.04	0%	25%	.08	.04	-.12	.05	-.11	.04	21.03**
	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HH Size	A	3	2,874	-.01	18	19,994	-0.01	0%	16%	.04	.03	-.07	.05	-.05	.02	33.95**
	H	-	-	-	2	710	0.00	50%	0%	.02	.05	-.10	.10	-	-	0.21**
Children at home	A	8	6,343	.07	23	17,670	0.07	35%	4%	.13	.04	-.01	.14	-.09	.23	301.34**
	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Education	A	5	5,037	.04	17	21,518	0.02	17%	6%	.06	.03	-.03	.08	-.04	.09	75.84**
	H	-	-	-	7	6,181	0.05	38%	13%	.05	.03	-.01	.12	.00	.11	17.64**
Income	A	6	5,468	-.01	27	26,817	0.01	14%	21%	.05	.03	-.05	.07	-.05	.06	78.12**
	H	-	-	-	6	3,204	0.00	0%	14%	.01	.04	-.09	.08	-	-	0.16
Homeownership	A	6	5,607	-.06	24	24,343	-0.10*	0%	52%	.07	.03	-.16	-.04	-.18	-.03	105.55**
	H	-	-	-	3	1,242	0.06	33%	0%	.02	.04	-.04	.16	-	-	0.46**
Risk Area	A	5	2,458	.19	18	12,883	0.17*	84%	0%	.13	.04	.09	.24	.00	.33	241.68**
	H	-	-	-	3	4,116	0.20*	75%	0%	.09	.03	.15	.25	.09	.30	32.96**
HrrExperience	A	6	4,058	.00	17	11,660	0.02	24%	6%	.11	.04	-.06	.09	-.11	.14	133.01**
	H	-	-	-	2	710	-0.06	0%	50%	.03	.05	-.17	.04	-	-	0.79**
Unnecessary Experience	A	3	1,281	-.07	5	2,055	-0.06	0%	80%	.11	.05	-.15	.04	-.18	.06	22.79**
	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Official Warning	A	7	6,348	.25¥	16	16,706	0.36*	88%	0%	.16	.03	.31	.42	.16	.57	587.24**
	H	-	-	-	4	2,353	0.15*	100%	0%	.06	.04	.07	.23	.09	.20	8.84**
Storm Condition	A	2	1,069	.17	2	1,069	0.17*	100%	0%	.05	.04	.09	.25	.14	.21	2.83**
	H	-	-	-	4	2,278	0.17*	50%	0%	.09	.04	.09	.25	.06	.27	20.69**
Peers Evacuating	A	5	2,180	.35	8	3,729	0.32*	100%	0%	.06	.04	.24	.40	.26	.38	18.40**
	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 2.1 continued

		K_corr	N_corr	r_corr	K_corr+reg	N_corr+reg	r_corr+reg	% of PS	% of NS	SD	SE	95%CI$^-$	95%CI$^+$	80%CV$^-$	80%CV$^+$	X^2
Businesses Closing	A	2	1,069	.20	2	1,069	0.20*	100%	0%	.04	.04	.12	.28	-	-	1.85**
	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hurricane Intensity	A	2	2,443	.08	8	13,372	0.07*	100%	0%	.01	.02	.02	.12	-	-	2.83**
	H	-	-	-	2	1,064	0.31*	60%	0%	.09	.04	.24	.39	.21	.41	9.76**
Nearby Landfall	A	1	562	.04	1	562	0.04	0%	0%	.00	.04	-.04	.12	-	-	0.00
	H	-	-	-	1	532	0.00	100%	0%	.00	.04	-.08	.09	-	-	0.00
Rapid Onset	A	1	562	-.03	3	2,678	-0.01	0%	67%	.01	.03	-.08	.05	-	-	0.52**
	H	-	-	-	2	1,064	-0.03	0%	100%	.03	.04	-.11	.06	-	-	0.79**
Surge Risk	A	3	1,103	.30	5	1,644	0.22*	60%	0%	.13	.05	.11	.32	.06	.37	31.18**
	H	-	-	-	1	607	0.06	100%	0%	.00	.04	-.02	.14	-	-	0.00
Flood Risk	A	5	2,243	.13	11	5,848	0.13*	64%	0%	.08	.04	.05	.22	.05	.22	39.51**
	H	-	-	-	3	1,962	0.12*	25%	0%	.07	.04	.04	.19	.04	.20	10.95**
Wind Risk	A	4	1,673	.19	8	4,117	0.14*	75%	0%	.07	.04	.05	.22	.06	.21	21.99**
	H	-	-	-	4	2,272	-0.01	20%	20%	.10	.04	-.09	.07	-.13	.11	22.95**
Casualties	A	3	986	.28	6	1,838	0.22*	50%	0%	.19	.05	.11	.32	-.01	.45	70.32**
	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Job Disruption	A	2	2,557	.00¥	3	4,552	-0.07*	0%	33%	.07	.03	-.12	-.02	-.15	.02	23.19**
	H	-	-	-	1	532	-0.10*	0%	100%	.00	.04	-.18	-.01	-	-	0.00
Service Disruption	A	1	562	.07	1	562	0.07	100%	0%	.00	.04	-.01	.15	-	-	0.00
	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Looting	A	2	1,069	-.06	2	1,069	-0.06	0%	50%	.02	.04	-.15	.02	-	-	0.43**
	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Property Protect	A	2	1,069	.01	3	1,497	-0.05	0%	33%	.11	.04	-.14	.03	-.18	.07	18.00**
	H	-	-	-	1	400	-0.16*	0%	0%	.00	.05	-.26	-.07	-	-	0.00
Evacuation Expense	A	2	1,069	.08	2	1,069	0.08	50%	0%	.06	.04	-.01	.16	.02	.13	3.88**
	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Traffic Jams	A	3	1,281	.04	4	1,493	0.05	0%	0%	.06	.05	-.05	.15	.01	.09	5.42**
	H	-	-	-	1	400	0.10	0%	0%	.00	.05	.00	.20	-	-	0.00

¥: *r*_corr is outside of 95%CI of *r*_corr+reg

*: 95%CI of *r*_corr+reg is different from 0

**: result of $\chi 2$ test is significant at 5% level

K_corr: Number of correlations from correlational analysis; N_corr: Combined sample size among correlational analyses; r_corr: Estimated mean correlation of correlational analysis; K_corr+reg: Number of correlations from both correlational and regression analyses; N_corr+reg: Combined sample size among both correlational and regression analyses; r_corr+reg: Estimated mean correlation of both correlational and regression analyses; % of PS: Percentage of positive significant case; % of NS: Percentage of negative significant case; SD: Standard deviation; SE: Standard error; 95%CI: 95% confidence interval; 80%CV: 80% credibility interval; X^2: Chi-square; % of overlap: Percentage of overlap of 95% confidence interval between actual studies and hypothetical scenario.

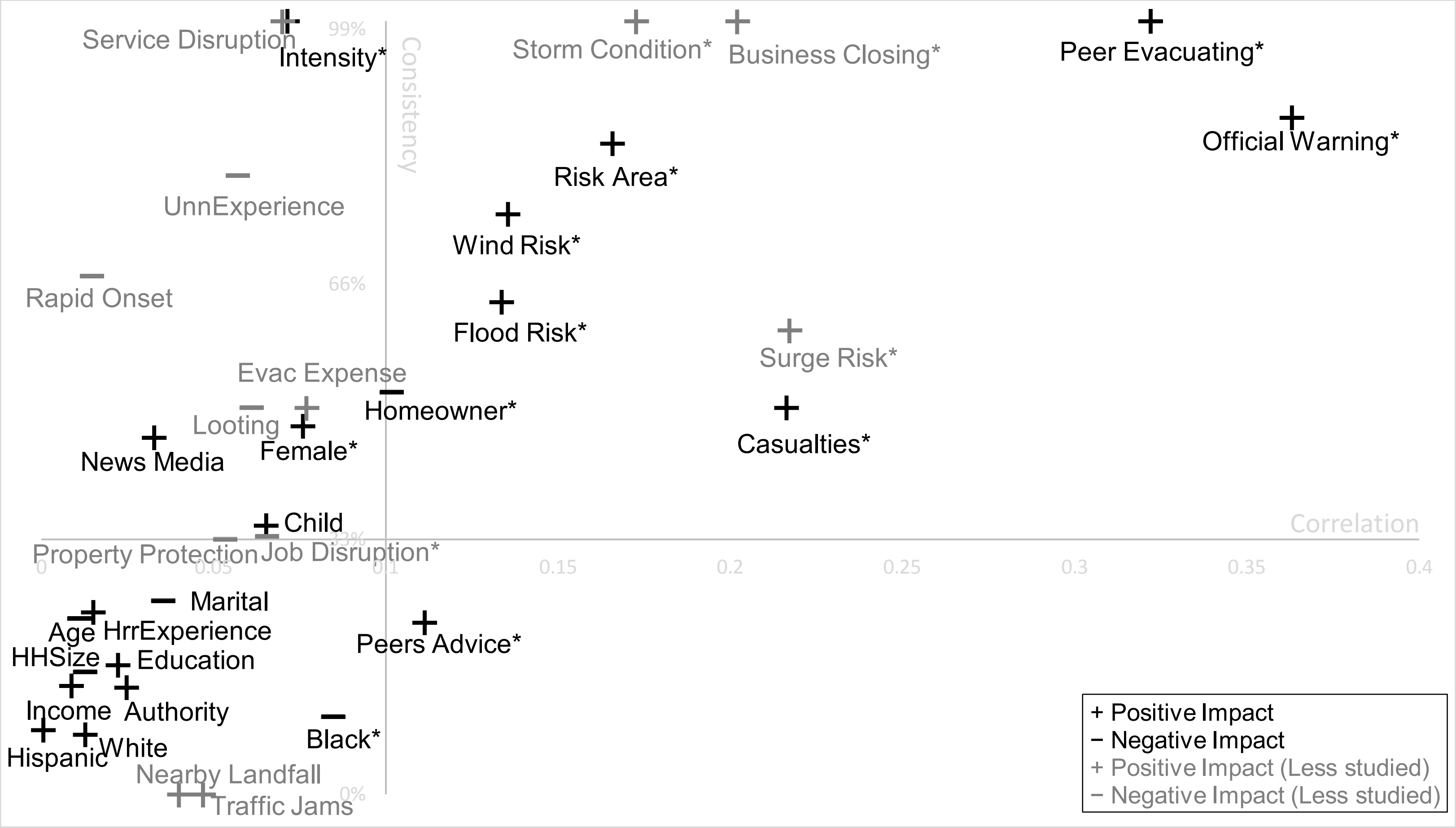

Figure 2.1 Intersection of Consistency by Correlation (effect size) among Actual Studies

Table 2.2 Comparison between Actual and Hypothetical Studies

	Study type	K	N	Range		*r*	95%CI		Sign	Overlap**
Age	A	22	16,742	-.15	.12	-.01	-.08	.06	-	H
	H	2	710	-.01	.01	.00	-.11	.10	-	
Female	A	21	20,317	-.08	.21	.08*	.01	.14	+	L
	H	6	5,649	-.10	.14	-.02	-.09	.04	-	
White	A	13	6,370	-.10	.23	.01	-.08	.10	+	M
	H	4	2,362	-.09	.08	-.04	-.12	.04	-	
HH Size	A	18	19,994	-.13	.11	-.01	-.07	.05	-	M
	H	2	710	-.01	.02	.00	-.10	.10	+	
Education	A	17	21,518	-.10	.17	.02	-.03	.08	+	M
	H	7	6,181	-.02	.11	.05	-.01	.12	+	
Income	A	27	26,817	-.21	.33	.01	-.05	.07	+	H
	H	6	3,204	-.02	.01	.00	-.09	.08	-	
Homeowner	A	24	24,343	-.46	.04	-.10*	-.16	-.04	-	L
	H	3	1,242	.03	.08	.06	-.04	.16	+	
Risk Area	A	18	12,883	-.02	.49	.17*	.09	.24	+	M
	H	3	4,116	.05	.25	.20*	.15	.25	+	
Hrr Experience	A	17	11,660	-.12	.30	.02	-.06	.09	+	M
	H	2	710	-.09	-.02	-.06	-.17	.04	-	
Official Warning	A	16	16,706	.04	.64	.36*	.31	.42	+	L
	H	4	2,353	.06	.23	.15*	.07	.23	+	
Storm Condition	A	2	1,069	.12	.22	.17*	.09	.25	+	H
	H	4	2,278	.09	.31	.17*	.09	.25	+	
Intensity	A	8	13,372	.04	.11	.07*	.02	.12	+	L
	H	2	1,064	.23	.40	.31*	.24	.39	+	
Rapid Onset	A	3	2,678	-.03	.00	-.01	-.08	.05	-	H
	H	2	1,064	-.05	.00	-.03	-.11	.06	-	
Flood Risk	A	11	5,848	-.05	.32	.13*	.05	.22	+	H
	H	3	1,962	.04	.20	.12*	.04	.19	+	
Wind Risk	A	8	4,117	.06	.29	.14*	.05	.22	+	L
	H	4	2,272	-.16	.09	-.01	-.09	.07	-	

A: Actual evacuation study; H: Hypothetical evacuation study; K: Number of correlations; N: Combined sample size; *r*: Estimated mean correlation; 95%CI: 95% confidence interval; Overlap: The level of overlap on 95%CI between actual and hypothetical studies.

*: 95%CI of *r* is different from 0

**: H (high): percentage of overlap ≥ 67%; M (moderate): 34% ≤ percentage of overlap ≤ 66%; L (low): percentage of overlap ≤ 33%

2.2 Conceptual Model and Research Hypotheses

In general, the SMA results are consistent with the Huang et al. (2012) abbreviated version of PADM, which shows how stakeholders' characteristics and information from warnings and social and environmental cues directly affect people's perceptions of storm characteristics which, in turn, affect risk perceptions (i.e., expected personal impacts), and, ultimately, their final evacuation decisions. Nonetheless, this SMA finds significant impacts of minority ethnicity and homeownership, which were not significant in the Hurricane Ike evacuation study (Huang et al., 2012). In addition, some of the variables (e.g., perceived evacuation impediments) that were not significant in the SMA are still worth retesting because they were only examined by a few previous studies. Thus, this study proposes a revised conceptual model (depicted in Figure 2-2) that yields 14 hypotheses when applied to the Hurricane Katrina and Rita evacuations:

H1: Risk area residents will rely on some information sources more than others and the order will be local news media > national news media > local authorities > peers.

H2: Female gender will be positively related to perceived storm characteristics.

H3: Minority ethnicity will be negatively related to perceived storm characteristics.

H4: Homeownership will be negatively related to perceived storm characteristics.

H5: Information sources will be positively related to perceived storm characteristics.

H6: Official warnings will be positively related to perceived storm characteristics.

H7: Previous hurricane experience will be positively related to perceived storm characteristics.

H8: Coastal proximity will be positively related to perceived storm characteristics.

H9: Observation of environmental and social cues will be positively related to perceived storm characteristics.

H10: "Unnecessary" evacuation experience will be positively related to perceived evacuation impediments.

H11: Perceived storm characteristics will be positively related to expected personal impacts.

H12: Expected personal impacts will be positively related to evacuation decisions.

H13: Perceived evacuation impediments will be negatively related to evacuation decisions.

H14: Communities closer to the point of landfall and risk areas closer to the coastline will have higher evacuation rates than those that are farther from the point of landfall.

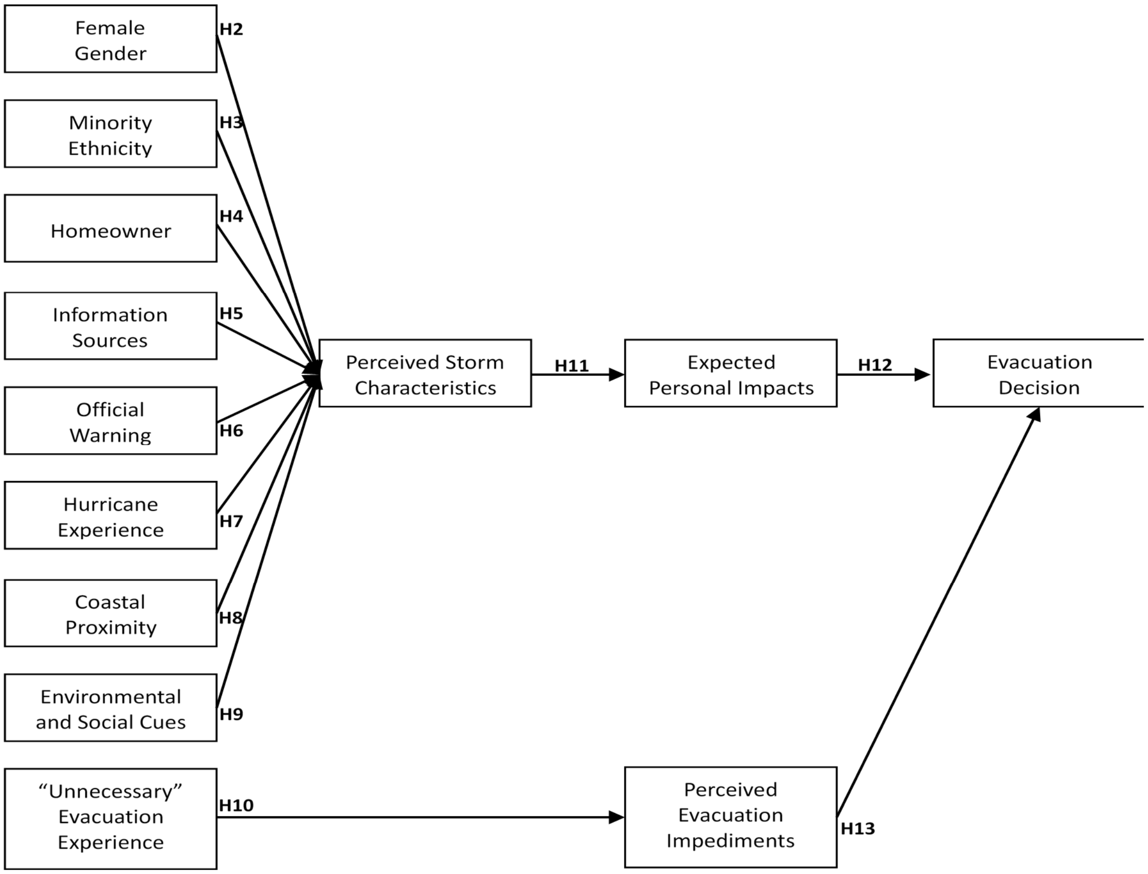

Figure 2.2 The Conceptual Model of the Study

CHAPTER III

METHOD

3.1 Data Collection

This dissertation will analyze two datasets derived from households' responses to Hurricanes Katrina and Rita. The Katrina data were collected from two Louisiana parishes (Jefferson Parish and St. Charles Parish) whereas the Rita data were collected from seven Texas counties (Orange, Jefferson, Newton, Jasper, Hardin, Galveston and Harris). Both datasets were collected from late 2005 to early 2006. The following description of the survey procedures is based upon Lindell and Prater's (2008) preliminary analysis of these data.

3.1.1 Hurricane Katrina Two Parish Mail Survey

Hurricane Katrina, which was one of the most powerful and deadly hurricanes in the history of the Atlantic basin, originally formed as Tropical Depression Twelve in the southeastern Bahamas on August 23rd, 2005. The storm moved toward the northwest and was upgraded to a hurricane only two hours before it made its first landfall on the southeastern coast of Florida on August 25th. The storm intensity dropped significantly when it was over the land but reached hurricane intensity again when it entered the Gulf of Mexico a few hours later. Then, Katrina rapidly grew from a Category 3 to a Category 5 hurricane on August 28th. The National Hurricane Center (NHC) had issued a hurricane watch at 10:00 a.m. (CDT) on Saturday, August 27th, but modified and extended the impact area six hours later and eventually issued a hurricane warning at 11:00 p.m. (CDT) on Saturday, August 27th. Finally, Katrina made its second landfall closed to Buras, Louisiana at 6:10 a.m. on Monday, August 29th as a Category 3 hurricane. When Hurricane Katrina made its Louisiana landfall, the wind speed exceeded 120 mph and the storm surge was reported as 8-22 feet along the Louisiana, Mississippi, and Alabama coasts and 24-28 feet at its peak. In addition, the storm also produced 8-12 inches of rainfall and 43 recorded tornadoes .As the deadest and costliest U.S. hurricane in a century, Katrina killed 1,833 people, severely damaged or destroyed much of the New Orleans metropolitan area, and inflicted an economic loss around $108 billion (2005 USD). Although there were over 1.2 million people who received an evacuation order, no clear record identified how many people actually did evacuate.

The Texas A&M University Hazard Reduction & Recovery Center (HRRC) conducted a mail survey in the Louisiana parishes of Jefferson and St. Charles beginning four months after Hurricane Katrina. Respondents were selected with a disproportionate stratified sampling procedure designed to yield 200 households in each of the parishes, assuming a 50% response rate. Thus, the questionnaire was mailed to 400 households that were randomly selected from each Zip Code within each county. The survey generally followed Dillman's (1999) procedure. Selected households were sent a packet containing a cover letter, a questionnaire, and a stamped, self-addressed reply envelope. A reminder post card was sent to those who did not return a completed questionnaire within two weeks. Replacement packets were sent at two week intervals thereafter. This process was terminated when the respondents had either returned a completed questionnaire or had received as many as one reminder post card and three questionnaire packets. Of the 800 selected households, 123 households had either incorrect addresses or could not be forwarded and 275 households returned questionnaires. However, only 270 of them returned usable questionnaires for a response rate of 39.9% (37% in Jefferson Parish and 43% in St. Charles Parish).

Table 3.1 summarizes the demographic characteristics for the Hurricane Katrina mail survey. The respondents were predominantly female (52%), White (77%), middle-aged (arithmetic mean, *M* = 50.15 years), married (64%), and homeowners (81%) with an average of 14.15 years of education. Households had an average annual income of US$ 39,332 and an average of 3.05 household members. Compared to the 2000 Census data, the survey tended to have higher percentages of Whites, married persons, and homeowners with older age, more years of education, and lower annual incomes. The study received fewer responses from Hispanics but received more returns from larger size households in Jefferson Parish.

Table 3.1 Sample Descriptive Statistics for the Hurricane Katrina Data

Variables	All			Jefferson			St. Charles		
	N	M	SD	Census 2000	Census 2010	Survey	Census 2000	Census 2010	Survey
Population / N	270			455,466	432,369	129	48,072	52,676	141
Age*	265	50.15	14.46	43.58	45.52	49.44	41.84	43.80	50.79
Female	267	0.52	0.50	0.52	0.51	0.56	0.51	0.51	0.48
White	264	0.77	0.42	0.70	0.64	0.71	0.72	0.72	0.82
Black	264	0.14	0.35	0.23	0.27	0.17	0.25	0.27	0.11
Hispanic	264	0.05	0.21	0.07	0.12	0.06	0.03	0.05	0.04
Married*	267	0.64	0.48	0.51	0.48	0.59	0.57	0.53	0.70
Single*	267	0.18	0.38	0.28	0.34	0.21	0.26	0.29	0.15
Divorced*	267	0.11	0.32	0.12	0.12	0.15	0.10	0.11	0.08
Widowed*	267	0.06	0.24	0.07	0.07	0.05	0.06	0.07	0.07
HHSize	259	3.05	1.72	2.56	2.57	3.15	2.90	2.80	2.97
Education	266	14.15	2.42	13.14	13.28	14.09	12.92	13.36	14.20
Income	247	39,332	12,158	49,200	64,754	38,319	54,086	73,120	40,273
Homeowner	260	0.81	0.40	0.64	0.63	0.71	0.81	0.83	0.90

* Age and marital status for census data were evaluated for people who were older than 15 yrs.

3.1.2 Hurricane Rita Seven County Mail Survey

Hurricane Rita, the 17th tropical storm and one of the four Category 5 hurricanes to strike the U.S. in the 2005 Atlantic hurricane season, reached weak hurricane status before it entered the Gulf of Mexico on September 20th, but the warmer water in the Gulf of Mexico fostered its rapid growth. Rita's intensity increased from a Category 2 to a Category 5 hurricane in one day and remained at Category 5 intensity for the next 18 hours. The NHC issued a hurricane watch at 4:00 p.m. CDT on Wednesday, September 21st, modified it 12 hours later, and upgraded its notification to a hurricane warning at 10:00 a.m. on Thursday, September 22nd. Finally, Rita made landfall between Sabine Pass, Texas, and Johnson Bayou, Louisiana, at 02:38 a.m. CDT on September 24th. During the period that Rita struck the border between Texas and Louisiana, the storm maintained its intensity as a strong Category 3 hurricane with 120 mph wind speed. Rita generally produced a 4-7 feet storm surge, with a depth of 17 feet. Gauges recorded 5-9 inches of rainfall and at least 90 tornadoes were reported. Hurricane Rita caused 120 deaths, most of whom were killed in Texas. In the aftermath of Hurricane Katrina, Hurricane Rita provoked the largest evacuations in U.S. history, with more than two million people in Texas reporting they left their homes as Rita approached. The total economic loss was estimated to be $12 billion (2005 USD).

The Hurricane Rita survey was conducted beginning three months after Hurricane Rita, was processed at the same time as the Hurricane Katrina survey, and used the same procedures. The study included two coastal counties of the Lake Sabine Study Area (SSA): Orange and Jefferson Counties. It also included three inland SSA counties: Newton, Jasper, and Hardin Counties. Finally, the sample included one coastal county from the Houston-Galveston Study Area (GSA)—Galveston County, and one GSA inland county—Harris County. The mail survey processed a total of 2,800 households with 392 households that either had an incorrect address or could not be forwarded but 1,087 households did return their questionnaires. Among those who responded, only 1,007 respondents completed the survey, for an overall response rate of 41.8%, which was relatively similar across counties (46% in Orange, 42% in Jefferson, 36% in Newton, 44% in Jasper, 48% in Hardin, 41% in Galveston, and 36% in Harris).

Table 3.2 summarizes the demographic characteristics for the Hurricane Rita mail survey. The respondents were predominantly female (51%), White (77%), middle-aged (M = 54.43 years), married (71%), homeowners (89%) with an average of 13.96 years of education. Households had an average annual income of US$ 37,445 and 2.74 household members. The demographic characteristics of the Rita dataset were generally consistent with 2000 Census data but the survey respondents were more likely to be married rather than single, homeowners rather than renters, older, and have a lower annual household income. Respondents from Jefferson County were more likely to be White and had longer years of education, respondents from Galveston County were less likely to be Hispanic, and respondents from Harris County were 1.9 years better educated than average.

Table 3.2 Sample Descriptive Statistics for the Hurricane Rita Data

Variables	All			Orange			Jefferson			Newton		
	N	M	SD	Census 2000	Census 2010	Survey	Census 2000	Census 2010	Survey	Census 2000	Census 2010	Survey
Population / N	1008			84,966	82,017	160	252,051	252,170	146	15,072	14,445	125
Age*	993	54.43	15.25	44.13	45.93	55.49	43.85	44.31	55.17	44.85	46.44	55.98
Female	998	0.51	0.50	0.51	0.50	0.50	0.50	0.49	0.53	0.49	0.48	0.53
White	978	0.77	0.42	0.88	0.88	0.85	0.57	0.56	0.71	0.76	0.76	0.70
Black	978	0.10	0.30	0.08	0.09	0.05	0.34	0.34	0.17	0.21	0.21	0.15
Hispanic	978	0.04	0.21	0.04	0.06	0.05	0.11	0.17	0.05	0.04	0.03	0.02
Married*	989	0.71	0.46	0.60	0.56	0.73	0.54	0.47	0.71	0.60	0.58	0.70
Single*	989	0.08	0.27	0.19	0.23	0.05	0.25	0.33	0.08	0.20	0.22	0.11
Divorced*	989	0.11	0.31	0.12	0.13	0.09	0.11	0.14	0.10	0.10	0.12	0.10
Widowed*	989	0.10	0.31	0.07	0.07	0.13	0.08	0.07	0.11	0.08	0.08	0.09
HHSize	950	2.74	1.55	2.65	2.62	2.63	2.55	2.55	2.55	2.59	2.68	2.75
Education	979	13.96	2.44	12.67	12.86	13.82	12.89	13.06	14.32	11.99	12.42	12.94
Income	902	37,445	13,132	46,875	59,878	37,014	45,698	58,464	37,336	35,401	47,659	31,250
Homeowner	976	0.89	0.32	0.77	0.77	0.89	0.66	0.63	0.83	0.85	0.83	0.90

Variables	Jasper			Hardin			Galveston			Harris		
	Census 2000	Census 2010	Survey	Census 2000	Census 2010	Survey	Census 2000	Census 2010	Survey	Census 2000	Census 2010	Survey
Population / N	35,604	35,817	149	48,073	54,756	160	250,158	291,960	141	3,400,578	4,108,374	127
Age*	45.72	47.46	56.03	43.92	45.91	54.13	43.42	44.54	53.26	40.25	41.48	50.47
Female	0.51	0.51	0.51	0.51	0.51	0.53	0.51	0.51	0.43	0.50	0.50	0.54
White	0.78	0.81	0.79	0.91	0.91	0.85	0.73	0.80	0.75	0.59	0.64	0.72
Black	0.18	0.17	0.13	0.07	0.06	0.03	0.15	0.14	0.06	0.19	0.19	0.11
Hispanic	0.04	0.06	0.01	0.03	0.05	0.01	0.18	0.23	0.10	0.33	0.41	0.10
Married*	0.61	0.59	0.68	0.63	0.62	0.66	0.56	0.55	0.77	0.54	0.51	0.70
Single*	0.18	0.21	0.07	0.19	0.19	0.04	0.24	0.27	0.06	0.29	0.35	0.15
Divorced*	0.10	0.13	0.12	0.10	0.10	0.17	0.12	0.12	0.09	0.10	0.10	0.11
Widowed*	0.09	0.06	0.13	0.07	0.09	0.13	0.06	0.06	0.08	0.05	0.04	0.04
HHSize	2.58	2.51	2.93	2.68	2.62	2.63	2.60	2.65	2.86	2.79	2.90	2.84
Education	12.40	12.78	13.26	12.70	13.04	13.48	13.32	13.69	14.56	13.22	13.32	15.41
Income	38,994	50,724	34,366	46,642	65,668	36,799	54,730	78,803	42,460	56,557	75,317	42,991
Homeowner	0.81	0.79	0.92	0.83	0.79	0.93	0.66	0.69	0.86	0.55	0.57	0.88

* Age and marital status for census data were evaluated for people who were older than 15 yrs.

3.2 Measurement

Each participant was asked to fill out a questionnaire comprising 35 items examining their information sources, risk perceptions (e.g., perceptions of storm characteristics, expected personal impacts, social and environmental cues, and evacuation impediments), evacuation decisions (e.g., whether they evacuated and when), and demographic characteristics (see Appendixes C and D). Then, the study used mailing addresses to identify each household's the risk area.

3.2.1 Information Sources

Each respondent was asked, on average, how many times per day they consulted four different sources—local authorities (e.g., mayor, sheriff/police chief, or emergency coordinator), local news media (e.g., newspapers, radio stations, or television stations), national news media (e.g., network news, CNN, or weather channel), and peers (e.g., friends, relatives, neighbors, or coworkers)—about hurricane information in the three days before the hurricane made its landfall. Each item was measured on a five category scale of 0 times (= 1), 1-2 times (= 2), 3-4 times (= 3), 5-6 times (= 4), and 7 or more times (= 5).

3.2.2 Risk Perceptions

Participants first were asked to rate the extent to which they thought the storm would have three characteristics—nearby landfall, major intensity, and rapid onset—and six expected personal impacts—surge damage, inland flood damage, storm wind damage, personal and family casualties, job disruption, and basic services disruption. Each item was measured on a scale from not at all likely (= 1) to almost certain (= 5).

Next, the questionnaire assessed the extent to which respondents considered 11 different issues when deciding to evacuate. There were three items about environmental and social cues (observations of environmental cues, businesses closing, and peers evacuating), two items about official warnings (hearing a hurricane watch or warning and receiving an official evacuation order), and four items about perceived evacuation impediments (protecting property from looters, protecting property from storm impact, evacuation expenses, and traffic accidents during evacuation). There was one additional item measuring participants' previous personal experience with hurricane storm conditions and another item measuring respondents' previous experience on "unnecessary" evacuation. Each item was rated on a scale from not at all (= 1) to very great extent (= 5).

3.2.3 Evacuation Decision

Respondents were asked about their evacuation decision using a dichotomous variable in which the respondent was asked whether they evacuated (= 1) or not (= 0).

3.2.4 Demographic Characteristics

Respondents' demographic characteristics—age, gender, ethnicity, marital status, household size, annual income level, education, and ownership—were obtained in the fourth part of the questionnaire. Specifically, respondents were asked to report their age in years. Gender was measured by a dichotomous variable in which the respondent reported either male (= 1) or female (= 2). Respondents were asked to identify their ethnic group among seven categories (African American = 1, Asian/Pacific Islander = 2, Caucasian = 3, Hispanic = 4, Native American = 5, Mixed = 6, or other = 7) and marital status among four categories (married = 1, single = 2, divorced = 3, or widowed = 4). Household size was measured through respondents' self-reports of the number of their household members who were less than 18 years, between 18-65 years, and over 65 years. Respondents were also asked to identify their highest level of education in five categories (some high school = 1, high school graduate = 2, some college/vocational school = 3, college graduate = 4, or graduate school =5), and their yearly household income level in the other 5 categories (less than \$15,000 = 1, \$15,000-24,999 = 2, \$25,000-34,999 = 3, \$35,000-44,999 = 4, or more than \$50,000 = 5). Finally, home ownership was measured by a dichotomous variable in which the respondent was asked if they rent the house in which they lived (= 1) or own it (= 2).

3.2.5 Risk Area

Whether a household was located within a hurricane risk area and how much danger they were in was identified by an official evacuation map. However, the definition of an evacuation zone varied in SSA, GSA, and Louisiana. In SSA, the evacuation map issued by the Texas Division of Emergency Management split the risk area into five categories from Risk Area 1 to Risk Area 5 (see Figure 3.1). Risk Area numbers correspond to hurricane categories. For example, residents who lived in Risk Areas 1, 2, and 3 should evacuate for a Category 3 hurricane.

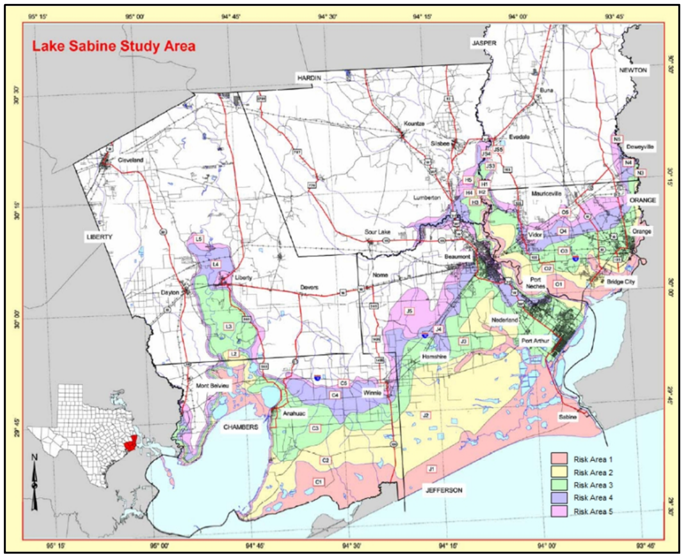

Figure 3.1 Evacuation Map of Lake Sabine Study Area (SSA)

As Figure 3.2 indicates, GSA risk areas are determined by matching each household's Zip Code to the evacuation zone map, which is less directly linked to hurricane categories. Specifically, the GSA map only divides the study area into three evacuation zip-zones. Thus, residents in Zip-Zone A should evacuate from all hurricane threats, residents in Zip-Zone B should respond to a Category 3 hurricane or greater, and Zip-Zone C should respond to a Category 4 hurricane or greater. The boundaries of the risk area in Louisiana were defined to match geographic conditions, such as Intracoastal Waterway, Mississippi River, and Interstate Highways (see Figure 3.3). The Louisiana state government published a phased evacuation plan in which residents in the Phase I area were identified as vulnerable to hurricanes in Category 1 and 2 Hurricanes and were advised to evacuate 50 hours before the onset of storm winds. Residents in the Phase II area were vulnerable to hurricanes of Category 2 or greater and were asked to evacuate 40 hours before the onset of Tropical Storm-force winds and residents in the Phase III were vulnerable to a slow-moving Category 3 hurricane or any Category 4 or 5 storms and were advised to leave 30 hours before onset of Tropical Storm-force wind.

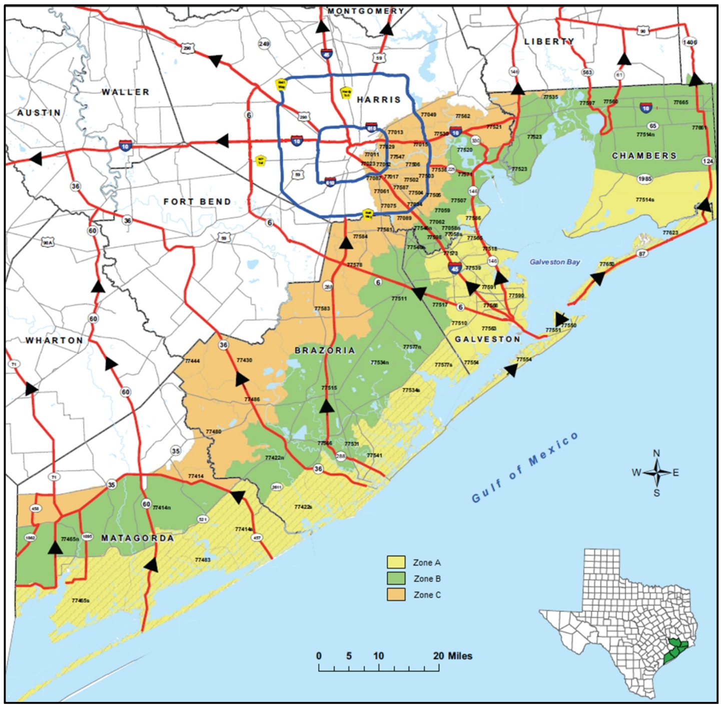

Figure 3.2 Evacuation Map of Houston-Galveston Study Area (GSA)

In order to have comparable codes for all three Study Areas (GSA, SSA, and Louisiana), this study recoded risk area into five levels. Each household was coded 0 for those who lived on a barrier island; 1 for those who lived in the remainder of Risk Area 1 and 2 for SSA, Zip-Zone A for GSA, and Phase I for Louisiana State; 2 for those who lived in Risk Area 3 for SSA, Zip-Zone B for GSA, and Phase II for Louisiana State; 3 for those who lived in Risk Area 4 and 5 for SSA, Zip-Zone C for GSA, and Phase III for Louisiana, or 4 for those who lived inland from the hurricane Study Area.

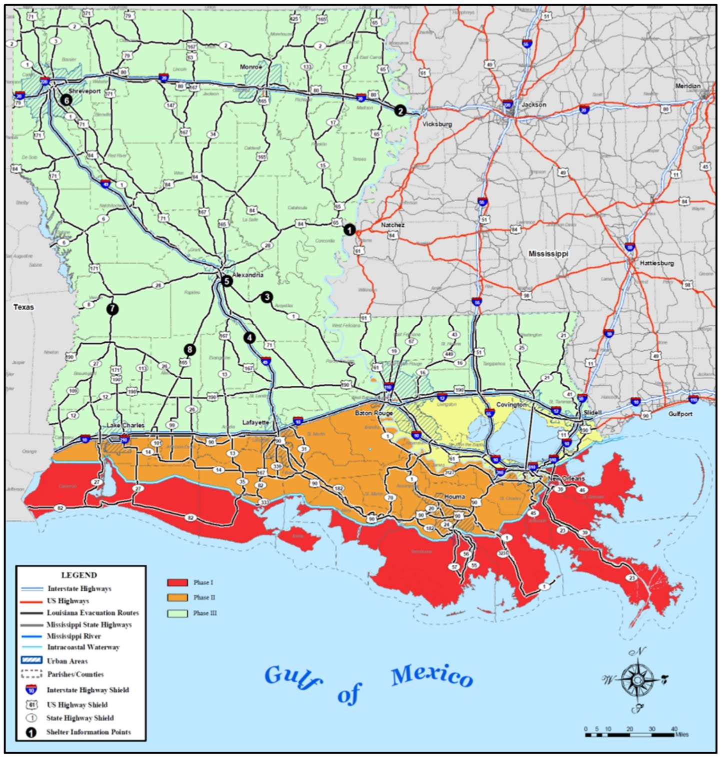

Figure 3.3 Evacuation Map of Louisiana State

3.3 Methodology

The data analyses will begin by testing the homogeneity across study areas of the intercorrelations among the variables to verify that a single model can be fit to all two samples. Second, the analyses will assess the level interrater agreement on each item to verify that correlations are not attenuated by variance restriction. Third, a factor analysis will be conducted to verify the assignment of items to scales. Fourth, reliability analysis will be conducted to assess the internal consistency reliability (Cronbach's α) of the scales. Fifth, the analysis will assess the correlations among the variables to be included in the prediction of evacuation decisions and, finally there will be a logistic regression analysis to test the research hypotheses and draw final conclusions.

3.3.1 The Reliability and Validity of Study Variables

Homogeneity of Correlations Across Multiple Geographic Areas

Although the Hurricane Katrina and Rita surveys were conducted at the same time, the datasets were collected from different hurricanes that occurred in different geographic areas. Thus, a homogeneity of intercorrelations test is needed to determine if the correlations in these two samples are homogeneous. The test, following Gnanadesikan's (1977) procedure (see Arlikatti et al., 2007, and Huang et al., 2012, for examples) takes the obtained value of each correlation for respondents from the Hurricane Katrina dataset and plots it against the corresponding value of that correlation for respondents from the Hurricane Rita dataset. For example, one data point is defined by plotting the value of the correlation between White and perceived wind damage for the Hurricane Katrina sample on the x-axis and the corresponding value of the correlation between White and perceived wind damage for the Hurricane Rita sample on the y-axis. Thus, the total number of data points is equal to the number of distinct correlation coefficients in the correlation matrix for each sample — k(k-1)/2.

If the cross-plot of interitem correlations for Hurricane Katrina and Hurricane Rita respondents is approximately linear and has no obvious outliers, then it indicates a similar overall pattern of intercorrelations among the responses to the questionnaire items in the two samples. Consequently, a pooled correlation matrix can be created that ignores the distinction between the two samples in the following analysis. Conversely, if the cross-plot of interitem correlations is widely dispersed or has obvious outliers, the two samples have to be analyzed separately to avoid an aggregation error.

Interrater Agreement

This study tests some hypotheses by calculating and comparing mean ratings across variables. However, the meanings of a given mean rating might be quite ambiguous when it is close to the midpoint of the rating scale (Lindell & Brandt, 1999). For example a mean rating of M = 3.0 in responding to a 1-5 scale can occur if the responses are identical (i.e., all respondents give a rating of 3, so the item variance is zero), uniformly distributed (i.e., an equal number of responses in each of the five categories), or bipolar (i.e., half of the responses are 1 and the remainder are 5). Even though these three patterns share a same mean rating, the implications of respondents' perceptions are significantly different from one another. Thus, interrater agreement, assessed by r^{*}_{WG}, can be used to determine if some variables have such small variances that their correlations with other variables have been attenuated. Specifically, this interrater agreement index is defined as:

$$r^{*}_{WG} = 1 - (s^2_X / \sigma^2_{EU}) \tag{3.1}$$

where s^2_X = the observed variance in the responses on a specific rating dimension

σ^2_{EU} = the variance of a uniform distribution

$$= (c^2 - 1)/12 \tag{3.2}$$

where c = the number of response categories

Thus, σ^2_{EU} = 2 when using a five point scale (Lindell & Brandt, 1999). An approximate test of interrater agreement can be accomplished by using the $\chi 2$ test:

$$\chi^2_{K-1} = (K-1)(s^2_X / \sigma^2_{EU}) \tag{3.3}$$

where K = the number of raters.

The r^*_{WG} index ranges between +1.0 and -1.0 where +1.0 means the item variance is zero, 0 indicates ratings are uniformly distributed, and -1.0 indicates the ratings are bipolar (Lindell & Brandt, 1999). In rare circumstances, $r^*_{WG} < -1.0$ (see Lindell, Brandt and Whitney, 1999).

3.3.2 Analytical Approaches

Factor Analysis

This study is designed to test hypotheses about the effects of information sources, perceived storm characteristics, expected personal impacts, social and environmental cues, personal experience, and perceived evacuation impediments, where each factor is measured by multiple items. However, it can be misleading to use a single number (scale score) to represent several items (variable scores) if the items do not measure a single underlying construct (Acock, 2008). Therefore, factor analysis will be used to test the construct validity of the variables in this study—the degree to which the items measure their intended constructs. A factor analysis will be processed using principal factor as the extraction method, a scree test combined with the number of eigenvalues greater than one to determine the number of factors, and equamax as the rotation method.

Correlational Analysis

Correlation analysis examines the statistical relationship between two variables. A statistically significant correlation implies that there might be a causal relationship between two variables. In addition, a pair of variables having a higher correlation coefficient indicates that the independent variable might better predict the dependent variable rather than other predictors could (Acock, 2008). Bivariate correlations will be examined to determine if the results are consistent with Hypotheses 2 to 13.

Regression Models

Finally, the demographic and psychological variables will be entered into a logistic regression analyses to generate a prediction model of households' evacuation decisions. In addition, ordinary least squares regression analyses will be conducted to predict expected personal impacts and perceived storm characteristics. Thus, households' evacuation decision can be modeled as follows:

$$EV_i = f(S_i, C_i, P_i, Im_i) + \hat{\beta}_{ij} \cdot V(\hat{I}_i, \hat{D}_i, \hat{G}_i, \hat{E}_i, \hat{U}_i, \hat{W}_i) + \hat{\varepsilon}_i \tag{3.4}$$

where (1) EV_i is the dichotomous choice of evacuation decision for household *i*; (2) S_i, C_i, P_i, Im_i are the factors defined by the respondents' perceived storm characteristics, observed social and environmental cues, expected personal impacts, and perceived evacuation impediments, respectively; (3) $\hat{I}_i, \hat{D}_i, \hat{G}_i, \hat{E}_i, \hat{U}_i, \hat{W}_i$ are the vectors of information sources, demographic characteristics, geographic characteristics, personal experiences, unnecessary evacuation experiences, and warning, respectively; (4) $\hat{\beta}_{ij}$ is the vector of regression coefficients; and (5) ε_i is the vector of measurement errors.

CHAPTER IV

RESULTS

4.1 MAR/MCAR Tests and Treatment of Missing Data

Only 719 of 1,277 (57.3%) respondents completed all of the questions, so it is necessary to characterize the nature of missing data and to make adjustments for it. For the Katrina dataset, Table 4.1 indicates that the completion rate was 61.1% (165/270) with the missing data rates ranging from 0.4% (1 case) to 15.6% (42 cases). This dataset has a 5.0% average percentage of missing data, with 19 variables below 5.0%. For the Rita dataset, Table 4.2 indicates that the completion rate was 49.1% (494/1007) with the missing data rates ranging from 1.0% (10 cases) to 21.8% (219 cases). This dataset has a 5.0% average percentage of missing data, with 19 variables below 5.0%. This result meets Schafer's (1999) standard that a missing rate of 5% or less is inconsequential. However, even though each variable has a minor level of missing data, the aggregate level of missing data across all variables might have significant impacts on the results. Thus, the treatment of missing data must be examined before further analyses.

Table 4.1 Summary Statistics for the Treatment of Missing Data by Listwise Deletion (LD), Pairwise Deletion (PD) and Expectation-Maximization (EM) Methods (Hurricane Katrina).

Variable	# of missing	% of missing	*p*-value of MAR+	Correlation of missing	Mean					Stand Deviation				
					LD	PD	EM	EM v.s. LD	EM v.s. PD	LD	PD	EM	EM v.s . LD	EM v.s. PD
Age	5	1.9%	<.001	.19*	47.65	50.15	50.16	5.3%	0.0%	13.54	14.46	14.38	6.1%	-0.6%
Female	3	1.1%	.32	.10	.50	.52	.52	3.5%	0.0%	.50	.50	.50	-0.7%	-0.5%
White	6	2.2%	<.001	-.21*	.83	.77	.77	-7.4%	0.0%	.38	.42	.42	11.0%	-1.1%
Married	3	1.1%	.003	-.17	.70	.64	.64	-8.6%	-0.3%	.46	.48	.48	4.2%	-0.5%
Children	11	4.1%	.32	-.06	.87	.86	.85	-3.0%	-1.2%	1.12	1.17	1.15	2.6%	-1.5%
HHSize	26	9.6%	.05	-.02	3.13	3.07	3.13	0.1%	1.9%	1.49	1.72	1.71	15.0%	-0.2%
Edu	4	1.5%	.001	-.16	14.50	14.15	14.13	-2.6%	-0.1%	2.18	2.42	2.41	10.5%	-0.5%
Income	23	8.5%	<.001	-.37*	42.5k	39.8k	39.6k	-6.8%	-0.4%	10.8k	12.2k	11.9k	10.9%	-2.3%
HmOwn	10	3.7%	.70	-.05	.81	.81	.81	-0.6%	-0.1%	.39	.39	.39	-0.9%	-1.7%
RiskArea	1	0.4%	.02	-.11	2.55	2.50	2.50	-2.1%	0.0%	.50	.50	.50	0.2%	-0.2%
HrrExp	20	7.4%	.73	.01	3.55	3.52	3.53	-0.7%	0.1%	1.40	1.42	1.38	-2.0%	-3.3%
UnnecEvac	19	7.0%	.65	-.06	3.04	3.02	3.03	-0.2%	0.3%	1.45	1.49	1.44	-0.7%	-3.2%
LocAuth	42	15.6%	.31	-.02	1.95	1.87	1.88	-3.7%	0.4%	1.35	1.29	1.20	-11.1%	-7.1%
LocNew	9	3.3%	.40	-.10	3.87	3.85	3.85	-0.5%	0.0%	1.27	1.28	1.26	-0.5%	-1.5%
NatNew	22	8.1%	.28	.02	3.45	3.55	3.53	2.3%	-0.6%	1.52	1.46	1.42	-6.6%	-2.7%
Peers	19	7.0%	.57	-.07	3.29	3.26	3.25	-1.3%	-0.3%	1.36	1.36	1.32	-2.5%	-2.9%
HearWarn	13	4.8%	.01	.15	3.55	3.68	3.69	3.8%	0.0%	1.27	1.27	1.25	-1.7%	-1.7%
OffOrder	12	4.4%	.03	.15	3.88	3.98	3.98	2.5%	0.0%	1.29	1.26	1.24	-3.9%	-1.7%
BusClos	14	5.2%	.40	.10	2.79	2.86	2.86	2.4%	0.1%	1.37	1.43	1.40	2.2%	-1.9%
PeerEvac	13	4.8%	.94	-.02	3.33	3.35	3.37	1.0%	0.4%	1.34	1.35	1.33	-1.1%	-1.7%
EnvCues	10	3.7%	.77	-.01	3.78	3.77	3.77	-0.3%	0.2%	1.47	1.50	1.48	0.5%	-1.5%
ExRapOnset	13	4.8%	.74	.15	1.56	1.60	1.61	2.8%	0.2%	.93	1.01	.99	6.9%	-2.1%
NearbyLand	14	5.2%	.44	-.05	3.39	3.33	3.34	-1.3%	0.4%	1.11	1.21	1.18	6.4%	-1.8%
Intensity	7	2.6%	.78	.05	3.87	3.84	3.85	-0.7%	0.1%	1.15	1.23	1.22	5.4%	-1.1%
SurgeRisk	15	5.6%	.18	.00	2.37	2.29	2.30	-2.8%	0.4%	1.18	1.20	1.17	-0.7%	-2.4%
FloodRisk	14	5.2%	.001	-.16	2.71	2.55	2.56	-5.5%	0.6%	1.18	1.20	1.17	-0.7%	-2.2%
WindRisk	11	4.1%	.96	.06	3.23	3.21	3.22	-0.3%	0.3%	1.21	1.23	1.21	0.6%	-1.6%
Causality	16	5.9%	.19	.06	3.02	3.11	3.11	3.0%	0.2%	1.43	1.44	1.40	-1.8%	-2.2%
JobDrpt	21	7.8%	.10	-.09	2.97	2.88	2.88	-2.9%	0.2%	1.47	1.54	1.49	1.5%	-3.3%
ServDrpt	5	1.9%	.57	-.06	4.42	4.46	4.46	1.0%	0.1%	1.07	1.02	1.01	-5.2%	-0.9%
ProtLoot	16	5.9%	.47	.00	2.60	2.67	2.69	3.6%	0.9%	1.51	1.56	1.52	0.7%	-2.3%
ProtStm	15	5.6%	.43	.07	2.95	3.01	3.03	2.8%	0.8%	1.41	1.48	1.45	2.6%	-2.3%
EvacExp	13	4.8%	.89	.01	2.98	3.00	3.04	2.1%	1.2%	1.55	1.56	1.54	-0.8%	-1.6%
TrafRisk	12	4.4%	.35	.11	2.70	2.77	2.80	3.7%	0.9%	1.50	1.57	1.54	2.3%	-1.7%
EvDec	0			-.11	.89	.86	.86	-3.1%	0.0%	.31	.34	.34	10.2%	0.0%

*: significant at the level of $p < .001$.

Table 4.2 Summary Statistics for the Treatment of Missing Data by Listwise Deletion (LD), Pairwise Deletion (PD) and Expectation-Maximization (EM) Methods (Hurricane Rita)

Variable	# of missing	% of missing	*p*-value of MAR+	Correlation of missing	Mean					Stand Deviation				
					LD	PD	EM	EM v.s. LD	EM v.s. PD	LD	PD	EM	EM v.s . LD	EM v.s. PD
Age	15	1.49%	<.001	.34*	50.68	54.41	54.43	7.4%	0.0%	13.55	15.25	15.14	11.8%	-0.7%
Female	10	0.99%	<.001	.07	.45	.51	.51	13.1%	0.0%	.50	.50	.50	-0.1%	-0.5%
White	30	2.98%	<.001	-.13*	.82	.77	.77	-5.8%	-0.1%	.39	.42	.42	7.2%	-1.4%
Married	19	1.89%	<.001	-.15*	.76	.71	.71	-7.4%	-0.1%	.43	.46	.45	6.1%	-0.8%
Children	58	5.76%	.02	-.09	.72	.66	.65	-10.0%	-1.7%	1.15	1.08	1.05	-8.1%	-2.0%
HHSize	99	9.83%	<.001	-.14*	2.90	2.75	2.77	-4.6%	0.7%	1.62	1.55	1.52	-5.8%	-1.9%
Edu	29	2.88%	<.001	-.20*	14.31	13.96	13.94	-2.6%	-0.1%	2.33	2.45	2.42	4.0%	-1.1%
Income	106	10.53%	<.001	-.27*	40.9k	37.9k	37.7k	-7.9%	-0.6%	12.0k	13.3k	12.8k	6.4%	-3.3%
HmOwn	32	3.18%	.49	-.01	.88	.89	.89	0.8%	0.0%	.33	.32	.31	-4.1%	-1.3%
RiskArea	42	4.17%	.02	.05	2.92	3.01	3.02	3.2%	0.1%	1.28	1.22	1.19	-6.8%	-2.0%
HrrExp	89	8.84%	.49	.06	2.75	2.78	2.78	1.1%	0.1%	1.49	1.50	1.43	-3.7%	-4.2%
UnnecEvac	99	9.83%	.65	.03	2.12	2.15	2.16	1.7%	0.3%	1.36	1.39	1.32	-2.8%	-4.7%
LocAuth	219	21.75%	.09	.12*	1.50	1.56	1.59	5.5%	1.6%	.98	1.06	.95	-3.9%	-10.8%
LocNew	92	9.14%	.12	.03	3.72	3.78	3.79	1.7%	0.2%	1.34	1.34	1.29	-3.5%	-4.2%
NatNew	104	10.33%	.31	.05	3.67	3.70	3.70	0.8%	0.2%	1.38	1.37	1.31	-4.9%	-4.6%
Peers	111	11.02%	.01	.06	3.12	3.23	3.24	3.9%	0.3%	1.42	1.40	1.33	-5.9%	-4.7%
HearWarn	78	7.75%	.19	.03	3.47	3.51	3.52	1.5%	0.4%	1.29	1.31	1.27	-1.4%	-3.3%
OffOrder	72	7.15%	.76	.02	4.04	4.02	4.03	-0.2%	0.2%	1.19	1.21	1.18	-1.3%	-3.0%
BusClos	89	8.84%	.10	.05	2.73	2.81	2.84	3.7%	0.7%	1.41	1.47	1.42	0.4%	-3.5%
PeerEvac	80	7.94%	.55	.04	3.22	3.25	3.26	1.2%	0.4%	1.38	1.42	1.37	-0.3%	-3.3%
EnvCues	71	7.05%	.75	.01	3.52	3.51	3.52	-0.1%	0.3%	1.53	1.53	1.48	-3.1%	-3.2%
ExRapOnset	63	6.26%	.49	-.03	1.68	1.71	1.72	2.2%	0.3%	1.03	1.09	1.06	2.7%	-2.9%
NearbyLand	52	5.16%	.54	-.04	3.00	2.98	3.00	-0.1%	0.5%	1.39	1.41	1.38	-0.8%	-1.9%
Intensity	37	3.67%	.64	.00	3.61	3.56	3.55	-1.6%	0.0%	1.17	1.26	1.24	5.9%	-1.5%
SurgeRisk	61	6.06%	.04	-.06	2.02	1.97	1.99	-1.7%	1.1%	1.36	1.33	1.30	-4.3%	-2.2%
FloodRisk	62	6.16%	.01	-.04	2.18	2.12	2.14	-2.0%	0.6%	1.28	1.28	1.25	-2.7%	-2.4%
WindRisk	46	4.57%	.48	.02	3.29	3.29	3.30	0.5%	0.2%	1.23	1.28	1.26	2.1%	-1.8%
Causality	64	6.36%	.08	.02	2.82	2.90	2.92	3.5%	0.4%	1.43	1.47	1.43	-0.1%	-2.5%
JobDrpt	120	11.92%	.01	-.07	3.22	3.08	3.08	-4.2%	0.0%	1.54	1.60	1.52	-1.6%	-5.1%
ServDrpt	36	3.57%	.89	-.01	4.45	4.42	4.42	-0.6%	0.0%	1.00	1.06	1.04	3.8%	-1.6%
ProtLoot	76	7.55%	.10	.09	2.70	2.75	2.76	2.0%	0.2%	1.54	1.56	1.50	-2.6%	-3.5%
ProtStm	81	8.04%	.09	.07	3.02	3.07	3.08	2.1%	0.4%	1.47	1.49	1.44	-2.4%	-3.5%
EvacExp	71	7.05%	.01	.10	3.00	3.12	3.13	4.1%	0.1%	1.62	1.63	1.58	-2.8%	-3.1%
TrafRisk	67	6.65%	.01	.10	2.91	3.01	3.01	3.5%	0.1%	1.56	1.57	1.52	-2.2%	-3.1%
EvDec	0			-.08	.83	.82	.82	-1.6%	0.0%	.37	.38	.38	3.1%	0.0%

*: significant at the level of $p < .001$.

Howell (2013) recommended that the treatment of missing data should begin by identifying the causes of missing data. Among the variables in this study, missing data in RiskArea resulted from a system issue; it is not possible to geocode respondents' risk area when there are only post-office box addresses. Missing data in other variables arose because respondents declined to respond to the questions, so it is appropriate to determine if the nonresponses are random. Little's (1998, see Howell, 2013) MCAR (missing completely at random) test examines whether this is the case. The MCAR test was implemented by assigning variables to three categories—demographic variables (Age, Female, White, Married, Children, HHSize, Edu, Income, and HmOwn), warning variables (RiskArea, HrrExp, UnnecEvac, LocAuth, LocNews, NatNews, Peers, HearWarn, OffOrder, BusClos, PeerEvac, and EnvCues), and risk perception variables (ExRapOnset, NearbyLand, Intensity, SuregeRisk, FloodRisk, WindRisk, Causality, JobDrpt, ServDrpt, ProtLoot, ProtStm, EvacExp, and TrafRisk)—and then running a χ^2 test. The results reveal that warning variables were consistent with the MCAR assumption ($\chi^2_{250} = 233.14$, $p > .05$ for the Katrina dataset and $\chi^2_{734} = 789.89$, $p > .05$ for the Rita dataset). Although demographic variables in the Katrina dataset ($\chi^2_{113} = 159.22$, $p < .01$) and risk perception variables for both datasets ($\chi^2_{181} = 236.10$, $p < .01$ for Katrina dataset and $\chi^2_{629} = 706.88$, $p < .05$ for Rita dataset) had significant χ^2 values, these significance levels were relatively small given the large number of degrees of freedom. Only the demographic variables in the Rita dataset had a very significant χ^2 value ($\chi^2_{254} = 403.84$, $p < .001$) which rejected the null hypothesis that the data are missing completely at random.

As a followup test, the Potthoff et al. (2006) MAR+ test—which is processed through the Jonckheere-Terpstra test—was used to test whether each variable is missing at random (MAR). As Table 4.1 and 4.2 indicate, the *p*-values are below 0.001 for Age, White, and Income in the Katrina dataset and for Age, Female, White, Married, HHSize, Edu, and Income in the Rita dataset. Other than that, none of the variables are significant after multiplication by 34 (the number of variables having missing data) to apply the Bonferroni inequality (Potthoff et al., 2006). Consequently, there is no reason to reject the null hypothesis of that MAR is correct. In addition, the results of a correlation analysis support the MAR+ test by showing that respondents who are old, Black or Hispanic ethnics, single, less educated, and poorer have a significantly higher probability of missing data. Nevertheless, even though the significant results of MAR+ test on those demographic variables imply the data are associated with some variables (Howell, 2013), the probability of missing data among these demographic groups is generally low or nonsignificantly related to the warning and risk perception variables. Because the data either are at least MAR or have small impacts on analyses, the mechanism for missingness will be ignored in further analyses (Howell, 2013).

Two common approaches for survey studies to deal with missing data are pairwise deletion (PD) and listwise deletion (LD, also known as casewise deletion). Peng et al. (2006) found that 97% of quantitative studies reporting missing data issues that were published in 11 education and psychology journals during the period 1998-2004 adopted either the PD or LD method to deal with missing data. With pairwise deletion (PD), a correlation matrix is computed using all cases in which scores are present in both variables, but omits cases in which either or both of the scores are missing. The advantage of PD is that the correlations will be based on a larger sample size. However, the disadvantage of this method is that each correlation is calculated on a somewhat different data set. This can lead to non-Gramian (nonpositive definite) matrices that prevent regression coefficients from being estimated. Thus, the PD method is generally not recommended (Howell, 2013).

With listwise deletion (LD), the analysis simply drops all cases that have any missing values and runs the analysis with the remaining cases. Adoption of LD in this study would reduce the sample size from 270 to 165 (a 38.9% reduction) for Katrina dataset and from 1,007 to 494 (a 50.9% reduction). Although LD yields parameter estimates that are unbiased, a 20% reduction in sample size would significantly affect the standard errors of all parameter estimates and reduce the statistical power of all significance tests (Rubin, 1987; Arbuckle, 1996; Schafer, 1999; Dong & Peng, 2013; Howell, 2013). A third procedure, the Expectation-Maximization algorithm (known as the EM algorithm), does not exclude any of the cases. Instead, it replaces the missing data by estimating the missing values from the available data and, thus, retains as much data as possible (Little & Rubin, 1987; Rubin, 1987). The EM algorithm has been recognized as producing unbiased, or nearly unbiased, estimates of means, variances, and covariances. Moreover, it works well when the assumption of a multivariate normal distribution of observations is in error (Howell, 2013). Hence, this study uses the EM algorithm to replace missing data.

Figure 4.1 presents the cross-plot of interitem correlations between PD (which has the largest sample size) and EM; Figure 4.2 describes the cross-plot of interitem correlations between LD (which have substantially smaller sample sizes) and EM. The correlations between PD and EM (r = .99) and between LD and EM (r = .94-.98) are almost perfectly linear with no obvious outliers.

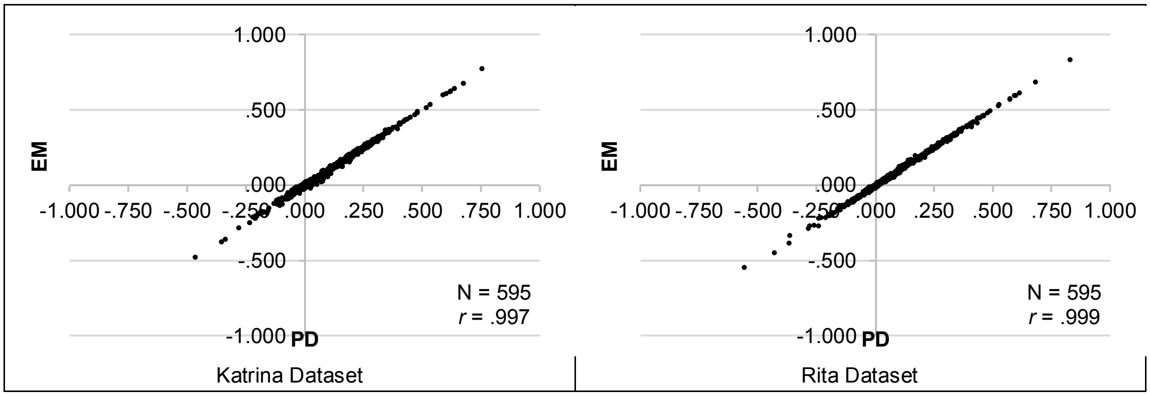

Figure 4.1 Cross-plot of Interitem Correlations for PD and EM

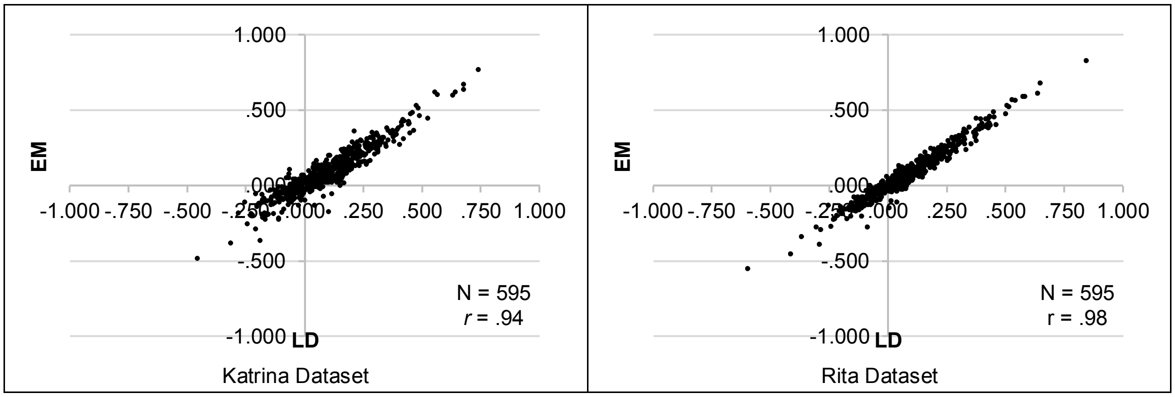

Figure 4.2 Cross-plot of Interitem Correlations for LD and EM

Table 4.1 and 4.2 present the mean and standard deviation of each variable estimated by LD, PD, and EM, and the percentage difference between unadjusted and adjusted values. The results reveal that the differences between the PD and EM values are generally less than 1% for the means and less than 4% for the standard deviations. On the other hand, the differences between the LD and EM values are much larger by 3-8% for the means and 2-7% for the standard deviations. In addition, obvious outliers can be observed on some of demographic variables (e.g., Age, Edu, and Income), which is not surprising because LD deletes all cases with missing data that are highly correlated with those variables. Moreover, the amount of deletion is as large as 39-51%, which enlarges the differences between unadjusted and adjusted values. Although PD is not generally recommended for correlation analysis, the similar values for means and standard deviations for PD and EM indicate that both missing data adjustment procedures yielded similar results for the Katrina/Rita data. Furthermore, as Table 4.3 indicates, the means and standard deviations for the correlations estimated by each of the methods are very similar. Those results reveal that the EM adjustment for missing data produces very similar means, SDs, and correlations for the PD and LD data. Although all three methods yield similar results, the EM adjustment is used here because it avoids the reductions in sample size associated with the other two methods.

Table 4.3 Means (*M*), SD, and Intercorrelations (r_{ij}) among Adjustment Methods

Katrina Dataset

	M	SD	Correlations (r_{ij})	
			LD	PD
LD	.091	.160	1.000	
PD	.095	.151	.941	1.000
EM	.096	.153	.939	.997

Rita Dataset

	M	SD	Correlations (r_{ij})	
			LD	PD
LD	.092	.163	1.000	
PD	.092	.162	.978	1.000
EM	.095	.164	.976	.999

4.2 Homogeneity of Correlations Across Multiple Geographic Areas

Prior to analyzing the data from the Hurricane Katrina and Hurricane Rita surveys, a test of the homogeneity of the covariance matrices was conducted to determine if the correlations among demographic characteristics, geographic location, information sources, personal experience, official warning, observed social and environmental cues, perceived storm characteristics, expected personal impacts, perceived evacuation impediments, and evacuation decision were equal in the two samples. This test (Box's M = 1019.13, $F_{630, 203367} = 1.46$) was highly significant, indicating that the two covariance matrices were unequal. However, given the extremely large number of degrees of freedom, this test has the statistical power to detect trivial levels of heterogeneity. Thus, Gnanadesikan's (1977) graphical homogeneity test was performed. As with the correlations for the missing data analyses, the test took the obtained value of each correlation for respondents from the Hurricane Katrina dataset and plotted it against the corresponding value of that correlation for respondents from the Hurricane Rita dataset. Thus, the total number of data points is equal to the distinct correlation coefficients in the correlation matrix for each sample—k(k-1)/2 = 35(34)/2= 595.

Figure 4.3 displays the result of the cross-plot of interitem correlations from the Hurricane Katrina and Hurricane Rita samples is approximately linear (*r* = .85) and has no obvious outliers. That is, there is a similar pattern of intercorrelations among the responses to the questionnaire items in the two samples. Consequently, a pooled correlation matrix is used in the following analysis.

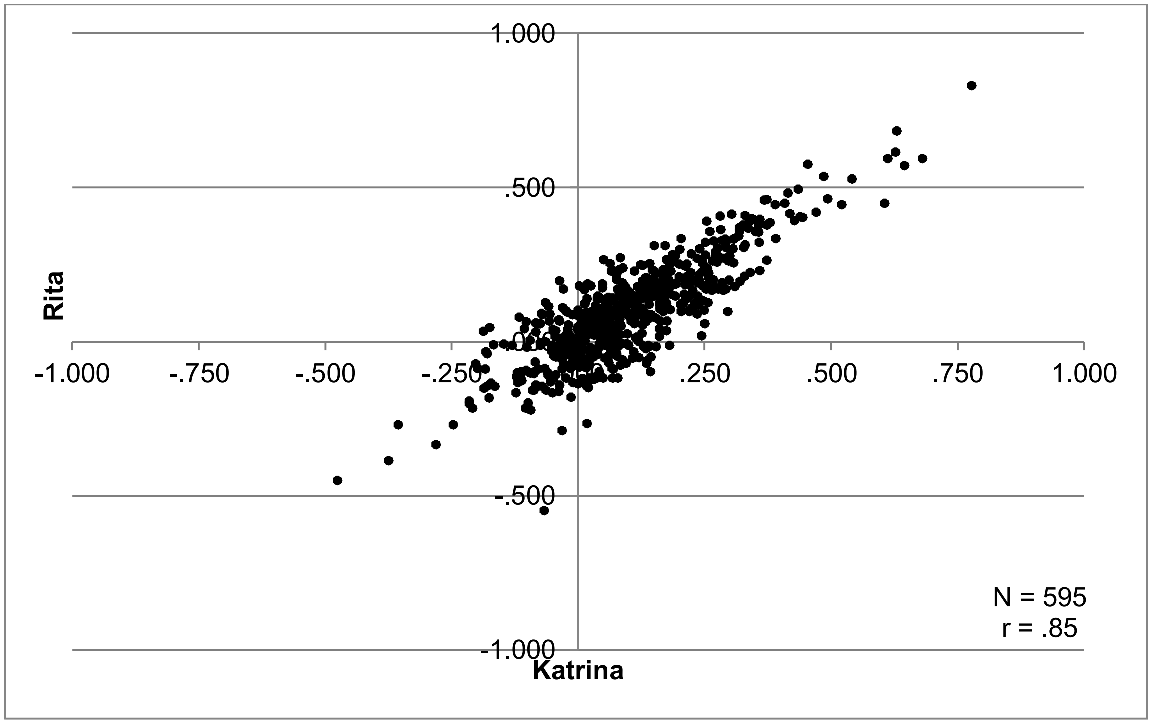

Figure 4.3 Cross-plot of Interitem Correlations for Katrina and Rita Respondents

4.3 Interrater Agreement and Factor Analysis

Table 4.4 indicates that ten of the 24 variables (local authority, local news media, expected rapid onset, intensity, surge risk, flood risk, wind risk, service disruption, hear warning, and official order) have relatively high interrater agreement r_{WG} values larger than .12 (the critical value for $p < .001$ with $df = 1{,}276$), but none of them have r_{WG} larger than .50—the mid-point between a uniform distribution ($r_{\mathrm{WG}} = 0$) and concentration of all values at a single point ($r_{\mathrm{WG}} = 1$). On the other hand, the level of interrater agreement is generally low for remaining variables—especially for casualties, job disruption, environmental cues, hurricane experience, property protection from looters, property protection from the storm, evacuation expense, and traffic accidents. This result provides evidence that respondents varied substantially in their perceptions of these variables. Consequently, the intercorrelations among variables and evacuation decisions will not be artifactually depressed by variance restriction.

Next, a factor analysis was conducted to assess the construct validity of the psychological variables. The results suggest a seven-factor solution in which items with factor loadings greater than 0.40 on a given factor can be averaged to identify seven scales (see Table 4.4). However, among the three variables measuring perceived storm characteristics, only nearby landfall (NearbyLand) and hurricane intensity (Intensity) were included in a scale, which has been renamed expected storm threat (ExStmThreat). Moreover, one of the factors has six items (nearby landfall, intensity, wind risk, casualties, job disruption, and service disruption) that theory suggests are defined by two different constructs, so the third factor has been divided into two distinct scales—expected hydrological impacts (ExHydroImp) and expected wind impacts (ExWindImp). Thus, the statements of hypotheses H2-H9 regarding the correlations of perceived storm characteristics are replaced by expected storm threat (ExStmThreat). In addition, expected personal impacts is divided into two scales — expected hydrological impacts (ExHydroImp) and expected wind impacts (ExWindImp)—in H11 and H12. Thus, the remaining analyses involve eight scales comprising news media (NewsMedia), expected storm threat (ExStmThreat), expected hydrological impacts (ExHydroImp), expected wind impacts (ExWindImp), social cues (SocCues), official warnings (OffWarn), previous experiences (Exper), and expected evacuation impediments (ExEvacImp).

Among these scales, seven (NewsMedia, ExStmThreat, ExHydroImp, ExWindImp, SocCues, OffWarn, and ExEvacImp) reached conventionally acceptable level of reliability (one has Cronbach's α between .60 and .69 and the other four have Cronbach's α exceeding .70, see George & Mallery, 2003 for a discussion of the conventional levels of coefficient α) whereas Exper has a lower level of reliability (Cronbach's α = .57). Meanwhile, although contact with peers (Var 2) and environmental cues (Var 14), which loaded on the NewsMedia factor and the SocCues factors, respectively, have factor loadings greater than .40, these factor loadings are far different from other items in these scales. In addition, the scale reliabilities of NewsMedia and SocCues would increase if contact with peers and environmental cues were deleted from their respective scales. Hence, instead of including these variables in these factors, respondents' previous hurricane experience (HrrExp), unnecessary evacuation experience (UnnecEvac), contact with peers (Peers), and environmental cues (EnvCues) are retained as separate variables, as are contacts with local authorities (LocAuth) and expected rapid onset (ExRapOnset).

Table 4.4 Interrater Agreement (r_{WG}), Principal Axis Factors, and Scale Reliabilities

Variable	r_{WG}	Factors							Scale α
		1	2	3	4	5	6	7	
1.LocAuth	.49*	.08	.15	.03	.02	.14	.31	.06	
2.Peers	.12	.13	.29	-.03	.11	.07	.47	.01	
3.LocNews	.18*	-.02	-.01	.13	.08	.01	**.71**	.10	
4.NatNews	.11	.07	.03	.06	.09	.02	**.63**	.06	
NewsMedia (Item 3-4)									.65
5.ExRapOnset	.45*	.17	.16	.11	-.09	.39	.07	-.01	
6.NearbyLand	.09	-.02	.13	**.60**	.10	.25	.08	.15	
7.Intensity	.23*	-.03	.08	**.54**	.14	.19	.11	.12	
ExStmThreat (Item 6-7)									.70
8.SurgeRisk	.18*	-.04	.01	.18	.22	**.64**	.01	.20	
9.FloodRisk	.23*	.01	.07	.17	.18	**.65**	.08	.11	
ExHydroImp (Item 8-9)									.70
10.WindRisk	.22*	.22	.05	**.53**	.39	.35	.10	.02	
11. Causality	-.02	.14	.08	**.41**	.52	.29	.11	.10	
12.JobDrpt	-.15	.12	.12	**.41**	.11	.22	.09	-.01	
13.ServDrpt	.47*	.08	.03	**.58**	.09	.10	.02	.08	
ExWindImp (Item 10-13)									.73
14.EnvCues	-.10	.17	.41	.25	.18	.11	.11	.17	
15.BusClos	.00	.23	**.71**	.06	.10	.15	.13	.14	
16.PeerEvac	.07	.18	**.75**	.02	.23	.14	.14	.10	
SocCues (Item 15-16)									.81
17.HearWarn	.20*	.09	.55	.15	**.45**	.03	.13	.14	
18.OffOrder	.29**	.08	.39	.08	**.57**	.04	.17	.12	
OffWarn (Item 17-18)									.75
19.HrrExp	-.06	.01	.05	.16	.13	.07	.05	**.64**	
20.UnnecEvac	.03	.25	.07	-.09	.04	.06	.06	**.57**	
Exper (Item 19-20)									.57
21.ProtLoot	-.13	**.62**	.12	.06	-.06	.07	.06	.29	
22.ProtStm	-.04	**.61**	.20	.14	-.02	.05	.12	.24	
23.EvacExp	-.23	**.73**	.11	.01	.15	.08	.10	.02	
24.TrafRisk	-.17	**.64**	.18	.03	.04	.06	.06	.11	
ExEvacImp (Item 21-24)									.79
EvaDec (Corr)		.36	-.21	-.24	-.14	.15	-.16	.27	
(Rotated)		-.07	.09	.06	.58	.10	.06	.11	

Note: Bold entries have factor loadings > .40 and are included in the scales listed following the group of items loading on the corresponding factor. Entries with star (*) have a significant Interrater Agreement (r_{WG}) with the significant level at $p < .001$.

4.4 Correlation Analysis

Table 4.4 reveals that three pairs of variables have extremely high correlations—Children and HHSize ($r = .82$), OffWarn and SocCues ($r = .57$) with reliability estimates of $\alpha = .75$ and .81 and ExStmThreat and ExWindImp ($r = .53$) with reliability estimates of $\alpha = .70$ and .73. The high correlation between Children and HHSize is an artifact that the number of children is one of the three components of household size so inclusion of both variables would be very likely to produce multicollinearity issues in the regression analysis. To avoid this problem, Children was omitted from the regression analyses. On the other hand, OffWarn, SocCues, ExStmThreat, and ExWindImp are measured by multi-item scales, so the disattenuated correlations between pairs of scales can be used to test whether each pair is measuring the same construct. A disattenuated correlation is calculating by dividing the observed correlation of each pair of scales by the product of the square roots of the two reliability estimates (see Nunnally & Bernstein, 1994, p. 257). The disattenuated correlations of both pairs of scales yield the values of $r = .73$-.74, which is substantially below 1.0. Thus, the results indicate that these four variables are psychometrically distinct, as are NewsMedia, ExHydroImp, and ExEvacImp.

Partially consistent with H1 (Risk area residents will rely on some information sources more than others and the order will be local news media > national news media > local authorities > peers), a MANOVA test revealed that there was a significant difference among information sources (Wilks $\Lambda = .28$, $F_{2,\,1275} = 1670.46$, $p < .001$). In terms of the frequency of consulting information sources (Var 13-15), Column 1 of

Table 4.5 Means (*M*), SD, and Intercorrelations (r_{ij}) among Variables

	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1.Age	53.5	15.1																							
2.Female	.51	.50	-.12																						
3.White	.77	.42	.05	-.10																					
4.Married	.69	.46	-.09	-.20	.11																				
5.Children	.69	1.08	-.46	.04	-.10	.16																			
6.HHSize	2.84	1.57	-.39	-.01	-.07	.32	.82																		
7.Edu	14.0	2.42	-.15	-.04	.11	.09	-.01	.02																	
8.Income¥	38.1	12.7	-.29	-.15	.24	.43	.09	.15	.44																
9.HmOwn	.87	.33	.16	-.07	.09	.25	-.01	.02	.02	.17															
10.RiskArea	2.91	1.10	.00	.05	.01	-.04	.02	.00	-.07	-.11	.06														
11.HrrExp	2.94	1.45	.15	-.03	.07	.01	-.07	-.03	.08	.04	.05	-.21													
12.UnnecEvac	2.34	1.40	.01	.01	.04	-.02	-.02	-.01	-.02	-.02	-.01	-.14	.40												
13.LocAuth	1.65	1.01	-.03	.09	-.10	.01	-.01	-.01	-.01	-.04	-.05	-.05	.11	.07											
14.Peers	3.24	1.33	-.14	.18	-.13	-.08	.09	.07	-.11	-.08	-.03	.05	.07	.12	.27										
15.NewsMedia	3.73	1.13	-.01	.08	.01	.08	.07	.08	.00	.05	.04	-.01	.12	.10	.24	.37									
16.OffWarn	3.79	1.10	-.02	.19	-.11	-.03	.02	.02	-.08	-.09	-.05	-.10	.23	.13	.16	.30	.22								
17.SocCues	3.06	1.27	-.04	.16	-.14	-.08	.04	.02	-.14	-.12	-.07	-.03	.16	.23	.21	.35	.17	.57							
18.EnvCues	3.57	1.48	-.10	.11	-.03	.01	.04	.02	-.10	.00	-.01	-.04	.22	.16	.14	.19	.17	.40	.49						
19.ExRapOnset	1.69	1.05	-.10	**.02**	**-.14**	-.02	.07	.07	-.06	-.03	**-.08**	**-.02**	**.04**	.08	**.12**	**.14**	**.05**	**.10**	**.22**	**.13**					
20.ExStmThreat	3.34	1.14	-.03	**.07**	**.01**	-.01	-.01	.00	.03	.03	**-.07**	**-.21**	**.25**	.04	**.12**	**.10**	**.18**	**.29**	**.21**	**.28**	.21				
21.ExHydroImp	2.14	1.11	-.10	.07	-.07	.02	.03	.02	.04	.06	-.05	-.43	.22	.12	.14	.08	.12	.26	.23	.23	.28	**.38**			
22.ExWindImp	3.43	.98	-.11	.11	-.02	.03	.06	.06	-.05	.00	-.02	-.17	.23	.09	.13	.17	.22	.39	.31	.37	.22	**.53**	.47		
23.ExEvacImp	2.97	1.18	-.01	.10	-.11	-.06	.02	.00	-.23	-.24	-.02	.03	.17	**.34**	.16	.21	.14	.28	.40	.30	.22	.13	.13	.28	
24.EvDec	.83	.38	-.06	.11	-.02	-.01	.05	.04	-.01	-.02	-.05	-.26	.14	.10	.06	.13	.11	.38	.21	.20	-.04	.20	**.24**	**.31**	**.02**

1. ¥ (in $1,000 USD)
2. Yellow cells indicate a significant correlation with the significant level at $p < .05$.
3. Bold entries are correlations predicted in Hypotheses 1 and 3-13. Meanwhile, green cells provide significant results in supporting Hypotheses 1 and 3-13.

Table 4.5 indicates that respondents were most likely to seek information from the news media (*M* = 3.73), followed by peers (*M* = 3.24), and local authorities (*M* = 1.65). Moreover, the correlations show that information was more often sought from local authorities by females, minority ethnicities, and renters. The frequency of seeking information from peers was associated with respondents who were younger, female, minority ethnicity, single, with children, from larger households, less educated, and poorer. Information from the news media was more likely to be sought by respondents who were female, married, had children at home, were from larger households, and were higher income households. The findings suggest that, consistent with previous hazard warning studies, females were more likely than males to seek all kinds of hazard information. In addition, married and single respondents tended to seek information from different sources; married respondents more frequently accessed the news media whereas singles sought information from peers.

Consistent with H4 (homeownership will be negatively related to perceived storm characteristics), Table 4.5 indicates that homeownership was significantly and negatively correlated with both expect rapid onset ($r = -.08$) and expected storm threat ($r = -.07$). On the other hand, Table 4.5 provides only partial support for H2 (female gender will be positively related to perceived storm characteristics) and for H3 (minority ethnicity will be negatively related to perceived storm characteristics) because female gender and ethnicity were only significantly correlated with *either* expected rapid onset or expected storm threat. None of the demographic variables had statistically significant correlations with expected storm threat (see Var 1-9), but younger respondents, larger households, and less educated respondents were more sensitive with expected rapid onset (*r* = -.10, .07, and -.06, respectively). In addition, there were other significant findings associated with the demographic variables. Table 4.5 indicates a low percentage of significant correlations—33.3% (9/27)—between demographic variables (Var 1-9) and experience variables (Var 10-12). However, consistent with Lindell and Hwang (2008), these data were contrary to the common social vulnerability hypothesis that respondents with lower socioeconomic status would more likely to live in high risk areas. Unsurprisingly, older respondents reported higher levels of hurricane experience. The correlations of Var 1-9 with Var 16-18 in Table 4.5 indicate that 48.1% (13/27) of the correlations between demographic variables (Var 1-9) and cue variables (Var 16-18) were statistically significant. Females, as expected, were more sensitive to official warnings (*r* = .19), social cues (*r* = .19), and environmental cues (*r* = .11). Minority ethnicities were more likely to be responsive to social contexts (e.g., official warnings and social cues) whereas younger respondents were more likely to respond to environmental cues (*r* = -.13 and -.10YY, respectively). Conversely, less attention to social and environmental cues by respondents who were white (*r* = -.14 and -.03, respectively) or had higher education levels (*r* = -.14 and -.10, respectively) or higher annual household incomes (*r* = -.12 and .00, respectively). The correlations of Var 1-9 with Var 19-23 in Table 4.5 indicate that 51.1% (23/45) of correlations between demographic variables (Var 1-9) and perception variables (Var 19-23) were statically significant. These results indicate that respondents with higher education and income levels were less concerned about evacuation impacts (*r* = - .24 and - .25). On the other hand, minority ethnicity was significantly correlated with expected rapid onset, evacuation impacts, and expected hydrological impact, but not expected storm threat and expected wind impact. Other than that, the significant correlations in this matrix were generally small in magnitude. Finally, female gender (*r* = .11), age (*r* = -.06), and homeownership (*r* = -.05) had significant correlations with evacuation decisions. However, minority ethnicity and the other demographic variables had nonsignificant correlations with evacuation decisions.

H5 (information sources will be positively related to perceived storm characteristics), H6 (official warnings will be positively related to perceived storm characteristics), and H9 (observation of environmental and social cues will be positively related to perceived storm characteristics) were supported by the statistically significant correlations of contact with local authorities (LocAuth—*r* = .12 and .12), contacts with peers (Peers—*r* = .14 and .10), contact with news media (NewsMedia—*r* = .05 and .18), official warnings (OffWarn—*r* = .10 and .29), social cues (SocCues—*r* = .22 and .21), and environmental cues (EnvCues—*r* = .13 and .28) with expected rapid onset and expected storm threat (ExStmThreat), respectively. However, H7 (previous hurricane experience will be positively related to perceived storm characteristics), H8 (coastal proximity will be positively related to perceived storm characteristics) were only partially supported by the statistically significant correlations of previous hurricane experience (HrrExp—*r* = .25) and risk area (RiskArea—*r* = -.21) with expected storm threat (ExStmThreat).

The correlations of Var 10-12 with Var 10-24 in Table 4.5 indicate that risk area, previous hurricane experience, and unnecessary evacuation experience were significantly correlated with each other (average *r* = .25), which is unsurprising because coastal residents were more likely than inland residents to face to hurricane threats and evacuation issues, and those hurricane experiences were likely to include unnecessary evacuations. This matrix also indicates that 77.8% (14/18) of the correlations of experience variables (Var 10-12) with warning variables (Var 13-18) and 73.3% (11/15) of the correlations with perception variables (Var 19-23) were statistically significant. Among them, risk area was significantly, but only slightly, correlated with official warning (*r* = -.10) and contact with local authorities (*r* = -.05). However, it was more strongly correlated with expected hydrological impacts (*r* = -.43), expected storm threat (*r* = -.21), and expected wind impacts (*r* = -.17), undoubtedly because coastal residents recognized that they had greater environmental vulnerabilities than inland residents. Consequently, risk area was strongly correlated with evacuation decision (*r* = -.26).

Prior hurricane experience (HrrExp) was positively correlated with "unnecessary" evacuation experience (*r* = .40), almost all aspects of risk perception (*r* = .07-.25), and evacuation decision (*r* = .15). However, prior hurricane experience was much more strongly correlated with other warning and perception variables (Var 16-23), with an average *r* = .21, than with the three information sources (average *r* = .10) and evacuation decision (*r* = .15). Previous experience of an unnecessary evacuation, on the other hand, was significantly correlated with expected evacuation impediments (*r* = .34) and, to a lesser extent, evacuation decision (*r* = .10), which supports H10 ("unnecessary" evacuation experience will be positively related to perceived evacuation impediments). The correlations of Var 13-15 with Var 13-24 in Table 4.5 indicate that those who had higher levels of contact with local authorities had higher levels of contact with peers and the news media. That is, those who frequently consulted any information source tended to consult all information sources.

Frequency of contact with information sources was more highly correlated with official warnings (average $r = .23$), environmental cues (average $r = .17$), social (average $r = .25$) cues, expected wind impacts (average $r = .17$), and expected evacuation impediments (average $r = .17$) than with evacuation decisions (average $r = .10$). Finally, the correlations of Var 16-18 with Var 16-24 in Table 4.5 indicate that social and environmental cue variables (Var 16-18) were highly correlated with each other (average $r = .49$). These variables were significantly correlated with all aspects of risk perception (average $r = .27$) and evacuation decision (average $r = .26$).

As predicted by H11 (perceived storm characteristics will be positively related to expected personal impacts), Table 4.5 indicates that expected storm threat (ExStmThreat) was significantly and highly correlated with expected hydrological impacts and expected wind impacts ($r = .38$ and .53, respectively). Meanwhile, H12 (expected personal impacts will be positively related to evacuation decisions) was supported by the statistically significant correlations of expected hydrological impacts and expected wind impacts with evacuation decisions ($r = .24$ and .31, respectively). Moreover, expected hydrological impacts was highly correlated with expected wind impacts ($r = .47$) and with expected evacuation impediments and evacuation decision ($r = .13$ and .24, respectively) but expected wind impacts had higher correlations with the latter two variables ($r = .28$ and .31, respectively). However, contrary to H13 (perceived evacuation impediments will be negatively related to evacuation decisions), expected evacuation impediments had a nonsignificant correlation with evacuation decision (*r* = .02).

4.5 Evacuation Rates

Table 4.6 presents the evacuation rates in Hurricanes Katrina and Rita among Louisiana, SSA, and GSA. Even though evacuation rates generally decrease with distance from the coast in all areas and evacuation rates in SSA (where Hurricane Rita made its landfall) were higher than in GSA, results of χ^2 tests only partially support H14 (Communities closer to the point of landfall and risk areas closer to the coastline will have higher evacuation rates than those that are farther from the point of landfall). With Louisiana in Hurricane Katrina, a χ^2-test indicates that there was no significant difference on evacuation rates between Risk Area 2 and 3 ($\chi^2_1 = .58$, $p > .05$) because both areas received evacuation orders. With SSA in Hurricane Rita, a χ^2 test indicates significant differences on evacuation rates existed among the risk areas and the inland area ($\chi^2_3 = 48.81$, $p < .001$). Even though there was a sharper decline between the risk areas and the inland area, the inland evacuation rate of 77.8% indicated that inland residents had extremely high rates of evacuation shadow.

Table 4.6 Evacuation Rates by Risk Area

Risk Area	Hrr Katrina			Hrr Rita					
	Louisiana			SSA			GSA		
	No	Yes	Cases	No	Yes	Cases	No	Yes	Cases
Barrier Island							6.7%	93.3%	30
1				0.0%	100.0%	26	5.3%	94.7%	95
2	12.6%	87.4%	135	2.2%	97.8%	137	7.4%	92.6%	27
3	14.9%	85.1%	134	5.6%	94.4%	125	23.5%	76.5%	17
Inland Area				22.2%	77.8%	410	64.3%	35.7%	98
Total	37	232	269	101	597	698	76	191	267
	13.8%	86.2%	100.0%	14.5%	85.5%	100.0%	28.5%	71.5%	100.0%

One possible reason for the similar evacuation rates inside risk areas and the high level of shadow evacuation in the inland area is that *all* risk areas in the SSA coastal counties received an evacuation order. With GSA in Hurricane Rita, there were significant differences on evacuation rates between the risk areas and the inland area ($\chi^2_4 = 99.95$, $p < .001$) but there were no significant differences among the evacuation rates within the risk areas. Meanwhile, although the overall evacuation rate in SSA was significantly higher than in GSA ($\chi^2_1 = 26.71$, $p < .001$), the differences were significant only in Risk Area 3 ($\chi^2_1 = 6.73$, $p < .05$) and the inland area ($\chi^2_1 = 66.33$, $p < .001$), and not in Risk Areas 1 ($\chi^2_1 = 1.43$, $p > .05$) and 2 ($\chi^2_1 = 2.08$, $p > .05$). It is not so surprising that Louisiana and SSA had high evacuation rates in all risk areas and the inland area because both locations were close to the point of hurricane landfall. Although it might seem difficult to understand why GSA had evacuation rates that were as high among all risk areas as those in SSA, it is important to note that GSA had earlier been the expected point of landfall before Rita gradually shifted its track eastward toward SSA. Moreover, the Houston mayor warned everyone to evacuate who had ever previously experienced flooding, which was a relatively common occurrence in the very flat Harris County, Thus, the inland evacuation rate of 35.7% in Harris County was much higher than would otherwise be expected.

4.6 Regression Models

Although the correlation analysis in the previous section clarifies the bivariate associations among expected storm threat, expected hydrological impacts, expected wind impacts, expected evacuation impediments, and evacuation decisions, the conceptual model (see Figure 2.2) requires additional tests to identify direct and indirect (mediated) effects of each variable on the risk perception variables and evacuation decision (Arlikatti et al., 2007; Huang et al., 2012). Thus, the additional hypotheses include: (AH1) when demographic variables (Var 1-9 in Table 4.4), warning variables (Var 10-18), and risk perception variables (Var 19-23) are controlled in the model of evacuation decision, only expected wind impacts, expected hydrological impacts, and expected evacuation impediments will receive statistically significant regression coefficients; (AH2a) when demographic variables, warning variables, expected rapid onset, expected storm threat, and expected evacuation impediments are controlled in the prediction model of expected wind impacts, only expected rapid onset and expected storm threat will receive statistically significant regression coefficients; (AH2b) when demographic variables, warning variables, expected rapid onset, expected storm threat, and expected evacuation impediments are controlled in the model of expected hydrological impacts, only expected rapid onset and expected storm threat will receive statistically significant regression coefficients; (AH3a) when "unnecessary" evacuation experience is controlled in the model of expected storm threat, female gender, white ethnicity, homeownership, reliance on information sources, official warning, hurricane experience, risk area, and environmental and social cues will all receive statistically significant regression coefficients; (AH3b) when "unnecessary" evacuation experience is controlled in the model of expected rapid onset, female gender, white ethnicity, homeownership, reliance on information sources, official warning, hurricane experience, risk area, and environmental and social cues will all receive statistically significant regression coefficients; and (AH4) when demographic variables, warning variables, expected rapid onset, and expected storm threat are controlled in the model of expected evacuation impediments, only “unnecessary” evacuation experiences will receive a statistically significant regression coefficient.

The first additional hypothesis (AH1) is partially supported by the Model 1 results in Table 4.7. On one hand, the results are partially consistent with the hypothesis because, when all of the variables are entered into the regression model of evacuation decision, expected wind impacts had the hypothesized significant positive effect ($b = .66, p < .001$) and expected evacuation impediments had the hypothesized significant negative effect ($b = -.45, p < .001$). Moreover, most of the demographic variables, information sources, previous experiences, and social and environmental cues had nonsignificant coefficients.

However, contrary to the hypothesis, expected hydrological impacts had a nonsignificant coefficient ($b = .18, p > .05$), official warnings received a significant positive coefficient ($b = .78, p < .001$) and income ($b = -.00, p < .05$), risk area ($b = -.72$, $p < .001$), and expected rapid onset ($b = -.37, p < .001$) had significant coefficients.

Table 4.7, Model 2, shows the result of the re-estimation by regressing evacuation decisions onto the five significant variables, which resulted in the elimination of the significant effect of income ($b = -.00, p > .05$). Model 3 re-estimated the model by regressing evacuation decision onto the five retained variables and this yielded stable coefficients. However, expected rapid onset and expected evacuation impediments, which had nonsignificant correlations with evacuation decision (see Table 4.4), continued to receive significant negative coefficients in Models 1-3. Thus, three additional regression models (Models 4-6) were estimated, which deleted either expected rapid onset or expected evacuation impediments or both. These analyses reveal that the changes in the regression coefficients and the increased error in prediction associated with Models 4-6 (measured by the percentage of correct classification, the reduction in the Cox & Snell R^2, and the reduction in the Nagelkerke R^2) were minimal.

Table 4.7 Prediction of Evacuation Decision

	Model 1			Model 2			Model 3		
	b	SE(*b*)	Exp(*b*)	*b*	SE(*b*)	Exp(*b*)	*b*	SE(*b*)	Exp(*b*)
Age	-.01	.01	.99						
Female	.23	.19	1.26						
White	.19	.23	1.21						
Married	-.04	.24	.96						
HHSize	.06	.07	1.06						
Edu	.03	.04	1.03						
Income	.00*	.00	1.00	-.00	.00	1.00			
HmOwn	-.18	.32	.83						
RiskArea	-.72***	.11	.49	-.79***	.11	.45	-.77***	.10	.46
HrrExp	-.01	.08	.99						
UnnecEvac	.11	.08	1.12						
LocAuth	-.06	.10	.94						
Peers	.09	.08	1.10						
NewsMedia	.05	.09	1.05						
OffWarn	.78***	.10	2.19	.85***	.09	2.34	.85***	.09	2.35
SocCues	.02	.10	1.02						
EnvCues	.05	.08	1.05						
ExRapOnset	-.37***	.09	.69	-.33***	.08	.72	-.33***	.08	.72
ExStmThreat	-.04	.10	.96						
ExHydroImp	.18	.12	1.20						
ExWindImp	.66***	.13	1.94	.75***	.10	2.11	.72***	.10	2.06
ExEvacImp	-.45***	.10	.64	-.37***	.09	.69	-.34***	.09	.71
Constant	.55	1.05	1.72	1.06	.59	2.89	.42	.49	1.52
X^2	347.60***			331.38***			327.38***		
df	22			6			5		
% Correct	86.9			86.3			86.3		
Cox & Snell R^2	.24			.23			.23		
Nagelkerke R^2	.40			.38			.38		
	Model 4			Model 5			Model 6		
	b	SE(*b*)	Exp(*b*)	*b*	SE(*b*)	Exp(*b*)	*b*	SE(*b*)	Exp(*b*)
RiskArea	-.77***	.10	.46	-.78***	.10	.46	-.78***	.10	.46
OffWarn	.83***	.08	2.30	.77***	.08	2.16	.74***	.08	2.09
ExRapOnset				-.38***	.08	.69			
ExWindImp	.65***	.10	1.92	.64***	.10	1.89	.55***	.09	1.73
ExEvacImp	-.38***	.09	.68						
Constant	.24	.49	1.28	.06	.49	1.06	-.20	.48	.82
X^2	311.97***			312.03***			291.68***		
df	4			4			3		
% Correct	86.3			85.1			85.3		
(% Difference)	(0.0%)			(-1.4%)			(-1.2%)		
Cox & Snell R^2	.22			.22			.20		
(% Difference)	(-4.2%)			(-4.2%)			(-9.7%)		
Nagelkerke R^2	.36			.36			.34		
(% Difference)	(-4.2%)			(-4.2%)			(-9.7%)		

*Significant at $p < .05$
**Significant at $p < .01$
***Significant at $p < .001$

The first part of the second additional hypothesis (AH2a) was tested by regressing expected wind impacts onto all of the other variable except evacuation decisions and expected hydrological impacts. Table 4.8, Model 1 indicates that expected storm threat received the largest standardized regressions coefficient (β = .38) where as expected rapid onset received a significant, but small, regressions coefficient (β = .07). Nevertheless, age (β = -.09), risk area (β = -.07), previous experience (β = .06), unnecessary evacuation experience (β = -.05), news media (β = .06), official warning (β = .16), environmental cues (β = .12), and expected evacuation impediments (β = .13) also received significant positive regression coefficients. It is somewhat surprising that age, risk area, previous experience, unnecessary evacuation experience, news media, official warning, and environmental cues had direct effects on expected wind impacts rather than the indirect effects that were hypothesized to occur through expected storm threat. However, the unpredicted significant coefficient for expected evacuation impediments is rather surprising. One possible explanation for the unpredicted effect of expected evacuation impediments is that people who expected one set of bad things to happen (evacuation impediments) also expected another set of bad things to happen (wind impacts). Otherwise, Table 4.8, Model 2 shows the re-estimated regression results after the nonsignificant variables have been deleted from the equation. There were minimal changes in the regression coefficients and the error in prediction associated with Model 2 (measured by the increase in R^2), and the following models.

Table 4.8 Prediction of Expected Wind Impacts

	Model 1			Model 2		
	b	SE(*b*)	*β*	*b*	SE(*b*)	*β*
Age	-.01***	.00	-.09	-.01***	.00	-.08
Female	.06	.05	.03			
White	.06	.05	.03			
Married	.07	.06	.03			
HHSize	.00	.02	.00			
Edu	-.01	.01	-.02			
Income	.00	.00	-.02			
HmOwn	.09	.07	.03			
RiskArea	-.06**	.02	-.07	-.05**	.02	-.06
HrrExp	.04*	.02	.06	.04*	.02	.06
UnnecEvac	-.04*	.02	-.05	-.04*	.02	-.05
LocAuth	-.01	.02	-.01			
Peers	-.01	.02	-.01			
NewsMedia	.06**	.02	.06	.06**	.02	.06
OffWarn	.14***	.03	.16	.14***	.02	.16
SocCues	.00	.02	.01			
EnvCues	.08***	.02	.12	.08***	.02	.12
ExRapOnset	.07**	.02	.07	.06**	.02	.07
ExStmThreat	.33***	.02	.38	.33***	.02	.38
ExEvacImp	.11***	.02	.13	.11***	.02	.13
Constant	1.34***	.25		1.30***	.15	
F	(20,1256)=42.51***			(10,1266)=84.30***		
Adj R^2	.39			.40		

*Significant at $p < .05$
**Significant at $p < .01$
***Significant at $p < .001$

The second part of the second additional hypothesis (AH2b) was tested by regressing expected hydrological impacts onto all of the other variables except evacuation decisions and expected wind impacts. Table 4.9 Model 1 indicates that risk area had the largest standardized regressions coefficient (β = -.36) followed by expected rapid onset (β = .20). These results are not surprising because coastal residents were more likely to face the threat of flooding and storm surge and worry that they would not have enough time to evacuate safely if the hurricane made its landfall too rapidly. Other than that, expected storm threat, as predicted, had the third largest regression coefficient (β = .20), but age (β = -.09), previous hurricane experience (β = .06), official warning (β = .06), and environmental cues (β = .06) also had significant (but small) regression coefficients.

A revised model (Model 2 in Table 4.9) indicates that expected hydrological impacts was not only significantly predicted by expected storm threat, risk area, and expect rapid onset, but also age, previous hurricane experience, official warning, and environmental cues. Overall, there were minimal changes in the regression coefficients and the error in prediction from Model 1 to Model 2.

Table 4.9 Prediction of Expected Hydrological Impacts

	Model 1			Model 2		
	b	SE(*b*)	*β*	*b*	SE(*b*)	*β*
Age	-.01**	.00	-.09	-.01**	.00	-.08
Female	.09	.05	.04			
White	-.08	.06	-.03			
Married	.05	.07	.02			
HHSize	-.03	.02	-.04			
Edu	.01	.01	.02			
Income	.00	.00	.00			
HmOwn	.05	.08	.01			
RiskArea	-.36***	.02	-.36	-.36***	.02	-.36
HrrExp	.05*	.02	.06	.05*	.02	.06
UnnecEvac	.00	.02	.00			
LocAuth	.04	.03	.03			
Peers	-.03	.02	-.04			
NewsMedia	.03	.02	.03			
OffWarn	.06*	.03	.06	.09***	.03	.09
SocCues	.05	.03	.05			
EnvCues	.04*	.02	.06	.06**	.02	.08
ExRapOnset	.21***	.03	.20	.22***	.02	.21
ExStmThreat	.19***	.03	.19	.19***	.02	.20
ExEvacImp	.00	.03	.00			
Constant	1.68***	.29		1.76***	.17	
F	(20,1256)=35.07***			(7,1269)=97.79***		
Adj R^2	.35			.35		

*Significant at $p < .05$
**Significant at $p < .01$
***Significant at $p < .001$

The first part of the third additional hypothesis (AH3a) was tested by regressed expected storm threat onto the remaining variables (i.e., excluding expected hydrological impacts, expected wind impacts, expected rapid onset, expected evacuation impediments, and evacuation decision). Table 4.10 Model 1 indicates that homeownership (β = -.06), risk area (β= -.16), previous hurricane experience (β= .18), "unnecessary" evacuation experiences (β = -.11), news media (β = .11), official warning (β = .15), and environmental cues (β= .16) were all significant predictors of expected storm threat. Table 4.10 Model 2 shows the re-estimated regression results after the nonsignificant variables have been deleted from the equation. Their deletion produced minimal changes in the estimated coefficients and the estimated R^2.

Table 4.10 Prediction of Expected Storm Threat

	Model 1			Model 2		
	b	SE(*b*)	β	*b*	SE(*b*)	β
Age	.00	.00	-.02			
Female	.05	.06	.02			
White	.07	.07	.03			
Married	-.05	.08	-.02			
HHSize	-.01	.02	-.01			
Edu	.01	.01	.02			
Income	.00	.00	.02			
HmOwn	-.21*	.09	-.06	-.23**	.09	-.07
RiskArea	-.16***	.03	-.16	-.17***	.03	-.16
HrrExp	.14***	.02	.18	.14***	.02	.18
UnnecEvac	-.09***	.02	-.11	-.09***	.02	-.11
LocAuth	.04	.03	.03			
Peers	-.02	.03	-.03			
NewsMedia	.11***	.03	.11	.11***	.03	.11
OffWarn	.15***	.03	.15	.16***	.03	.15
SocCues	.01	.03	.02			
EnvCues	.13***	.02	.16	.13***	.02	.17
Constant	2.18***	.31		2.35***	.18	
F	(17,1259)=18.93***			(7,1269)=44.99***		
Adj R^2	.19			.19		

*Significant at $p < .05$
**Significant at $p < .01$
***Significant at $p < .001$

The second part of the third additional hypothesis (AH3b) was tested by regressing expected rapid onset onto all of the other variable except hydrological impacts, expected wind impacts, expected rapid onset, expected evacuation impediments, and evacuation decision. Table 4.11 Model 1 indicates that age (β= -.07), white ethnicity (β= -.10), contacts with local authorities (β= .06), and social cues (β= .18) were all significant predictors of expected storm threat. Table 4.11 Model 2 shows the re-estimated regression results after the nonsignificant variables have been deleted from the equation. Their deletion produced minimal changes in the estimated coefficients and the estimated R^2.

Table 4.11 Prediction of Expected Rapid Onset

	Model 1			Model 2		
	b	SE(*b*)	β	*b*	SE(*b*)	β
Age	-.01*	.00	-.07	-.01**	.00	-.09
Female	-.07	.06	-.03			
White	-.26***	.07	-.10	-.26***	.07	-.11
Married	-.01	.08	.00			
HHSize	.02	.02	.03			
Edu	-.02	.01	-.04			
Income	.00	.00	.01			
HmOwn	-.14	.09	-.04			
RiskArea	-.01	.03	-.01			
HrrExp	.02	.02	.02			
UnnecEvac	.02	.02	.03			
LocAuth	.06*	.03	.06	.07*	.03	.07
Peers	.04	.03	.05			
NewsMedia	.00	.03	.00			
OffWarn	-.05	.03	-.05			
SocCues	.14***	.03	.18	.15***	.02	.18
EnvCues	.02	.02	.02			
Constant	1.90***	.31		1.65***	.14	
F	(17,1259)=6.50***			(4,1272)=24.32***		
Adj R^2	.07			.07		

*Significant at $p < .05$
**Significant at $p < .01$
***Significant at $p < .001$

The fourth additional hypothesis (AH4) was tested by regressing expected evacuation impediments onto all of the other variables except expected hydrological impacts, expected wind impacts, and evacuation decision. As predicted by AH10, Table 4.12 Model 1 indicates that unnecessary evacuation experience had the largest standardized regression coefficient (β= .26), but there were another six variables that also had significant regression coefficients. Three demographic variables—age (β= -.08), education (β = -.11), and income (β = -.19)—had significant negative regression coefficients whereas risk area (β= .07), social cues (β= .20), and environmental cues (β= .11) had significant positive coefficients. Table 4.12 Model 2 shows the re-estimated regression results after the nonsignificant variables have been deleted from the equation. Their deletion produced minimal changes in the estimated coefficients and the estimated R^2.

Table 4.12 Prediction of Expected Evacuation Impediments

	Model 1			Model 2		
	b	SE(*b*)	β	*b*	SE(*b*)	β
Age	-.01**	.00	-.08	-.00*	.00	-.06
Female	-.01	.06	-.01			
White	-.10	.07	-.03			
Married	.11	.07	.04			
HHSize	-.02	.02	-.02			
Edu	-.05***	.01	-.11	-.05***	.01	-.11
Income	-.00***	.00	-.19	-.00***	.00	-.17
HmOwn	.10	.09	.03			
RiskArea	.07**	.03	.07	.06*	.03	.06
HrrExp	.03	.02	.03			
UnnecEvac	.22***	.02	.26	.23***	.02	.27
LocAuth	.06	.03	.05			
Peers	.01	.02	.01			
NewsMedia	.04	.03	.04			
OffWarn	.03	.03	.03			
SocCues	.19***	.03	.20	.22***	.03	.24
EnvCues	.09***	.02	.11	.10***	.02	.13
Constant	2.56***	.30		2.82***	.26	
F	(17,1259)=33.20***			(7,1269)=76.90***		
Adj R^2	.30			.29		

*Significant at $p < .05$
**Significant at $p < .01$
***Significant at $p < .001$

The overall results of the regression analyses are summarized in Figure 4.4, which revises the abbreviated PADM in Figure 2.2 to show that there are, as predicted, two paths affecting households' evacuation decisions. The first path begins with households' personal characteristics—age, ethnicity, homeownership, previous hurricane experience, "unnecessary" evacuation experiences, risk area—and reception of information from multiple sources—local authorities, news media, official warnings, social cues and environmental cues. It then continues with households' expected storm threat and expected rapid onset, expected hydrological and wind impacts on themselves and their property and, finally, the decision to evacuate.

The second path begins with households' personal characteristics (e.g., age, income, education, and risk area), social and environmental cues, and "unnecessary" evacuation experiences—all of which directly affect expected evacuation impediments. In turn, expected evacuation impediments affects evacuation decisions directly and also indirectly (via an effect on expected wind impacts).

In addition, some of the predicted regression coefficients were nonsignificant. Specifically, the regression coefficients for female gender and ethnicity failed to achieve statistical significance, which means these variables did not have the effects that were hypothesized in Figure 2.2 so these variables have been eliminated from Figure 4.4.

Overall, the most notable difference of Figure 4.4 from Figure 2.2 is that Figure 2.2 hypothesized completely mediated effects whereas, in fact, there are a number of significant unpredicted regression coefficients showing that some variables had effects on multiple levels of the hypothesized causal chain from expected storm threat, through expected hydrological impact and expected wind impacts to evacuation decisions. That is, some variables whose effects were predicted to be completely mediated had only partially mediated effects instead. These effects are discussed in the next section.

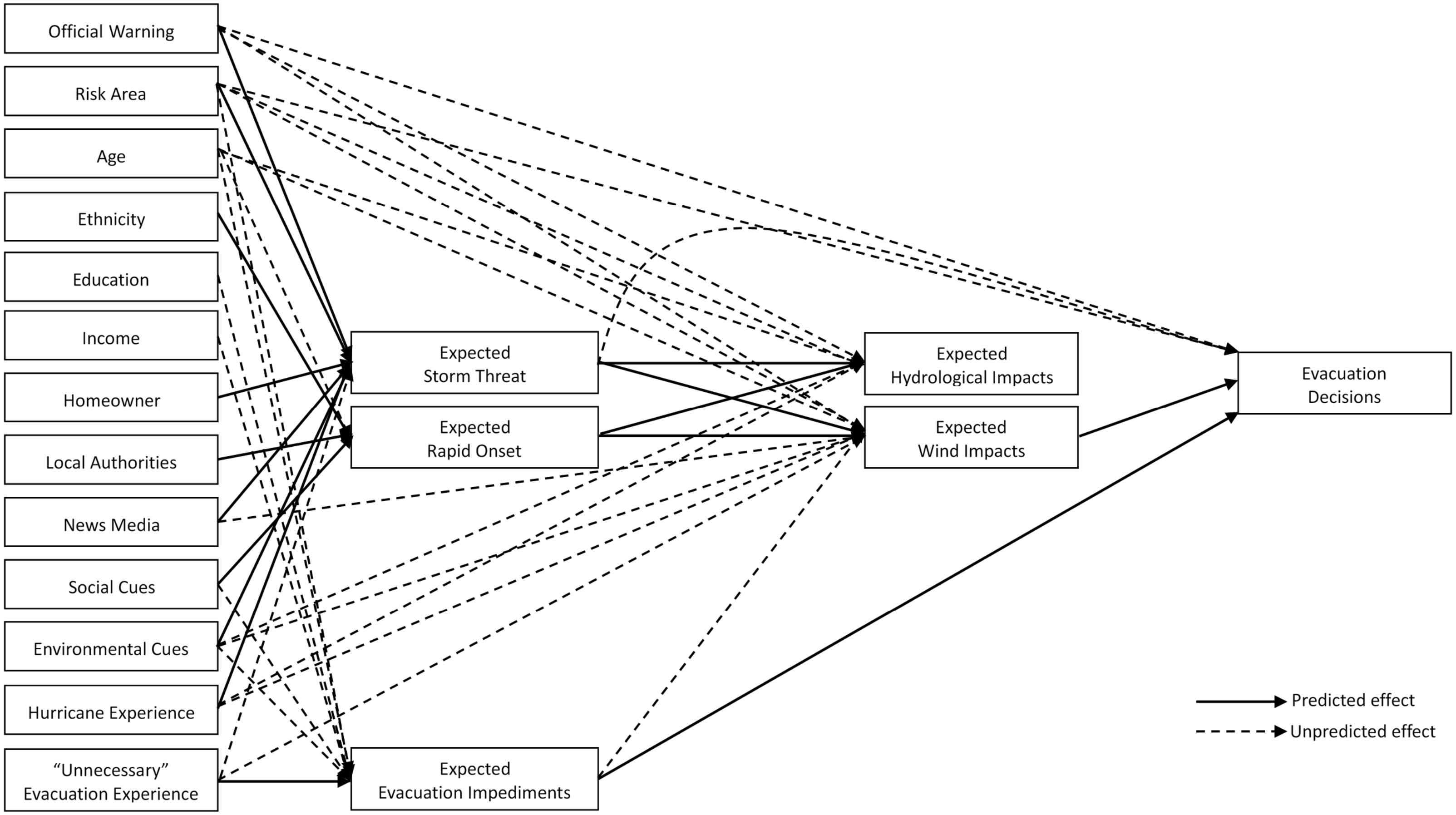

Figure 4.4 Revised Version of the Abbreviated PADM

CHAPTER V

DISCUSSION

5.1 Findings

Overall, the results generally support this study's hypotheses. Specifically, the data are consistent with H4, H5, H6, H7, H8, H10, H11, and H12; partially consistent with H1, H2, H3, H9, and H13; but contrary to H14. Moreover, the results also found some unpredicted direct effects. For example, the data support H12 (expected personal impacts will be positively related to evacuation decisions), which was revised to substitute expected wind impacts and expected hydrological impacts for expected personal impacts. However, other variables (official warnings, risk area, and expected rapid onset) have unpredicted direct effects. Similarly, the data also support H11 (perceived storm characteristics will be positively related to expected personal impacts), which was revised to substitute expected storm threat and expected rapid onset for perceived storm characteristics. Although expected storm threat and expected rapid onset do have direct effects on both expected hydrological and wind impact, other variables (age, news media, official warning, risk area, previous hurricane experience, unnecessary evacuation experience, environmental cues, and expected evacuation impediments) also have direct effects on either expected hydrological impact, expected wind impact, or both. In addition, the results also indicate that unnecessary evacuation experience has an unpredicted direct effect on expected storm threat as do official warning, risk area, homeownership, news media, previous hurricane experience, and environmental cues. Moreover, as predicted by

H10 ("unnecessary" evacuation experience will be positively related to perceived evacuation impediments), this variable has a direct effect on expected evacuation impediments, but there are another six variables (age, income, education, risk area, social cues, and environmental cues) that have unpredicted direct effects as well.

The data only partially support H1 (Risk area residents will rely on some information sources more than others and the order will be local news media > national news media > local authorities > peers). On one hand, respondents reported a relatively higher frequency of consulting information from both local and national news media whereas, on the other hand, the frequency of accessing information from peers stood at similar level with news media but two times more than local authorities. This result was contrary to many previous hurricane evacuation studies (e.g., Dow & Cutter, 1998; 2000; Lindell et al., 2005) that households rely more on information from news media or authorities than peers. This result is especially surprising because people, although tending to trust their peers, believe them to have lower expertise about environmental hazards (Arlikatti et al., 2007). This suggests that people distinguish between their peers' information about an imminent threat and their knowledge about a long-term hazard—a distinction that is consistent with French and Raven's (1959; Raven, 1965) differentiation of information power and expert power.

The low level of warning receipt from local authorities is somewhat surprising but not unique. Lindell and his colleagues found that 83% of Boston residents relied on either news media or peers as their first source of emergency information about a water contamination incident in 2011 but only 13% of the residents had been warned by authorities (Lindell et al., 2011). More recently, a household evacuation intention study in the Rio Grande Valley reported that households living in suburban areas thought they would be more likely to rely information from peers than authorities whereas those living in urban area would show the reverse pattern (Lindell et al., 2013). One possible explanation for the disparity of the Katrina/Rita data from the results of other studies is that both Katrina and Rita changed their tracks during the last 72 hours before landfall, which threatened jurisdictions that did not expect to be at risk. As a result, local authorities lacked enough emergency response personnel to warn such large populations at risk. Conversely, the threatened residents had limited access to information sources and limited time to make their evacuation decisions. Consequently, households tended to consult any information sources that were available—especially the news media and peers. Of course, consulting these other sources would not be a problem if local authorities' warnings were transmitted efficiently through the news media and peer networks (Lindell & Perry, 2004).

The findings are particularly consistent with residents' responses in Hurricane Ike (Huang et al., 2012) that, even though female gender failed to be a significant predictor in the regression model of expected storm threat as predicted by H2 (female gender will be positively related to perceived storm characteristics), female gender did have significant positive correlations with perceived storm characteristics (r = .07), many information sources (r = .08-.18), official warnings (r = .19), social cues (r = .16), environmental cues (r = .11), expected hydrological and wind impacts (r = .07-.11), environmental impediments (r = .10), and evacuation decision (r = .11). These results are consistent with a wide range of previous studies finding that women are generally more sensitive to environmental threats than are men (Bateman & Edwards, 2002). However, this mediation effect of female gender through expected storm threat has only been found previously in the Hurricane Ike evacuation (Huang et al., 2012) because other hurricane evacuation studies generally reported either correlation coefficients or regression coefficients, but not both. Hence, future research on the effects of female gender on risk perceptions and evacuation decisions should present results before and after controlling other variables.

The data only partially support H3 (minority ethnicity will be negatively related to perceived storm characteristics) that ethnic minorities were more sensitive with expected rapid onset but acted similar as other ethnicities on expected storm threat. The findings are particularly consistent with residents' responses in Hurricane Ike (Huang et al., 2012), even though there was no difference between ethnic minorities and others in their risk perceptions and evacuation decisions, minorities did have significant positive correlations with reliance on some information sources, such as local authorities (r = .10) and peers (r = .13), as well as official warnings (r = .11), and social cues (r = .14). This might be the reason that a weak but statistically significant effect size (see Figure 2.1) has been reported that minorities, in the end, would be just as affected as others but might face difficulties in receiving risk information because of higher risk exposure, lower socioeconomic status, and limited access to resources (Gladwin & Peacock, 1997). Consequently, the minorities tended to more concern about expected rapid onset which would significantly shrink available time for them seeking for and confirming the risk information.

Conversely, as predicted by H4 (homeownership will be negatively related to perceived storm characteristics), homeownership had a significant negative correlation coefficient and regression coefficient with expected storm threat and significant negative correlations with evacuation decision (*r* = -.05). This is important because evacuation studies repeatedly reported that homeowners are less concerned about warnings and possible storm impacts, and less likely to evacuate from a hurricane, but very few studies have tracked whether those homeowners stayed safely or were injured. Hence, more studies are needed to determine whether any dramatic warnings (e.g., Morss & Hayden, 2010; Wei et al., 2013) are required to motivate homeowners to evacuate.

The nonsignificant regression coefficients for social cues (H9—observation of environmental and social cues will be positively related to perceived storm characteristics) on expected storm threat, expected personal impacts, and evacuation decisions are surprising because observations of businesses closing and peers evacuating have been recognized as consistent and strong predictors of perceived personal impacts and evacuation decisions (see the SMA in Chapter II and the literature review in Huang et al., 2012). Nonetheless, it is important to note that social cues still had strong correlations with expected storm threat (*r* = .21), all other risk perception variables (*r* = .22-.40), and evacuation decision (*r* = .21). In addition, it was a significant correlate of environmental cues (*r* = .49). Thus, the correlations in this study were consistent with H9 even though the regression coefficients were not. One possible reason for the nonsignificant regression coefficients is that both social cues are correlated with other variables and, thus, the observed correlations social cues with other variables are spurious.

The support for H5 (information sources will be positively related to perceived storm characteristics) and H6 (official warnings will be positively related to perceived storm characteristics) by significant correlation coefficients and regression coefficients, is important because it confirms that National Weather Service information about storm conditions was communicated through multiple information channels (Lindell et al., 2007b); affected people's expected storm threat, expected hydrological and wind impacts; and influenced households' evacuation decisions. Moreover, the significant effects of prior hurricane experience (H7—previous hurricane experience will be positively related to perceived storm characteristics), risk area (H8—coastal proximity will be positively related to perceived storm characteristics), and environmental cues (H9—observation of environmental and social cues will be positively related to perceived storm characteristics) are also noteworthy because they confirm that people do not rely exclusively on information from National Weather Service. Instead, they look for other sources of supplemental information to interpret their risks. Indeed, extensive reliance on news media and receipt of official warnings that transmitted information from National Weather Service were expected to have stronger effects than previous hurricane experience, risk area, and environmental cues on expected storm threat, but all of these variables had relatively similar effects ($\beta = .11\text{-}.18$). The similarity in the coefficients for all of these variables might mean that people can access information from the National Weather Service only through these other sources, that they need these other sources to place the National Weather Service information into an appropriate context—that is, to translate storm conditions into assessments of personal risk, or both. Further, as mentioned by Huang et al. (2012), it is also important to recognize that local evacuation orders are generally based upon National Weather Service information. Thus, if the supplemental information conflicts with National Weather Service information, households would be confused and either delay or forego their evacuations. Consequently, further research is needed to assess the perceived characteristics (e.g., expertise, trustworthiness, and protection responsibility; see Arlikatti et al., 2007; Lindell et al., 2010) of information sources so emergency personnel can improve the credibility of their information (Lamb et al., 2012).

The significant regression coefficients for expected rapid onset and expected storm threat on both expected hydrological impacts and expected wind impacts and the significant regression coefficient for expected wind impacts on evacuation decisions provide supports for H11 (perceived storm characteristics will be positively related to expected personal impacts) and H12 (expected personal impacts will be positively related to evacuation decisions). This is important because, at first sight, it suggests that National Weather Service information about storm conditions, combined with other social context and environmental cues, does have its intended effect on people's expected personal impacts. In addition, these findings confirm the results of the SMA in Chapter II that expected personal impact is one of the consistent and strong predictors of households' evacuation decisions (Sorensen, 2000; Lindell & Perry, 1992, 2004, 2012). Moreover, it supports the proposition in Lindell and Perry's (1992, 2004, 2012) PADM that, once people receive a warning, they will try to determine if there is a real threat they need to pay attention to, followed by assessing their risk in terms of expected personal impacts, and finally deciding whether to adopt a protective action. Whereas the lower consideration of expected hydrological impacts—$M = 2.14$, comparing to $M = 3.43$ for expected wind impacts—and the nonsignificant coefficient for expected hydrological impacts on evacuation decisions are also noteworthy because it implies that residents considered expected injuries, job disruption and service disruption, which are loaded on the expected wind impacts, to be more dangerous and more important reason for evacuation than expected hydrological impacts (storm surge and inland flooding) was.

The support for H10 ("unnecessary" evacuation experience will be positively related to perceived evacuation impediments) is important because it suggests that previous bad memories of "false alarms" would plant the idea of "crying wolf" (Baker, 1991; Dow & Cutter, 1998), which arouses concerns about the negative consequences of evacuation. Significantly, the data indicate that "unnecessary" evacuation experience has not only the strongest effect in predicting expected evacuation impediments ($\beta = .26$), but also has a modest negative effect on expected storm threat ($\beta = -.11$) and a slight negative effect on expected wind impacts ($\beta = -.05$). However, it is also important to note the unpredicted effects of age, income, education, risk area, social cues, and environmental cues in the prediction of expected evacuation impediments. One logical explanation for the negative regression coefficient for age in predicting expected evacuation impediments is that older people are usually associated with more evacuation experiences and are more likely to know how to handle their evacuation. The negative effects of income and education on expected evacuation impediments indicate that households with higher socioeconomic status are less concerned about the negative effects of evacuation—probably because they usually have multiple transportation options, can afford to stay in hotels, and are more likely to have home insurance (Gladwin & Peacock, 1997). One seeming contradiction is the positive effects of social and environmental cues in predicting both expected storm threat (which would be expected to increase evacuation) as well as expected evacuation impediments (which would be expected to decrease evacuation). One explanation for this seeming contradiction is that severe storm threat motivates many households to evacuate which, in turn, is perceived to increase the severity of evacuation impediments.

The support for H10 is partially consistent with findings from the Hurricane Ike evacuation study (Huang et al., 2012), which found a negative effect of perceived evacuation impediments on evacuation decisions. However, the Katrina/Rita data are more ambiguous than the Ike data because they show that expected evacuation impediments had a nonsignificant correlation coefficient (see Table 4.5) but a significant regression coefficient in the prediction of evacuation decisions (see Table 4.7). Moreover, contrary to the Hurricane Ike data (Huang et al., 2012), the Katrina/Rita data showed that “unnecessary” evacuation experience, instead of having a direct effect on evacuation decision, only had an indirect effect that was mediated by expected evacuation impediments. This latter result is consistent with previous research on hurricane evacuation suggesting that false alarms have little or no effect on evacuation decisions (Baker, 1991; Dow & Cutter, 1998). On the other hand, this disparity between the two studies might reflect a cause-effect relationship in which people who were reminded of their “unnecessary” evacuation experience in Hurricanes Katrina and Rita reduced their evacuation willingness in Hurricane Ike. Because of the ambiguity of these results, further study to identify the mechanism of effect for “unnecessary” evacuations is required (e.g., Dow & Cutter, 1998; see also Dillon & Tinsley, 2008; Dillon, Tinsley & Cronin, 2011; Tinsley, Dillon & Cronin, 2012).

The findings were inconsistent with H14 (Communities closer to the point of landfall and risk areas closer to the coastline will have higher evacuation rates than those that are farther from the point of landfall) because the evacuation rates were similar in all risk areas. In addition, there was nonsignificant difference of evacuation rates between GSA (which was farther from Rita's eventual landfall) and SSA (which was closer to the point of landfall). These results appear to conflict with most previous reports that evacuation rates decline with distance along the coast from the point of landfall and distance inland from the coast (Baker, 1991). However, as mentioned earlier, the similar evacuation rates in all risk areas might have arisen from two important events. First, the high evacuation rates in GSA can be interpreted as a result of early evacuation warnings that were disseminated there before Hurricane Rita shifted its track eastward toward SSA would account for the high evacuation rates along the coast. Second, the warning from the Houston mayor for everyone to evacuate if they had ever experienced flooding in the past would account for the high evacuation rates inland from the coast.

Although these explanations are plausible, there are two broad issues requiring further research to resolve. First, research is needed to determine if the unusually high evacuation rates in GSA, especially inland GSA, were only a special case or if they can be attributed to households' misinterpretation of risk area maps. If the answer is the latter, then local authorities need to review and revise the risk area maps they use. Indeed, the Houston-Galveston Area Council subsequently adopted maps in which risk areas are defined by ZIP codes. In addition, further research needs to better understand whether residents continue to be confused by the new risk area maps and, if so, what can be done to reduce people's difficulties in reading and interpreting the risk area maps (e.g., Arlikatti et al., 2006; Zhang et al., 2004).

These results are also noteworthy for the large number of partially mediated effects. First of all, it is not entirely surprising that official warning and risk area have unpredicted direct effects on evacuation decision, in addition to the predicted indirect effects (see also Baker, 1991; Gladwin et al., 2001). However, it is quite significant that official warning and risk area have larger direct effects than expected wind impacts because the direct effect of official warning implies that many people in Hurricanes Katrina and Rita evacuated simply because they heard authorities' evacuation orders. Similarly, the direct effect of risk area implies that many people evacuated simply because they believed they were located in an area that was susceptible to hurricane impacts. In addition, expected rapid onset, which usually only has slight effect on evacuation decisions (Riad et al., 1999; Smith & McCarty, 2009), has a direct effect as well. A logical explanation is that both Hurricanes Katrina and Rita had late-changing tracks. Thus, residents had limited time to consider whether they needed to evacuate and, at the same time, had to determine whether they could reach safety if they departed late but the hurricane arrived soon. Consequently, people did not want to evacuate from a rapidly approaching storm to avoid the risk of being caught on the road, especially if there were major evacuation impediments. Unfortunately, there are too few previous studies that examined the impact of rapid onset, so further research is needed to determine its effect on evacuation decisions, especially for hurricanes with late-changing tracks.

The finding of an unpredicted effect of expected evacuation impediments on expected wind impacts is surprising, but might be the outcome of a correlation whose causality runs in the reverse direction; that is increased expectations of wind impacts cause increased expectations of evacuation impediments because of respondents' assumption that a more severe storm will increase the number of evacuees and, in turn, the severity of evacuation impediments. Moreover, although age, news media, official warnings, environmental cues, and previous hurricane experience also have direct effects on expected wind impacts (β = .06-.16), those effects are much smaller than the effect of expected storm threat (β = .38). Nonetheless, expected storm threat fails to have as strong an effect in predicting expected hydrological impacts (β = .19) as risk area (β = -.36) and expected rapid onset (β = .20). One explanation for this finding is that surge damage, and to a lesser extent inland flood damage, are greatest in coastal areas, so residents of these areas can expect hydrological impacts if a hurricane strikes anywhere near their location, not just if they receive a direct strike. Meanwhile, age, previous hurricane experience, official warning, and environmental cues also have significant effects on expected hydrological impacts although they are relatively small (β = .06-.09) .

Overall, the support for the conceptual model (see Figure 2.2) and the hypotheses in this study have two important theoretical implications. First, this study's results provide further empirical support for the results of the SMA in Chapter II which, itself, confirmed conclusions from Baker's (1991) review of household hurricane evacuation studies. In addition, this study generally confirms the major elements of the Huang et al. (2012) abbreviated PADM, which contends that households' evacuation decision can be interpreted as a multi-stage process. That is, a household's evacuation decision (on the right-hand side of Figure 5.1) is determined most directly by expected wind impacts and expected evacuation impediments. In turn, expected wind impacts and expected hydrological impacts are primarily determined by expected storm threat and expected rapid onset. Finally, expected storm threat, expected rapid onset, and expected evacuation impediments are determined by households' personal characteristics and their receptions of National Weather Service information from multiple information channels combined with some supplemental information such as social context and environmental cues (on the left-hand side of Figure 5.1). Figure 5.1 also shows that official warnings and risk area have direct effects on evacuation decisions in both this Katrina/Rita study and the Ike study (see solid arrows). Other than that, Figure 5.1 indicates that some effects are not consistent in both studies (see dashed arrows). It is possible that the inconsistencies are attributable to distinctive patterns in the behavior of Hurricanes Katrina and Rita, which changed their tracks at the last 72 hours before landfall, whereas Hurricane Ike maintained a stable track. Thus, further empirical research is needed to test not only this abbreviated PADM but also those partial mediation effects.

Moreover, this study highlights the need for future studies to report not only the final regression models or even the correlation and regression coefficients of predictor variables with evacuation decisions but the entire matrix of correlations among all independent and dependent variables. This is important because the incomplete correlation matrix, as presented in most previous studies, inhibits the understanding of mediation effects in evacuation decision models (Huang et al., 2012). In addition, this study also encourages further hurricane evacuation studies to adopt the multistage models (including the evacuation decision tree method of Gladwin et al. 2001) to clarify the cause-effect relationships among variables (Lindell et al., 2007a; Lindell, 2012).

5.2 Limitations

There were some limitations to this study. First, the response rate was only 41.4% (39.9% for Katrina survey and 41.8% for Rita survey). Although this is a relatively high response rate compared with other HRRC mail surveys—25.7% from the Hurricane Bret evacuation survey (Prater et al., 2000), 24.6% from the Texas coastal evacuation expectations survey (Lindell et al., 2001), 50.7% from the Hurricane Lili evacuation survey (Lindell et al., 2005), and 39.4% from the Hurricane Ike evacuation and reentry survey (Huang et al., 2012)—the sample may fail to represent some of specific demographic categories. In fact, as Table 3.1 and 3.2 indicates, respondents who participated in these two surveys were more likely to be Caucasian (76.9%), married (69.4%), and homeowners (87.0%) with more household members (2.82) and longer years of education (14.0). However, with the exception of an overrepresentation of homeowners, the sample's demographic characteristics was generally consistent with the average of the corresponding census data in both 2000 and 2010. Moreover, any overrepresentation of specific demographic categories will produce bias in other variables only to the degree that the demographic variables are correlated with those other variables. However, Table 4.5 shows that the correlations of demographic variables with other variables are small in this sample, as well as more generally (Lindell, 2013; Lindell & Perry, 2000; Huang et al., 2012). Another limitation is the disconfirmation of the MAR assumption underlying the adoption of the EM algorithm for estimating missing data. Estimation of missing data using the EM algorithm could produce bias in variables for which a substantial amount of missing data has been replaced. However, this study has a relatively low level of missing percentage on each variable and differences between unadjusted (LD and PD estimates) and adjusted (EM estimates) values of means and standard deviations are minor. Hence, even though the estimators may be biased, the bias is very likely to be small (Howell, 2013).

In addition, the regression models only accounted for a modest percentage of variance (R^2 is about 0.07 to 0.40). It is hard to determine the extent to which this moderate-low goodness-of-fit results from either the (unknown) reliabilities of single-item variables (e.g., expected rapid onset), or unmeasured causes of the dependent variables, but both problems are undoubtedly present. Another limitation is that this study is necessarily based on a nonexperimental design because it is not possible (or ethical) to manipulate the hurricane conditions or personal circumstances of the participants. Thus, the omission of important unmeasured causal variables could result in biases of path coefficients (Lindell, 2008). A third limitation is that this is a cross-sectional study that cannot verify the temporal ordering of the variables in each correlation. Although it is reasonable to assume that age, ethnicity, education, income, homeownership, risk area, hurricane experience, and “unnecessary evacuation experience preceded the other variables in the model, it is not possible to definitively determine the temporal ordering among the different types of respondents’ perceptions. For example, it is not possible to determine whether respondents’ beliefs about expected storm threat preceded their beliefs about expected hydrological impacts or vice versa. Expected storm threat was assumed to be prior to expected hydrological impacts and expected wind impacts because the items in the expected storm threat scale (storm proximity and intensity) and the expected rapid onset item are relatively similar to information that is disseminated by the National Weather Service. By contrast, beliefs about expected hydrological impacts and expected wind impacts involve inferences about the likely impacts of the publicized storm conditions on the respondents and their households.

Finally, the analyses are based on respondents’ self-reports of their personal experiences and perceptions that were collected months after the evacuation. Thus, there is no direct evidence whether the recall of these perceptions might have changed during the months between the evacuation and the time the respondents completed the survey. However, Lindell et al. (in press) report evidence from other research that people’s memories for events that occurred during disasters are reasonably accurate.

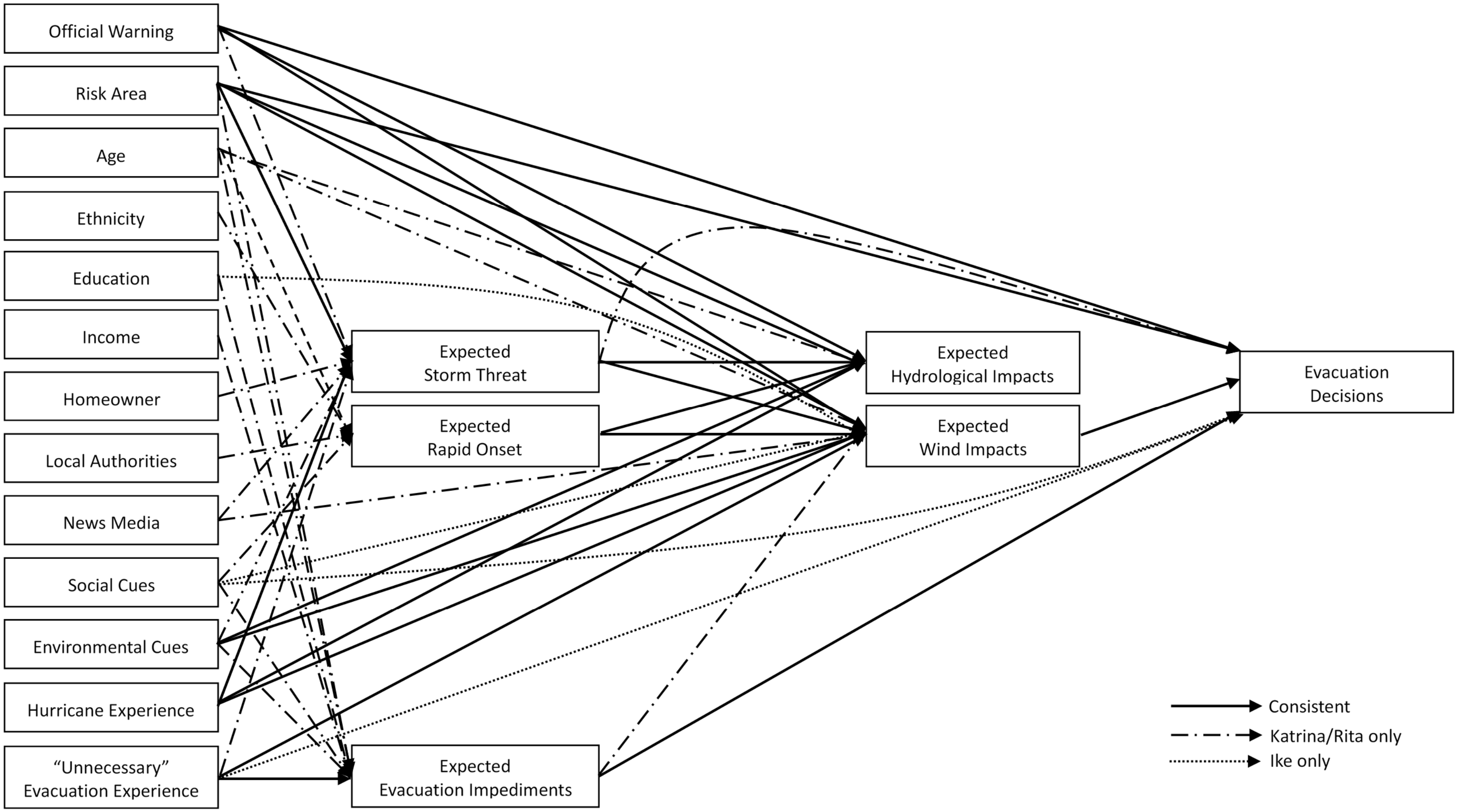

Figure 5.1 The Comparison of the abbreviated PADM between Hurricanes Katrina/Rita and Hurricane Ike

CHAPTER VI

CONCLUSION

This study examining households' hurricane evacuation decision began with a statistical meta-analysis (SMA), which is a procedure that has never been conducted previously in the field of disaster studies. The SMA indicates that homeownership, official warning, risk area, seeing peers evacuating, expected hydrological impacts, and expected wind impacts have strong and consistent effects on evacuation decisions whereas female gender, black ethnicity, presence of children in the home, reliance on news media for storm information, reliance on peers for storm information, and hurricane intensity have weaker effects that might be due to mediation through psychological variables. By contrast, other demographic characteristics and hurricane experiences have nonsignificant effects on evacuation decisions. Moreover, the SMA also indicates that social and environmental cues, expected rapid onset, unnecessary evacuation experience, and expected evacuation impediments have been less studied in previous research so any conclusions about their effects must be considered to be tentative.

Next, the data from the Hurricane Katrina and Rita evacuations was used to extend the results of the SMA by testing the abbreviated PADM published by Huang et al. (2012). The data collected from a two parish mail survey after Hurricane Katrina and a seven county mail survey after Hurricane Rita were pooled based on statistical and graphical tests that demonstrated the homogeneity of the correlations in the two samples. This study also assessed the nature of missing data and replaced missing values by the EM algorithm, a procedure that also has never been used in previous disaster studies. A factor analysis was conducted to organize individuals' risk perceptions into seven scales comprising reliance on news media (NewsMedia), expected storm threat (ExStmThreat), expected hydrological impacts (ExHydroImp), expected wind impacts (ExWindImp), social and environmental cues (SocCues), official warnings (OffWarn), and evacuation impediments (ExEvacImp). The evidence that expected hydrological impacts and expected wind impacts loaded on separate factors is important because expected injuries, job disruption and service disruption loaded on the expected wind impacts factor. That is, respondents generally considered wind impacts to be more dangerous than hydrological impacts (storm surge and inland flooding)—which might be an unintentional outcome of the Saffir-Simpson Scale of hurricane intensity being defined in terms of wind speed.

The results of the correlation and regression analyses were consistent with those of most previous hurricane evacuation studies (see Baker, 1991 and the SMA in Chapter II) and supported the Huang et al. (2012) abbreviated PADM by finding that evacuation decisions are most directly determined by expected wind impacts, expected hydrological impacts, and expected evacuation impediments. In turn, expected wind and hydrological impacts are primarily determined by expected storm threat but also by additional perceptions and conditions. Finally, expected storm threat, expected rapid onset, and expected evacuation impediments are determined by respondents' personal characteristics (e.g., age, income, education, and homeownership), multiple channels of National Weather Service information (news media reliance and official warning), hurricane experience, risk area, ”unnecessary” evacuation experience, social cues, and environmental cues. The results also identify a direct path from official warning and risk area to households' evacuation decisions which, like the results of Gladwin et al. (2001), suggest that some people evacuate on the basis of limited processing of the information available—a process that Petty and Cacioppo (1986) label the peripheral route to persuasion. In addition, the results also suggest that environmental cues, risk area, and hurricane experience have effects on individuals' expectations of storm threat, wind impacts, and hydrological impacts that are as important as the information they receive from the National Weather Service through the news media or official warnings. Nonetheless, some of the results conflict with the model presented by Huang et al. (2012), so further research is needed to determine whether the conflicting results can be replicated and, consequently, require revision of the model.

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APPENDIX A

ACTUAL HURRICANE EVACUATION STUDIES PUBLISHED 1991 TO 2012

Authors (publication year)	Hurricane (year)	Location	Eva Rate	Sample Size (Res rate)	Analytical Method[1]	Infor[2]	Demo[3]	Geo& /Exp[4]	Warn[5]	S&E Cues[6]	SC[7]	PI[8]	Eva Imped[9]
Aguirre (1991)	Gilbert (1988)	Cancun, Mexico	25%	431 (100%)	Corr Regress	NM	A G M HHS Inc						
Gladwin & Peacock (1997)	Andrew (1992)	FL	28%	1,131 (not reported)	Regress	Pe	E HHS C Inc	RA Exp					
Dow & Cutter (1998)	Bertha (1996)	SC NC	41%	323 (45.2%)	Descr	LA NM Pe		Exp	W	PE	Int NL	JD	TJ
	Fran (1996)		59%										
Riad et al. (1999)	Hugo (1989)	SC NC GA	42%	376 (100%)	Regress Descr		A G E HHS C Edu Inc O	Exp			RO		EX PP
	Andrew (1992)	FL		404 (100%)									
Whitehead et al. Case A (2000)	Bonnie (1998)	NC	26%	895 (66%)	Regress		G E Edu Inc		W			FR WR	
Dow & Cutter (2000)	Floyd (1999)	SC	64%	638 (96.8%)	Descr	LA NM Pe		Exp	W	PE	Int NL	FR JD	TJ

Authors (publication year)	Hurricane (year)	Location	Eva Rate	Sample Size (Res rate)	Analytical Method[1]	Infor[2]	Demo[3]	Geo& /Exp[4]	Warn[5]	S&E Cues[6]	SC[7]	PI[8]	Eva Imped[9]
Bateman & Edwards (2002)	Bonnie (1998)	NC	26%	1,008 (74%)	Regress Rating		A G E M HHS C Edu Inc	RA		PE		FR WR	
Van Willigen et al. (2002)	Bonnie (1998)	NC	48%	935 (76%)	Corr Rating		Inc					FR WR	
	Floyd (1999)	NC	54%	559 (58%)									
	Floyd (1999)	NC (inland flood plain)	29%	383 (70%)									
Fu Case A (2004)	Andrew (1992)	LA	36%	428 (65.7%)	Regress			RA	W		RO	Cas	PP
Fu Case B (2004)	Floyd (1999)	SC	60%	1688 (93.8%)	Regress			RA	W		RO		
Zhang et al. (2004)	Bret (1999)	TX	33%	312 (25.7%)	Corr Regress		A G E Edu Inc O	RA					
Lindell et al. (2005)	Lili (2002)	LA TX	54%	507 (50.7%)	Corr Rating	LA NM Pe	A G E M HHS C Edu Inc O	RA Exp Unn	W	StC BC PE			LT EX PP TJ

Authors (publication year)	Hurricane (year)	Location	Eva Rate	Sample Size (Res rate)	Analytical Method[1]	Infor[2]	Demo[3]	Geo& /Exp[4]	Warn[5]	S&E Cues[6]	SC[7]	PI[8]	Eva Imped[9]
Van Willigen et al. Case A (2005)	Floyd (residents) (1999)	NC	29%	309 (56.5%)	Regress		A G E M C Inc O					FR	
Van Willigen et al. Case B (2005)	Floyd (students) (1999)	NC	61%	852 (94.7%)	Regress		A G E C O					FR	
Noltenius (2008)	Wilma (2005)	FL	49%	287 (11.5%)	Corr		A G E M C Edu Inc O		W				
Smith & McCcarty Case A (2009)	2004 Hurricane season[10]	FL (All FL)	25%	1881 (24.5%)	Corr Regress		A G E HHS C Edu Inc O				Int		
Smith & McCcarty Case B (2009)	2004 Hurricane season[10]	FL (SE FL)	53%	2,739 (33.3%)	Regress		A G E HHS Edu Inc O				Int		

Authors (publication year)	Hurricane (year)	Location	Eva Rate	Sample Size (Res rate)	Analytical Method[1]	Infor[2]	Demo[3]	Geo& /Exp[4]	Warn[5]	S&E Cues[6]	SC[7]	PI[8]	Eva Imped[9]
Smith & McCcarty Case C (2009)	2004 Hurricane season[10]	FL (CL FL	29%	1,711 (33.3%)	Regress Descr		A G E HHS Edu Inc O				Int NL RO	JD	
Smith & McCcarty Case D (2009)	2004 Hurricane season[10]	FL (SW FL)	41%	2,105 (33.3%)	Regress		A G E HHS Edu Inc O				Int		PP
Smith & McCcarty Case E (2009)	2004 Hurricane season[10]	FL (Charlotte)	36%	568 (33.3%)	Regress Descr		A G E HHS Edu Inc O				Int	JD	
Smith & McCcarty Case F (2009)	2004 Hurricane season[10]	FL (NW FL)	44%	1,925 (33.3%)	Regress		A G E HHS Edu Inc O				Int NL		PP
Solís et al. Case A (2009)	Katrina Wilma Dennis (2005)	FL	43%	1,355 (100%)	Regress	LA NM Pe	HHS C Inc O	RA Exp					
Solís et al. Case B (2009)	Katrina (2005)	FL (SE FL)	34%	360 (100%)	Regress	LA NM Pe	HHS C Inc O	RA Exp					

Authors (publication year)	Hurricane (year)	Location	Eva Rate	Sample Size (Res rate)	Analytical Method[1]	Infor[2]	Demo[3]	Geo& /Exp[4]	Warn[5]	S&E Cues[6]	SC[7]	PI[8]	Eva Imped[9]
Solís et al. Case C (2009)	Wilma (2005)	FL (SE FL)	32%	506 (100%)	Regress	LA NM Pe	HHS C Inc O	RA Exp					
Solís et al. Case D (2009)	Dennis (2005)	FL (NW FL)	60%	305 (100%)	Regress	LA NM Pe	HHS C Inc O	RA Exp					
Solís et al. Case E (2009)	Katrina (2005)	FL (NW FL)	60%	184 (100%)	Regress	LA NM Pe	HHS C Inc O	RA Exp					
Vu et al. (2009)	Katrina (2005)	LA	78%	82 (64.1%)	Corr Rating Descr			RA				JD	LT EX
Horney et al. (2010a)[11]	Isabel (2003)	NC	28%	570 (86.8%)	Corr		A G E O	RA				FR	
Horney et al. (2010b) [11]	Isabel (2003)	NC	28%	570 (86.8%)	Corr Rating		A G E M C O	Exp	W	PE		FR WR	
Stein et al. Case A (2010)	Rita (2005)	TX (outside evacuation zone)	46%	318 (24%)	Corr Regress Rating	NM	A E C			PE		SR FR WR	
Stein et al. Case B (2010)	Rita (2005)	TX (inside evacuation zone)	76%	223 (24%)	Corr Regress Rating	NM	A E C			Pe		SR FR WR	
Hasan et al. (2011)	Ivan (2004)	AL FL LA MS	45%	1,995 (62.3%)	Corr Regress Descr	NM Pe	C Edu Inc O	Exp	W			JD	

Authors (publication year)	Hurricane (year)	Location	Eva Rate	Sample Size (Res rate)	Analytical Method[1]	Infor[2]	Demo[3]	Geo& /Exp[4]	Warn[5]	S&E Cues[6]	SC[7]	PI[8]	Eva Imped[9]
Sharma & Patt (2012)	Cy Fanoos (2005) Cy Ogni (2006)	India	65%	212 (89.5%)	Corr Regress			Exp Unn	W			Cas	TJ
Brackenridge et al. (2012)	Hrr Ike (2008)	TX	78.3%	120 (20%)	Regress		A G C						
Huang et al. (2012)	Hrr Ike (2008)	TX	61%	562 (39.4%)	Corr Regress Rating		A G E M HHS C Edu Inc O	RA Exp Unn	W	StC BC PE	Int NL RO	SR FR WR Cas JD SD	LT EX PP TJ

1. Analytical methods include: (1) Corr = correlational analysis, (2) Regress = regression models, (3) Rating = mean ratings, and (4) Descr = qualitative descriptions
2. Information sources include: (1) LA = local authorities, (2) NM = news media, and (3) Pe = peers' advices
3. Demographic characteristics include: (1) A = age, (2) G = gender, (3) E = ethnicity, (4) M = marital, (5) HHS= household size, (6) C = child, (7) Edu = education, (8) Inc = Income, and (9) O = homeownership
4. Geographic characteristics and hurricane experiences include: (1) RA = risk area, (2) Exp = hurricane experience, and (3) Unn = unnecessary evacuation experience
5. Warning includes: (1) W = watch/warning/order
6. Social and environmental cues include: (1) StC = storm condition, (2) BC = businesses closing, and (3) PE = peer evacuating
7. Storm characteristics include: (1) Int = intensity, (2) NL = nearby landfall, and (3) RO = rapid onset
8. Personal impacts include: (1) SR = storm surge risk, (2) FR = flood risk, (3) WR = wind risk, (4) Cas = casualties, (5) JD = job disruption, and (6) SD = service disruption
9. Evacuation impediments include: (1) LT = looting, (2) EX = evacuation expense, (3) PP = property protection, and (4) TJ = traffic jam
10. The 2004 Hurricane season in Smith & McCcarty's (2009) study included Hurricanes Charley, Frances, Ivan, and Jeanne.
11. Horney et al. (2010a) and (2010b) basically shared the same dataset but published in two different journals. Thus, some of the results from these journals are repeated.

APPENDIX B

HYPOTHETICAL HURRICANE EVACUATION INTENTION STUDIES PUBLISHED 1991 TO 2013

Authors (publication year)	Hurricane (year)	Location	Eva Rate	Sample Size (Res rate)	Analytical Method[1]	Infor[2]	Demo[3]	Geo& /Exp[4]	Warn[5]	S&E Cues[6]	SC[7]	PI[8]	Eva Imped[9]
Whitehead et al. Case B (2000)	Hypothetical hurricane with watch issued	NC	35.1%	895 (76%)	Regress		G E Edu Inc				Int	FR WR	
Whitehead et al. Case C (2000)	Hypothetical hurricane with Voluntary order issued	NC	16.4%	581 (57%)	Regress		G E Edu Inc				Int	FR WR	
Whitehead et al. Case D (2000)	Hypothetical hurricane with Mandatory order issued	NC	52.7%	486 (47%)	Regress		G E Edu Inc				Int	FR WR	
Lindell et al. (2001)	Hypothetical hurricane	TX	N/A	559 (22.4%)	Mean	LA NM	G	RA Unn	W	StC		Cas JD SD	LT EX TJ
Fu Case C (2004)	Hypothetical hurricane	LA	N/A	607 (100%)	Regress			RA	W	StC		SR	
Bhattacharjee et al. (2009)	Hypothetical hurricane	Al FL LA MI	29.9% ~38.8%	532 (30%)	Regress		E Edu Inc O	RA	W	StC	Int NL RO	JD	
Carrasco (2009)	Hypothetical hurricane	TX	7.8%	2,977 (96%)	Corr[10] Regress		G E Edu Inc	RA					
Brommer et al. (2010)	Hrr Gustav (2008) (pre landfall interview)	LA	N/A	275 (100%)	Rating Descr			Exp			Int	SR FR WR	

Authors (publication year)	Hurricane (year)	Location	Eva Rate	Sample Size (Res rate)	Analytical Method[1]	Infor[2]	Demo[3]	Geo&/Exp[4]	Warn[5]	S&E Cues[6]	SC[7]	PI[8]	Eva Imped[9]
Lazo et al. (2010)	Hypothetical hurricane	FL	N/A	400 (100%)[11]	Regress		A G E HHS Edu Inc O	Exp Unn			Int	FR WR	PP TJ
Cutter et al. (2011)	Hypothetical hurricane	SC	N/A	3,272 (21%)	Descr	LA NM Pe		RA	W	PE	Int NL	SR FR WR	PP TJ
Meyer et al. (2013)	Hypothetical hurricane	FL	N/A	310 (87%)	Regress Descr	NM Pe	A G HHS Edu Inc O	Exp				WR	

1. Analytical methods include: (1) Corr = correlational analysis, (2) Regress = regression models, (3) Rating = mean ratings, and (4) Descr = qualitative descriptions
2. Information sources include: (1) LA = local authorities, (2) NM = news media, and (3) Pe = peers' advices
3. Demographic characteristics include: (1) A = age, (2) G = gender, (3) E = ethnicity, (4) M = marital, (5) HHS= household size, (6) C = child, (7) Edu = education, (8) Inc = Income, and (9) O = homeownership
4. Geographic characteristics and hurricane experiences include: (1) RA = risk area, (2) Exp = hurricane experience, and (3) Unn = unnecessary evacuation experience
5. Warning includes: (1) W = watch/warning/order
6. Social and environmental cues include: (1) StC = storm condition, (2) BC = businesses closing, and (3) PE = peer evacuating
7. Storm characteristics include: (1) Int = intensity, (2) NL = nearby landfall, and (3) RO = rapid onset
8. Personal impacts include: (1) SR = storm surge risk, (2) FR = flood risk, (3) WR = wind risk, (4) Cas = casualties, (5) JD = job disruption, and (6) SD = service disruption
9. Evacuation impediments include: (1) LT = looting, (2) EX = evacuation expense, (3) PP = property protection, and (4) TJ = traffic jam
10. Carrasco (2009) only provided the results of the significance tests in his correlational analysis but did not provided specific number of his statistic results.
11. Lazo et al. (2010) only collected 80 respondents but repeatedly measure respondents' evacuation likelihood across Category 1 to 5 hurricanes. Therefore, the sample size in their study is 400.

APPENDIX C

HURRICANE KATRINA QUESTIONNAIRE

1. On average, how many *times per day* did you consult each of the following sources for information about Hurricane Katrina in the three days before landfall	**0**	**1-2**	**3-4**	**5-6**	**7 or more**
a. Local authorities (e.g., Mayor, Sheriff/Police Chief, Emergency Coordinator)	☐	☐	☐	☐	☐
b. Local newsmedia (e.g., newspapers, radio stations, television stations)	☐	☐	☐	☐	☐
c. National newsmedia (e.g., network news, CNN, or Weather Channel)	☐	☐	☐	☐	☐
d. Peers such as friends, relatives, neighbors, or coworkers	☐	☐	☐	☐	☐

2. As the storm was approaching, how likely did you think it was that…	**Not at all likely**		←→		**Almost certain**
a. the eye of the storm would track through your community?	☐	☐	☐	☐	☐
b. the storm would be a major (Category 4 or 5) hurricane when it struck?	☐	☐	☐	☐	☐
c. the storm would arrive before you could reach safety?	☐	☐	☐	☐	☐
d. your home would be inundated by (saltwater) storm surge?	☐	☐	☐	☐	☐
e. your home would be inundated by (freshwater) inland flooding?	☐	☐	☐	☐	☐
f. your home would be severely damaged or destroyed by storm wind?	☐	☐	☐	☐	☐
g. you and your family would be injured or killed if you stayed?	☐	☐	☐	☐	☐
h. there would be disruption to your job that would prevent you from working?	☐	☐	☐	☐	☐
i. there would be disruption to electrical, telephone, and other basic services?	☐	☐	☐	☐	☐

3. To what extent did you consider the following issues in deciding whether or not to evacuate?	**Not at all**		←→		**Very great extent**
a. Seeing storm conditions such as high wind, rain, or flooding	☐	☐	☐	☐	☐
b. Seeing area businesses closing	☐	☐	☐	☐	☐
c. Seeing friends, relatives, neighbors, or coworkers evacuating	☐	☐	☐	☐	☐
d. Hearing an announcement of a hurricane “watch” or “warning”	☐	☐	☐	☐	☐
e. Hearing local authorities issue official recommendations to evacuate	☐	☐	☐	☐	☐
f. Previous personal experience with hurricane storm conditions	☐	☐	☐	☐	☐
g. Previous experience with an unnecessary evacuation	☐	☐	☐	☐	☐
h. Concern about protecting your home from looters	☐	☐	☐	☐	☐
i. Concern about protecting your home from storm impact	☐	☐	☐	☐	☐
j. Concern about evacuation expenses such as gas, food, and lodging	☐	☐	☐	☐	☐
k. Concern about traffic accidents during evacuation	☐	☐	☐	☐	☐

4. Did you evacuate from Hurricane Katrina? ☐ **No** ☐ **Yes** If **No**, go to Question 7.

The National Hurricane Center issued a *Hurricane Watch* at 10:00 AM CDT on Saturday, August 27 and a *Hurricane Warning* at 10:00 PM CDT that night. The hurricane eye made landfall on the Louisiana/Mississippi border about 11:00 AM on Monday, August 29. When did you decide it was time to evacuate?

5. I finally left my home on: ☐ **Fri. Aug 26** ☐ **Sat. Aug 27** ☐ **Sun. Aug 28** ☐ **Mon. Aug 29**

6. I finally left my home at (*circle the correct time*):

|◄—— **AM** ——►|◄—— **PM** ——►|

1 2 3 4 5 6 7 8 9 10 11 Noon 1 2 3 4 5 6 7 8 9 10 11 Midnight

7. What is your age? _______ **years old**

8. What is your sex? ☐ **Male** ☐ **Female**

9. To which of the following ethnic groups do you belong and identify? ☐ **African American** ☐ **Asian/Pacific Islander** ☐ **Caucasian** ☐ **Hispanic** ☐ **Native American** ☐ **Mixed** ☐ **Other**

10. What is your marital status? ☐ **Married** ☐ **Single** ☐ **Divorced** ☐ **Widowed**

11. How many people in your household are: ______ **Less than 18 years** ______**18-65 years** ______ **Over 65 years**

12. What is your highest level of education? ☐ **Some high school** ☐ **High school graduate/GED** ☐ **Some college/vocational school** ☐ **College graduate** ☐ **Graduate school**

13. What is your *yearly* household income? ☐ **Less than $15,000** ☐ **$15,000—24,999** ☐ **$25,000—34,999** ☐ **$35,000—49,999** ☐ **More than $50,000**

14. Do you own or rent the home where you now live? ☐ **Rent** ☐ **Own**

If you have any comments about your evacuation experience, please write them on the back of this page.

Please return the survey in the envelope provided. ***Thank You.***

APPENDIX D

HURRICANE RITA QUESTIONNAIRE

1. On average, how many *times per day* did you consult each of the following sources for information about Hurricane Katrina in the three days before landfall	**0**	**1-2**	**3-4**	**5-6**	**7 or more**
a. Local authorities (e.g., Mayor, Sheriff/Police Chief, Emergency Coordinator)	☐	☐	☐	☐	☐
b. Local newsmedia (e.g., newspapers, radio stations, television stations)	☐	☐	☐	☐	☐
c. National newsmedia (e.g., network news, CNN, or Weather Channel)	☐	☐	☐	☐	☐
d. Peers such as friends, relatives, neighbors, or coworkers	☐	☐	☐	☐	☐

2. As the storm was approaching, how likely did you think it was that…	**Not at all likely**		←→		**Almost certain**
a. the eye of the storm would track through your community?	☐	☐	☐	☐	☐
b. the storm would be a major (Category 4 or 5) hurricane when it struck?	☐	☐	☐	☐	☐
c. the storm would arrive before you could reach safety?	☐	☐	☐	☐	☐
d. your home would be inundated by (saltwater) storm surge?	☐	☐	☐	☐	☐
e. your home would be inundated by (freshwater) inland flooding?	☐	☐	☐	☐	☐
f. your home would be severely damaged or destroyed by storm wind?	☐	☐	☐	☐	☐
g. you and your family would be injured or killed if you stayed?	☐	☐	☐	☐	☐
h. there would be disruption to your job that would prevent you from working?	☐	☐	☐	☐	☐
i. there would be disruption to electrical, telephone, and other basic services?	☐	☐	☐	☐	☐

3. To what extent did you consider the following issues in deciding whether or not to evacuate?	**Not at all**		←→		**Very great extent**
a. Seeing storm conditions such as high wind, rain, or flooding	☐	☐	☐	☐	☐
b. Seeing area businesses closing	☐	☐	☐	☐	☐
c. Seeing friends, relatives, neighbors, or coworkers evacuating	☐	☐	☐	☐	☐
d. Hearing an announcement of a hurricane “watch” or “warning”	☐	☐	☐	☐	☐
e. Hearing local authorities issue official recommendations to evacuate	☐	☐	☐	☐	☐
f. Previous personal experience with hurricane storm conditions	☐	☐	☐	☐	☐
g. Previous experience with an unnecessary evacuation	☐	☐	☐	☐	☐
h. Concern about protecting your home from looters	☐	☐	☐	☐	☐
i. Concern about protecting your home from storm impact	☐	☐	☐	☐	☐
j. Concern about evacuation expenses such as gas, food, and lodging	☐	☐	☐	☐	☐
k. Concern about traffic accidents during evacuation	☐	☐	☐	☐	☐

4. Did you evacuate from Hurricane Katrina? ☐ **No** ☐ **Yes** If **No**, go to Question 7.

The National Hurricane Center issued a *Hurricane Watch* at 4:00 PM CDT on Wednesday, September 21 and a *Hurricane Warning* at 11:00 AM CDT on Thursday, September 22. The hurricane eye made landfall near Sabine Pass about 4:00 AM on Saturday, September 24. When did you decide it was time to evacuate?

5. I finally left my home on: ☐ **Wed. Sep 21** ☐ **Thur. Sep 22** ☐ **Fri. Sep 23** ☐ **Sat. Sep 24**

6. I finally left my home at (*circle the correct time*):

|◄—— **AM** ——►|◄—— **PM** ——►|

1 2 3 4 5 6 7 8 9 10 11 Noon 1 2 3 4 5 6 7 8 9 10 11 Midnight

7. What is your age? _______ **years old**

8. What is your sex? ☐ **Male** ☐ **Female**

9. To which of the following ethnic groups do you belong and identify? ☐ **African American** ☐ **Asian/Pacific Islander** ☐ **Caucasian** ☐ **Hispanic** ☐ **Native American** ☐ **Mixed** ☐ **Other**

10. What is your marital status? ☐ **Married** ☐ **Single** ☐ **Divorced** ☐ **Widowed**

11. How many people in your household are: ______ **Less than 18 years** ______**18-65 years** ______ **Over 65 years**

12. What is your highest level of education? ☐ **Some high school** ☐ **High school graduate/GED** ☐ **Some college/vocational school** ☐ **College graduate** ☐ **Graduate school**

13. What is your *yearly* household income? ☐ **Less than $15,000** ☐ **$15,000—24,999** ☐ **$25,000—34,999** ☐ **$35,000—49,999** ☐ **More than $50,000**

14. Do you own or rent the home where you now live? ☐ **Rent** ☐ **Own**

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