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Factors Associated with Hurricane Evacuation in North Carolina

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1. Introduction

On September 18, 2003, Hurricane Isabel made landfall as a Category 2 storm between Ocracoke Island, North Carolina, and Cape Lookout, North Carolina. The storm entered the Albemarle Sound where strong winds of up to 105 miles per hour and storm surge of 4–6 feet caused extensive flooding and downed trees and power lines. One death and over $450 million in property damage were directly attributed to Hurricane Isabel.
Pasquotank, Perquimans, and Chowan counties are located in northeastern North Carolina between the Albemarle Sound and the Virginia-North Carolina border (Figure 1). In a 2005

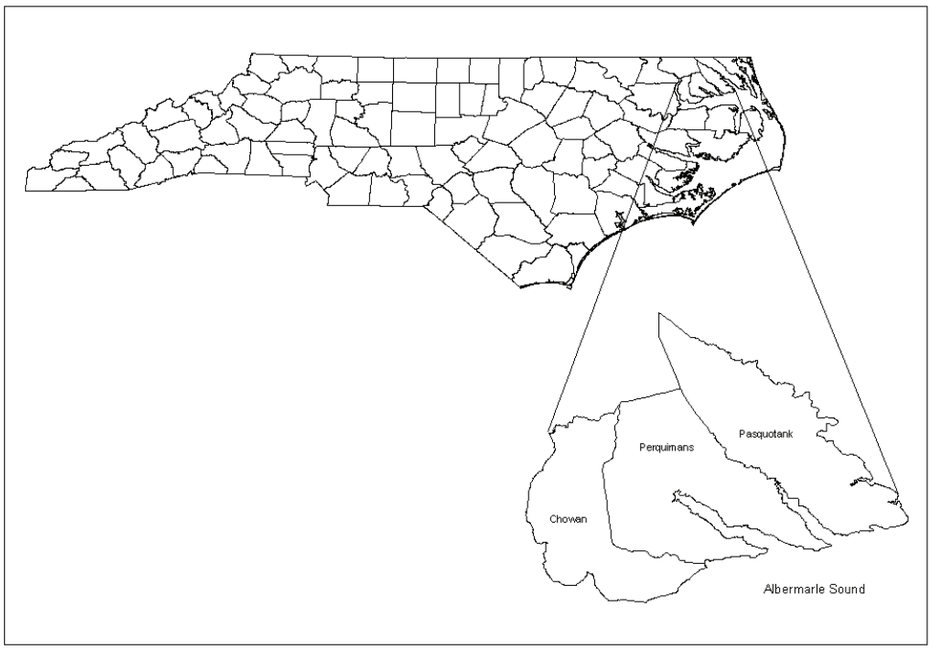

Fig. 1. Map of North Carolina with 3-county study area expanded

report, all 3 counties were classified by the U.S. Army Corps of Engineers as Category 1–3 storm surge areas for Hurricane Isabel, although prior to landfall only Pasquotank County was under a mandatory evacuation order, which replaced a voluntary order approximately 24 hours before landfall. A voluntary order was issued in Perquimans County and no evacuation order was issued in Chowan County. The three counties are part of the 7-county Albemarle Regional Health District and share staff, emergency preparedness plans and other area-level public health and emergency response resources.

2. Background

Existing research on evacuation behavior during hurricanes and flooding has focused primarily on individual demographic characteristics to understand why some households evacuate at higher rates than others. However, the inconsistency of published results and the inability of public health and safety officials to address these factors make it difficult to develop effective interventions or to draw conclusions that will hold true over multiple storms. Social factors such as access to social capital, levels of social control, and the extent of social cohesion also play a role in evacuation behavior. While social factors are generally considered to encourage evacuation, particularly for those with access to large networks and stocks of social capital, the potential for negative effects among certain groups are relatively unexamined.

Previous research has focused extensively on the role of prior disaster experience in evacuation decision making (Aguirre 1994; Dash and Gladwin 2007; Moore et al. 2004; Riad, Norris and Ruback 1999; Strope, Devaney and Nehnevajsa 1977; Wilkinson and Ross 1970). Individual stories of storms that did not make landfall as strongly as or in the location predicted are common, since relatively few areas have experienced direct hits by major hurricanes. Based on reports in the literature, this judgment of the risk of an approaching storm based on the last one that affected the area may lead to successful evacuation or failure to evacuate. Hurricane experience predicted evacuation for residents of Charleston, South Carolina, for Hurricane Emily, which made landfall just 4 years after Hurricane Hugo devastated that city, but hurricane experience was not associated with preparation for or evacuation from Hurricane Fran, which struck the area in 1999, 11 years after Hugo (Sattler 2001).

There is near consensus in the existing literature that people take action regarding evacuation on the basis of their perception of risk (Lindell and Hwang 2008; Lindell and Perry 2004; Riad and Norris 1998). However, how they develop this perception is unclear. In order to accurately assess risk, residents must feel that they are in danger and that leaving the area will be beneficial (Arlikatti et al. 2006; Fitzpatrick and Mileti 1991). Official watches, warnings, and evacuation orders are generally related to evacuation (Baker 2000; Drabek 1969; Edwards et al. 2001; Gladwin and Peacock 1997; Moore et al. 1963; Whitehead et al. 2000; Wilkinson and Ross 1970). However, several studies indicate that personal communications with family, friends, and co-workers and first-hand assessments of the dangers are even more important to the evacuation decision than official warnings (Drabek and Boggs 1968; Killian 1954; Windham, Ross and Spencer 1977).

Recent studies have reported significant associations between evacuation and gender (Bateman and Edwards 2002; Gladwin 2005; Lindell, Lu and Prater 2005; Whitehead et al. 2001), race (Riad et al. 1999; Van Willigen et al. 2005), having children at home (Lindell et al. 2005) and special medical needs (Maiolo et al. 2001; Van Willigen et al. 2002), although

overall, associations between personal characteristics and hurricane evacuation have been inconsistent in the published literature (Baker 1991).

Gender differences in evacuation have generally been attributed to variations in socio-economic status, care-giving responsibilities, and perception of risk (Bateman and Edwards 2002). Studies of Hurricane Bonnie (1998) found that female gender of the head of household and lower education levels were significant predictors of evacuation (Bateman and Edwards 2002; Whitehead et al. 2001). However, neither Whitehead (2001) nor Bateman (2002) found an association between gender and evacuation from Hurricanes Dennis (1999) or Floyd (1999), even though Bonnie, Dennis, and Floyd all made landfall in south-eastern North Carolina as Category 2 hurricanes within a 1-year period. In Gladwin's study of Hurricane Ivan evacuation, male gender of the respondent was significantly associated with increased evacuation (Gladwin 2005).

The majority of the literature finds no difference in evacuation based on race or ethnicity, although race and ethnicity may be more strongly correlated with vulnerability to property damage from hurricanes due to differential quality of housing than to evacuation (Van Willigen et al. 2005) and susceptibility of housing locations, particularly to flooding. Race may also be associated with differential access to information and services necessary for successful evacuation.

Quarantelli (1980) reported that evacuation from all types of events was positively associated with having children under age 18 living in the home. However, Baker's (1991) later review of evacuation studies of 12 hurricanes that made landfall between 1961 and 1989 did not find a consistent relationship between households with children under age 18 living at home and evacuation. In North Carolina, the effect of children on the evacuation decision may be explained by the fact that having children in the household typically increases the likelihood of living in a mobile home, generally a predictor of evacuation, by nearly 50% (Edwards et al. 2001).

Age is frequently included in studies of evacuation because of concerns about the limited mobility and special health needs of the elderly. Most studies have failed to find an association between age and evacuation. Those over age 60 were reportedly less likely to evacuate after Hurricanes Carla (Moore et al. 1963) and Andrew (Gladwin and Peacock 1997) made landfall in Florida, and each 5-year increase in age decreased the odds of evacuation by 10% when Hurricane Floyd made landfall in North Carolina (Van Willigen et al. 2005). However, in Perry and Lindell's (1997) review of nine disasters, those older than age 65 were no less likely to comply with disaster warnings than younger residents.

Previous research has been inconsistent with regard to the evacuation of those with special medical needs or disabilities. In a survey conducted following Hurricane Bonnie (1998), households that reported a special medical need were more likely to evacuate, while those with reported physical or mental disabilities were less likely to evacuate than households that did not report a medical need or disability (Whitehead et al. 2001). After Hurricane Floyd, households that included someone who was disabled reported the lowest rates of evacuation of any population sub-group (Van Willigen et al. 2002). Special medical needs may include conditions that require electricity, medical equipment, or home health care, all of which are likely to be disrupted during a hurricane. On the other hand, disabilities may make transportation and accommodation more difficult due to the need for handicap accessible accommodations and personal care facilities.

In terms of social factors, the evacuation literature has generally emphasized a positive association between social capital, social cohesion, and social control and evacuation

(Aguirre 1994; Bland et al. 1997; Dash and Gladwin 2007; Moore et al. 2004; Morrow 1999; Riad et al. 1999; Van Heerden and Streva 2004). However, a number of studies have found negative associations between high levels of social capital, social cohesion, or social control and evacuation (Buckland and Rahman 1999; Cordasco 2006; Gladwin, Gladwin and Peacock 2001; Solomon 1986).

Individuals look to others during an emergency for tangible assistance with evacuation, such as transportation, as well as for emotional support. When warnings or evacuation orders are issued, families tend to gather at home to reach consensus about what action to take (Drabek and Boggs 1968; Drabek and Stephenson 1971; Moore et al. 2004) and prefer to go to the homes of friends or relatives rather than public shelters (Aguirre 1994; Mileti, Sorensen and O'Brien 1992; Moore et al. 2004). For example, studies completed 1 year after Hurricane Hugo in 1989 and 6 months after Hurricane Andrew in 1992 found that perceived social support was a strong predictor of evacuation (Riad et al. 1999). In areas with high levels of social capital and social cohesion, community members may be able to act together to assist those who otherwise may not evacuate. For example, after Hurricane Floyd, residents of eastern North Carolina who believed their property to be safe from flooding reported being awoken by neighbors knocking on their doors during the night warning them of rising water (Moore et al. 2004).

Some research indicates that families with relatives outside the affected area are more likely to evacuate (Drabek and Boggs 1968; Drabek and Stephenson 1971). Called "evacuation by invitation," family members in safe areas provide accommodations for those in affected areas (Quarantelli 1980). This type of evacuation by invitation may be due to the strength of weak ties (Granovetter 1983). Weak ties with those outside ones primary social network may allow for access to information and organizational capacity that encourage evacuation but may not be available to those with a narrower and more local network.

Other research has examined the role of social capital in the receipt and provision of financial, information, and emotional support following major life events. After a disaster, social capital has been shown to be a strong predictor of the help that is received, but a weaker predictor of help that is provided (Kaniasty and Norris 1995). After other major life events (e.g. divorce) the most effective assistance generally comes from strong ties rather than weak ones (Lin, Woelfel and Light 1985). Stronger ties may be a more effective buffer against stress and other impacts of emergencies. However, during a disaster such as a hurricane, which affects entire communities, small dense network ties may not be able to function efficiently if all the members of the group have been negatively impacted by the storm. Individuals who are most strongly embedded in dense, homogeneous, or family dominated networks receive and expect more social support during normal times and during an emergency (Haines, Hulbert and Beggs 1996); whether or not this support encourages or discourages evacuation should be further explored.

Few previous studies have explored the influence of group memberships, such as churches, community organizations, or voluntary associations on hurricane evacuation. Buckland and Rahman's study of floods in several communities in Canada found that the more community organizations a person was a member of, the less likely they were to evacuate. Two studies have explored the role of religious organizations on the evacuation process in areas where the church was central to the community, including research around the Teton Dam floods, where the majority of the population was Mormon (Golec 1980) and the Toccoa Falls Dam flood in Toccoa, Georgia, which killed 39 on the campus of a fundamentalist Christian university.

Several studies have pointed to potential negative impacts of strong social factors on evacuation. Qualitative data collected following Hurricane Katrina from those evacuated to the Houston Astrodome indicated that even when respondents had access to transportation and the financial means to evacuate, some decided not to leave. In addition to financial considerations, "shared norms, local culture and traditions, responsibilities to social networks, and a collective history leading to trusting one's network rather than the authorities" all contributed to the decision not to evacuate (Cordasco 2006). Similar findings were reported by Buckland and Rahman (1999) regarding community preparedness for the 1997 Red River floods. Rosenort, the community with the highest level of social capital as measured by civic involvement, experienced the most conflict in decision making around evacuation. Although their social capital seemed to facilitate better preparation before the floods, peer pressure from residents who chose not to evacuate led many other residents to ignore the mandatory evacuation order.

For a theoretical framework to help understand the potential associations between social factors and evacuation, we turned to Weber's *Economy and Society*. Weber (1922) defined status groups as communities who share the same lifestyle and social restrictions. Certain groups set themselves apart as a status group by mobilizing and investing social resources for returns of wealth, status, or power (Lin 1999). During times of need, such as a disaster, these group ties may be more important than political or governmental structures. These group ties may evolve in such a way as to require "submission to the fashion that is dominant at a given time in society" (Gerth and Mills 1946), in this case, the refusal of certain residents to evacuate. They may also precipitate responsibility for the actions of many others, including friends, family, extended family, and pets, so it becomes less stressful to do nothing and avoid evacuation. Finally, the actions of these groups may be influenced by the "common experience of adversity" (Portes 1998) that are a result of their experiences with past storms or distrust of authorities.

Based on this theoretical framework and the existing literature, we hypothesized that social factors, such as high levels of social capital, social cohesion, and social control, may be more appropriate for explaining a social action such as evacuation than personal or household demographic characteristics. In addition, social factors could mediate the associations between demographic factors and evacuation, helping to explain some of the inconsistency of previous results. Examining associations between social factors and evacuation behavior may help to better understand differential patterns of evacuation and provide opportunities for interventions that could increase rates of evacuation among certain groups or improve preparedness of groups that have been identified as unlikely to evacuate.

3. Methods

3.1 Data sources

Flood insurance rate maps for the 3 counties were obtained from the North Carolina Floodplain Mapping Program. To ensure that each flood zone was represented in the study, census blocks were first stratified by flood zone based on the designation of the block's physical center. Thirty census blocks in each stratum were then randomly selected based on probability proportionate to population size. Within each selected block, 7 interview locations were chosen from a simple random sample of all existing parcels using a geographic information systems-based survey site selection toolkit developed by the North Carolina Division of Public Health in ESRI ArcMap 9.2 (Redlands, CA).

Data were collected between March 15, 2008, and August 23, 2008, using global positioning systems-equipped Trimble Recon Field Data Collectors via in-person interviews with one adult member of each selected household. Data were electronically recorded at the time of interview. Interviewers were routed to each location with a map generated with ESRI ArcPad 6.0.3 Street Map USA (Redlands, CA). Selected households were approached by an interviewer or interview team and gave informed consent. In order to qualify for inclusion, the resident had to be living in the same place as they did when Hurricane Isabel made landfall and all survey questions referred to the respondent's situation at the time of landfall. This research received approval by the Institutional Review Board of the UNC-Chapel Hill School of Public Health (Public Health IRB #06-0426).

3.2 Study variables

Evacuation from Hurricane Isabel was defined as self-reported relocation of a household or any household members to any location other than their primary residence prior to landfall of Hurricane Isabel on September 18, 2003. Social capital, social cohesion, and social control among the study sample were determined using established measures for social cohesion (Sampson, Raudenbush and Earls 1997), social control (Sampson et al. 1997), and social capital (Coleman 1990; Kawachi and Berkman 2000; Putnam 2000). Additional social control measures included markers of territoriality (Riad et al. 1999) and property preparation (Baker 1991; Buckland and Rahman 1999).

Social cohesion was represented by 5 survey questions that asked respondents about their willingness to help neighbors, how close-knit they felt their neighborhood was, whether they trusted their neighbors, how they got along with their neighbors, and whether neighbors shared their values. Responses to each question were on a 5 point Likert scale and had a possible total score of 4 (0 = strongly disagree, 4 = strongly agree) with higher values reflecting greater social cohesion. To determine the consistency of the 5 questions in measuring the single construct of social cohesion, a Cronbach's alpha statistic was calculated in SAS 9.1.3 (Cary, NC).

Social control was represented by 5 survey questions that asked respondents about their likelihood of taking action if they saw children from their neighborhood destroying property, skipping school, fighting, or being disrespectful to an adult. Respondents were also asked about the likelihood that they would write a letter or attend a community meeting if they heard that budget cuts were likely to eliminate a program that was important to them, such as a local fire station. Responses to each question were on a 5 point Likert scale and had a total possible score of 4 (0 = highly unlikely; 4 = highly likely) with higher values reflecting greater social control. Similar to social cohesion, a Cronbach's alpha statistic was calculated in SAS 9.1.3 (Cary, NC) to determine the consistency of responses to the 5 questions.

Social capital was measured in two ways. Following Putnam's (2000) model of civic involvement, respondents were asked to report any memberships in business, civic, community, and religions organizations (0 = no; 1 = yes). To measure engagement, respondents reported the number of meetings they attended each month. Information on organizational social capital specifically related to Hurricane Isabel was also collected, including dichotomous questions for whether the organization provided information or assistance to area residents affected by Hurricane Isabel and whether the respondent themselves volunteered through these organizations to provide assistance to anyone impacted by Hurricane Isabel (0 = no; 1 = yes). The density of friendship and kinship ties was also examined by having respondents report the number of local and non-local friends

and family, whether or not the respondent received assistance after Hurricane Isabel from local or non-local friends and family (0 = no; 1 = yes), and whether or not local friends and family evacuated from Hurricane Isabel (0 = no; 1 = yes). Respondents were also asked to report whether how many of their neighbors evacuated from Hurricane Isabel (0 = none; 1 = some; 2 = most or all). To determine if length of residence or hurricane experience was associated with evacuation, respondents were asked to report the number of years they had lived in their current home and in the county, as well as how may hurricanes they had experience in their lifetime. Tenure in the home and county were divided at the median value of 8 years for home and 22 years for county for analysis. Hurricane experience was divided at the median value of hurricanes that respondents reported they had experienced, which was 4.

Several other social factors were measured. Prior to starting an interview, interviewers recorded the presence of markers of territoriality at the residence, including names on mailboxes, no trespassing signs, beware of dog signs, and fenced in yards (0 = no; 1 = yes for each) (Riad et al. 1999). To measure the extent of property preparation and the potential for residents to fail to evacuate in order to monitor their property, residents were asked whether they prepared their property in advance of Hurricane Isabel by putting plywood on windows or taking other measures to protect their property (0 = no; 1 = yes). If residents reported making preparations, they were asked whether keeping an eye on those preparations was part of their reason for failing to evacuate (0 = no; 1 = yes) (Baker 1991; Buckland and Rahman 1999). To measure confidence in local governments' ability to provide evacuation-related services, residents were also asked if they agreed that their county or city provided services they needed in general, such as healthcare, after school and recreation programs for children and other municipal services and how likely they would be to intervene if they saw looters stealing from a neighbor after a hurricane. Responses to both of these questions were on a 5 point Likert scale and had a total possible score of 4 (0 = strongly disagree; 4 = strongly agree).

The interviewer assessed and recorded the type of home prior to the start of the interview. Homes were categorized by the interviewer as a stick built, mobile home or multi-unit dwelling (0 = stick-built; 1 = mobile home; 2 = multi-unit). Respondents were asked whether they owned or rented their homes (0 = rent; 1 = own). Additional demographic covariates measured included age (a bivariate variable was created around the median age of 50 years and used in analysis), race (0 = African-American or other; 1 = white), gender (0 = female; 1 = male), marital status (0 = widowed / divorced / never married; 1 = married), having children under age 18 living at home, having pets, or having a special medical need (0 = no; 1 = yes).

Respondents were asked whether they believed that their home was under an evacuation order prior to Hurricane Isabel's landfall (0 = no; 1 = yes; 2 = don't know). Respondents also were asked to report whether they had an evacuation plan and a disaster supply kit with at least three days of food and water for every member of the household and each pet (0 = no; 1 = yes). Perceived risk was measured by asking respondents to separately characterize the risk of flood and wind damage to their home during a hurricane similar to Hurricane Isabel. (0 = low; 1 = medium; 2 = high).

3.3 Data analysis

Bivariate analyses were performed using generalized linear models to identify any associations between hurricane evacuation and demographic, storm related, and social factor variables. Crude risk differences and 95% confidence intervals (CI) were estimated. CIs that did not include the null value were interpreted as indicating a statistically

significant difference in the absolute risk of evacuation between the referent group and the exposed group. For both dichotomous and multilevel exposures, reference categories were selected because they were considered to be most similar to a logical zero. All statistical analyses were conducted in SAS 9.1.3 (Cary, NC).

Multivariate analyses were used to create a parsimonious model of evacuation behavior and adjust for potential confounding. A full multivariable model was developed based on a review of published studies. Since the outcome of interest was common, generalized linear modeling was used to produce risk differences. In order to construct the full model, variables were removed from the full model 1 at a time except indicator variables, which were removed as a group. Based on the χ^2 values from Likelihood Ratio Tests (LRT), variables with a p-value of ≤ 0.20 were retained in the final model (Kleinbaum and Klein 2005). Confounding was assessed by removing variables one at a time from the full model, except indicator variables which were removed as a group. Variables that resulted in a change in the risk difference of greater than or equal to 10% were considered to be confounders and retained in the final model (Maldonado and Greenland 1993).

4. Results

Of those eligible to participate, 86.8% responded to the survey. In the study sample, 28% (n= 162) of the residents interviewed reported evacuating prior to Hurricane Isabel landfall, while 72% (n=408) did not evacuate.

Residents 50 years or older were 10% (95% CI: 2%, 18%) less likely to have evacuated when compared with younger residents. Households with children under the age of 18 living at home were 13% (5%, 22%) more likely to have evacuated than those without children. Race, gender and marital status were not significantly associated with evacuation status. Respondents who had lived in their home for more than the sample median of 8 years were 10% (95% CI: 3%, 18%) less likely to have evacuated. Those who had experienced more than the median number of 4 hurricanes were also 10% (95% CI: 3%, 18%) less likely to have evacuated (Table 1). These findings were consistent with previous studies that have reported lower rates of evacuation for older persons and higher rates for families with children. The finding that long-term residents and those with more hurricane experience were less likely to evacuate was consistent with the hypothesis, assuming that long-term residents generally have higher levels of social capital, social control, and social cohesion.

Those living in mobile homes were 36% (95% CI: 27%, 45%) more likely to have evacuated from Hurricane Isabel than those living in stick-built homes. Homeowners were 10% (95% CI: 0%, 21%) less likely to have evacuated compared to those who rented their homes. Having pets or having a special medical need was not significantly associated with evacuation status (Table 2). These finding were consistent with previous studies that have reported higher rates of evacuation for residents of mobile homes and renters. However, they were inconsistent with recent research reporting lower evacuation rates among pet owners.

Responses for the five social cohesion questions were closely associated (Cronbach's alpha = 0.92) and were therefore aggregated. The range for total social cohesion was 0 to 20 with a median of 15. In the crude analysis, a 1-unit increase in social cohesion was associated with a 1% (95% CI: 0%, 2%) decrease in evacuation. When the social cohesion factors were examined separately, those who strongly agreed they were willing to help neighbors were 6% (95% CI: 1%, 11%) less likely to have evacuated, those who characterized their

neighborhood as close knit were 5% (95% CI: 1%, 9%) less likely to have evacuated, those who strongly agreed that they trusted their neighbors were 6% (95% CI: 2%, 10%) less likely to have evacuated, and those who strongly agreed that their neighbors got along well were 5% (95% CI: 1%, 9%) less likely to have evacuated. These findings were consistent with the hypothesis that higher levels of reported social cohesion would be associated with lower rates of evacuation.

Responses for the five social control questions were closely associated (Cronbach's alpha = 0.87) and were therefore aggregated. The range for total social control was 0 to 20 with a median of 17. In the crude analysis, there was no change in evacuation for a 1-unit increase in social control. When the social control factors were examined separately, those who

Variable Description	Evacuated (n=162)		Did not evacuate (n=408)		Risk differences (95% CI)
	n	%	n	%	
Age					
Less than 50	91	33.83	178	66.17	REF
50 Years or Older	71	23.75	228	76.25	-0.10 (-0.18, -0.02)
Race					
African-American or Other	48	32.00	102	68.00	REF
White	114	27.14	306	72.86	-0.05 (-0.14, 0.05)
Gender					
Female	100	31.65	216	68.35	REF
Male	62	24.41	192	75.59	-0.07 (-0.15, 0.01)
Marital Status					
Widowed, Never Married, or Divorced	50	26.88	136	73.12	REF
Married	112	29.17	272	70.83	0.02 (-0.11, 0.06)
Children in Household					
No	77	36.84	132	63.16	REF
Yes	85	23.55	276	76.45	0.13 (0.05, 0.22)
Tenure in Home					
≤8 Years	95	33.57	188	66.43	REF
> 8 Years	67	23.34	220	76.66	-0.10 (-0.18, -0.03)
Hurricanes Experienced					
≤4	89	34.10	172	65.90	REF
> 4	73	23.62	236	76.38	-0.10 (-0.18, -0.03)

Table 1. Distribution, crude risk differences and 95% confidence intervals (95% CI) for demographic factors potentially associated with evacuation from Hurricane Isabel, 2003 (n=570)

strongly agreed they were willing to confront or report children skipping school were 3% (95% CI: 0%, 6%) less likely to have evacuated, while those who strongly agreed they were willing to confront or report children showing disrespect to elders were 3% (95% CI: 0%, 7%) less likely to have evacuated. The other individual social control variables had no effect on evacuation.

Variable Description	Evacuated (n=162)		Did not evacuate (n=408)		Risk differences (95% CI)
	n	%	n	%	
Home Type					
Stick Built	78	19.50	322	80.50	REF
Mobile Home	82	55.03	67	44.97	0.36 (0.27, 0.45)
Multi-Unit	2	9.52	19	90.48	-0.20 (-0.35, -0.04)
Homeownership					
Rent	44	36.67	76	63.33	REF
Own	118	26.22	332	73.78	-0.10 (-0.21, 0.00)
Pets					
No	93	29.43	223	70.57	REF
Yes	69	27.17	185	72.83	0.02 (-0.05, 0.10)
Special Medical Needs					
No	15	24.59	46	75.41	REF
Yes	147	28.88	362	71.12	-0.04 (-0.17, 0.08)

Table 2. Distribution, crude risk differences and 95% confidence intervals (95% CI) for contextual factors potentially associated with evacuation from Hurricane Isabel, 2003 (n=570)

Variable Description	Evacuated (n=162)		Did not evacuate (n=408)		Risk differences (95% CI)
	n	%	n	%	
Markers of Territoriality					
No	132	31.35	289	68.65	REF
Yes	30	20.13	119	79.87	-0.11 (-0.19, -0.03)
Prepared Property					
No	61	28.91	150	71.09	REF
Yes	101	28.13	258	71.87	-0.01 (-0.09, 0.07)

Table 3. Distribution, crude risk differences and 95% confidence intervals (95% CI) for social control measures potentially associated with evacuation from Hurricane Isabel, 2003 (n=570)

Contrary to our hypothesis, higher levels of social control had little to no effect on evacuation. However, other variables that may also measure social control were supportive of our hypothesis. Residents who had markers of territoriality at their homes, including names on mailboxes, no trespassing or beware of dog signs, or fenced-in yards were 11% (95% CI: 3%, 19%) less likely to have evacuated. Respondents who indicated that they spent time preparing their property prior to the storm were no more or less likely to have evacuated (Table 3).

Social capital was measured in two ways, including organizational participation and the number and location of friends and family. Organizational participation variables were supportive of our hypothesis. Respondents who reported that they were members of a church were 11% (95% CI: 3%, 19%) less likely to have evacuated compared with those who were not church members. Members of business or civic organization (e.g., Rotary, Ruritan, or the American Legion) were 16% (95% CI: 5%, 28%) less likely to have evacuated when compared with those who did not report membership this type of organization. Those who attended more church services or organizational meetings per month were no more or less likely to have evacuated than those who attended fewer meetings. There was also no difference in evacuation for respondents if the organizations they participated in provided relief services to those affected by Hurricane Isabel or if the organizations provided information about Hurricane Isabel to the respondent. However, if the respondent reported being a volunteer through one of these organizations following Hurricane Isabel they were 12% (95% CI: 3%, 21%) less likely to have evacuated (Table 4).

Variable Description		Evacuated (n=162)		Did not evacuate (n=408)		Risk differences (95% CI)
		n	%	n	%	
Attend Church						
	No	69	35.75	124	64.25	REF
	Yes	93	24.73	283	75.27	-0.11 (-0.19, -0.03)
Member of a Club						
	No	155	29.92	363	70.08	REF
	Yes	7	13.46	45	86.54	-0.16 (-0.28, -0.05)
Provided Hurricane Relief						
	No	103	27.83	267	72.17	REF
	Yes	42	24.85	127	75.15	0.03 (-0.05, 0.11)
Provided Hurricane Information						
	No	145	29.29	350	70.71	REF
	Yes	17	23.29	56	76.71	0.06 (-0.05, 0.17)
Volunteered						
	No	144	30.51	328	69.49	REF
	Yes	18	18.37	80	81.63	-0.12 (-0.21,-0.03)

Table 4. Distribution, crude risk differences and 95% confidence intervals (95% CI) for social capital measures potentially associated with evacuation from Hurricane Isabel, 2003 (n=570)

When considering their neighbors' behavior, respondents who indicated that some neighbors evacuated were 21% (95% CI: 11%, 31%) more likely to have evacuated, while those who indicated that most or all neighbors evacuated were 65% (95% CI: 53%, 78%) more likely to have evacuated. Residents who believed that their home was under an evacuation order issued by local authorities were 34% (95% CI: 18%, 50%) more likely to have evacuated when compared with those who believed that an evacuation order did not cover their home. Those who reported that they did not know whether or not an evacuation order covered their home were also 21% (95% CI: 6%, 37%) more likely to have evacuated when compared with those who believed that an evacuation order did not cover their home. Having an evacuation plan was important for successful evacuation, with those who had a

Variable Description	Evacuated (n=162)		Did not evacuate (n=408)		Risk differences (95% CI)
	n	%	N	%	
Neighbors' Evacuation					
None	71	18.07	322	81.93	REF
Some	48	39.02	75	60.98	0.21 (0.11, 0.31)
Most or All	41	83.67	8	16.33	0.65 (0.53, 0.78)
Believed Home Under Evacuation Order					
No	113	23.84	361	76.16	REF
Yes	26	57.78	19	42.22	0.34 (0.18, 0.50)
Don't Know	23	45.10	28	54.90	0.21 (0.06, 0.37)
Evacuation Plan					
No	31	19.25	130	80.25	REF
Yes	128	33.86	250	66.14	-0.15 (-0.23, -0.06)
Disaster Supply Kit					
No	67	30.73	151	69.27	REF
Yes	95	26.99	257	73.01	-0.04 (-0.12, 0.04)
Perceived Flood Risk					
Low	105	27.78	273	72.22	REF
Medium	32	25.81	92	74.19	-0.02 (-0.11, 0.07)
High	25	36.76	43	63.24	0.09 (-0.04, 0.22)
Perceived Wind Risk					
Low	35	22.15	123	77.85	REF
Medium	73	31.60	158	68.40	0.09 (0.00, 0.19)
High	54	29.83	127	70.17	0.08 (-0.02, 0.18)

Table 5. Distribution, crude risk differences and 95% confidence intervals (95% CI) for storm related measures potentially associated with evacuation from Hurricane Isabel, 2003 (n=570)

plan being 15% (95% CI: 6%, 23%) more likely to have evacuated when compared to those without an evacuation plan. On the other hand, having a disaster supply kit was not significantly associated with evacuation. Neither perceived risk for flood or wind damage was significantly related to hurricane evacuation (Table 5).

Since the associations between demographic, social, and storm-related variables may be confounded by other variables, a multivariable analysis approach was also used. Backward elimination modeling resulted in a final model that included home type, having an evacuation plan, and neighbor's evacuation status. Assessment of confounding resulted in retaining all of these variables in the model due to a change in the RD of more than 10% when each variable was removed from the model. Among survey respondents, those living in mobile homes were 14% (95% CI: 6%, 21%) more likely to have evacuated controlling for having an evacuation plan and neighbor's evacuation. Those with an evacuation plan were 9% (95% CI: 1%, 18%) more likely to have evacuated controlling for home type and neighbor's evacuation and those who reported that some, most, or all of their neighbor's evacuated were 46% (95% CI: 31%, 61%) more likely to have evacuated controlling for home type and having an evacuation plan.

5. Discussion

The associations between hurricane evacuation and individual and household demographic factors have been somewhat inconsistent in published studies. In this study, there were no significant associations between demographic variables and evacuation failure except age and having children under age 18 at home. The finding that older residents were less likely to evacuate may be due to actual or perceived difficulties in evacuation or based on experience with previous storms. Since the last major hurricane to affect this area was Hurricane Hazel in 1954, older residents may have believed that they were not at risk. The fact that there are few differences between demographic groups in this study leads us to question the construction of social difference in this region and suggests that further research focusing on other factors related to the evacuation decision is warranted.

The type of home and whether the respondent rented or owned the home were strongly predictive of evacuation. Those who live in mobile homes are clearly aware of added dangers of failing to evacuate during severe weather when compared to those who live in single family homes. It is also reasonable that renters have less at stake in terms of the damage that may occur to their homes. Renters are unlikely to have any financial or other responsibility for damages that may occur to a landlord's property, and therefore have little interest in staying through a storm to see how the property fares, although they do have their own contents such as furniture or clothing at risk of damage or loss.

The belief that their property was covered by an evacuation order issued by local government officials was an important factor in residents' decision to evacuate from Hurricane Isabel, indicating that the issuance of evacuation orders is effective in encouraging evacuation, or at least in shaping risk perception. In addition, those who reported that they did not know whether or not an evacuation order covered their home were also more likely to chose to evacuate, perhaps feeling that it was better to be safe than sorry. A closer examination of the covariate pattern for those reporting that they did not know whether their home was covered by an evacuation order showed that they were more than twice as likely to live in a mobile home and about three times as likely to have children under 18 years old living at home compared to the overall study sample.

Although it has been a consistent predictor of evacuation in the published literature (Drabek 1969; Drabek and Boggs 1968; Edwards et al. 2001; Gladwin and Peacock 1997; Killian 1954; Lindell and Hwang 2008; Lindell and Perry 2004; Moore et al. 1963; Riad and Norris 1998; Wilkinson and Ross 1970; Windham et al. 1977; Whitehead et al. 2001), the perception of risk of damage from either flooding or high winds was not associated with evacuation in this study (Horney 2010). This leads us to ask: How bad must respondents perceive conditions are before they decide to evacuate? Perceived risk includes not only the official or personal assessment of the severity of the threat (e.g., the issuance of the evacuation order) but also the individuals' perceived susceptibility (Houts et al. 1984; Perry et al. 1981; Riad and Norris 1998). While residents' perceived susceptibility to flooding or wind damage was not enough to spur evacuation from Hurricane Isabel, perceived severity as determined by an evacuation order was. Those who live in an area where they feel the risks for flood and wind damage are severe may not see a way to avoid the anticipated negative effects of a strong storm and decide to take no action. The issuance of an evacuation order removes perceived barriers by providing information on open shelters and evacuation routes as part of the issuance of the evacuation order. Having an evacuation plan may also provide a cue to action for evacuation similar to that of an evacuation order.

Higher levels of social cohesion were associated with an increase in hurricane evacuation failure. There is much scientific and anecdotal evidence that communities come together in the face of a disaster. It makes sense that neighbors who trust each another, get along well, and are willing to help each another may feel more comfortable remaining in their homes and neighborhoods rather than evacuating. The social resources available through direct ties to neighbors can provide access to the temporary support necessary for coping with storm impact and dealing with the initial phases of recovery (Lin 1999). These findings are consistent with the importance that neighbors' evacuation status had on the respondent's evacuation. Neighbors who do not evacuate may contribute to a downward leveling of norms which encourages those they know and trust not to evacuate. However, these results may be unrelated to social factors. Neighbors are likely to have the same information about a storm's anticipated severity, either due to location (e.g., areas near water or low-lying areas) or housing quality (e.g., trailer parks or suburban developments); therefore, their decision to evacuate may be unrelated to the influence of their neighbors.

Higher levels of overall social control were not associated with evacuation failure. However, indicators of social control such as markers of territoriality (Riad et al. 1999) were important. Posting no trespassing signs may indicate an unwillingness to follow government-issued evacuation orders or a lack of interest in taking part in the social action of an evacuation. Markers of territoriality may demonstrate a type of "territorial defense" (Riad et al. 1999) which makes residents who choose to utilize them more likely to avoid evacuation in order to protect their property from flooding, a storm surge, or looting. Personalization (names of mailboxes), signs (no trespassing) and barriers (fences) may also be markers of long-term ownership or territorial behavior (Riad et al. 1999). Since the presence of markers of territoriality were noted by the interviewer prior to making contact with the respondent, this measure may be a more unbiased indicator of whether or not a respondent would trust their neighbors as some respondents may be reluctant to report distrust of neighbors who they believe may also be approached by the interviewer.

Civic involvement was an important factor in hurricane evacuation failure. Members of churches and other community or civic groups were less likely to evacuate, as were volunteers. Clearly, civic engagement engenders ties to the community that may inhibit

evacuation, either through peer pressure or the anticipated need for assistance through volunteerism. Friendship and kinship ties were not associated with an increased risk of evacuation failure. Additional analyses of the density of relationships with friends and family using splines or other methods to account for outliers (e.g., some respondents who reported hundreds of local friends and relatives) should be explored in the future.

A strength of this study is the generalizability of the results to the entire three-county area. The GIS-based survey site selection toolkit allowed for random selection of households in the second stage of sampling. This ensured that selected households were independent and represented the totality of the households in the cluster (Lemeshow and Robinson 1985). This modification also prevented the selection bias that may have been introduced by allowing interviewers to select households for subsequent interviews after beginning at a random starting point (e.g., if interviewers avoided homes that appeared to be poorly maintained or had unrestrained pets). Additional strengths of the study include the strong local partnerships with public health and emergency management officials, which contributed to very high response rates, and the use of handheld technology for data collection, which has been demonstrated to improve data quality (Fletcher et al. 2003; Lal et al. 2000).

This study has several limitations. If those who are at highest risk for evacuation failure were also more likely to be missed in this survey, there is potential for response bias. To minimize this problem, interviews were conducted on weekends and weekdays during both day and evening hours. However, only those who were still living in the same location as they were when Hurricane Isabel made landfall were eligible to participate. Renters, those living in poverty, and other underserved groups may be more likely to move to different addresses or stay with friends or family members for a period of time and therefore would have been ineligible to participate. In addition, due to the nature of the questionnaire, only the characteristics and actions of residents were measured. Therefore the role that local governments and other agencies played in evacuation decision making of residents could not be assessed.

Since Hurricane Isabel made landfall nearly 5 years prior to the survey, recall bias could have been a factor in this study. However, a hurricane is a major event in the life of a community, so it seems unlikely that residents would have trouble remembering the effects of the storm or the actions they took in response to it. Some residents may not have wanted to report to the interviewers that they did not evacuate, particularly since accurate forecasted warnings regarding flooding for Hurricane Isabel were widely available prior to landfall. Additionally, since knowledge and beliefs were self-reported by survey respondents, the associations reported between these variables (e.g., the perception that an evacuation order covered your residence) and evacuation failure may have been the result of differential misclassification due to recall bias. Those who chose to evacuate may be more likely to report an evacuation order covered their home as a justification for their decision. Recall bias would not be a concern for variables that were rated by the interviewer or for self-reported demographic variables. Finally, since evacuation status and exposure to social factors were measured in the same interview, there is a potential for dependent errors that could bias results away from the null even if these errors were non-differential.

6. Conclusion

In this study, demographic characteristics including race, gender, martial status, having pets, or having a special medical need were not significantly associated with hurricane

evacuation. However, social cohesion, markers of territoriality, civic engagement, and volunteerism were associated with a decrease in hurricane evacuation. When studying a complex action such as hurricane evacuation, a compositional approach that considers only the demographic characteristics of individuals has many limitations. In addition, it is difficult to develop effective interventions based on demographic factors, many of which are non-modifiable by public health scientists or policymakers (e.g., we can't require pet ownership or marriage to encourage evacuation). Using a contextual approach, targeted interventions - such as house to house visits to encourage evacuation among those with markers of territoriality or in neighborhoods where evacuation rates are traditionally low or the development of educational programs on evacuation planning targeted to civic groups, churches and volunteers - could be developed by policy makers and planners to take advantage of neighborhood ties, civic engagement, and peer influence to encourage protective behavior and empower local residents.

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Recent Hurricane Research - Climate, Dynamics, and Societal Impacts

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This book represents recent research on tropical cyclones and their impact, and a wide range of topics are covered. An updated global climatology is presented, including the global occurrence of tropical cyclones and the terrestrial factors that may contribute to the variability and long-term trends in their occurrence. Research also examines long term trends in tropical cyclone occurrences and intensity as related to solar activity, while other research discusses the impact climate change may have on these storms. The dynamics and structure of tropical cyclones are studied, with traditional diagnostics employed to examine these as well as more modern approaches in examining their thermodynamics. The book aptly demonstrates how new research into short-range forecasting of tropical cyclone tracks and intensities using satellite information has led to significant improvements. In looking at societal and ecological risks, and damage assessment, authors investigate the use of technology for anticipating, and later evaluating, the amount of damage that is done to human society, watersheds, and forests by land-falling storms. The economic and ecological vulnerability of coastal regions are also studied and are supported by case studies which examine the potential hazards related to the evacuation of populated areas, including medical facilities. These studies provide decision makers with a potential basis for developing improved evacuation techniques.

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