

## Quick Response Report

### Explaining Hurricane Evacuation Failure: The Role of Social Factors as Modifiers

Jennifer A. Horney, PhD, MPH

Research Assistant Professor, Department of Epidemiology

University of North Carolina at Chapel Hill, Gillings School of Global Public Health

Campus Box # 8165

Chapel Hill, NC 27599

[jen.horney@unc.edu](mailto:jen.horney@unc.edu)

919-843-5566

919-843-5563 (fax)

Kristen Ricchetti-Masterson

Graduate Research Assistant, Department of Epidemiology

University of North Carolina at Chapel Hill, Gillings School of Global Public Health

Campus Box # 7435

Chapel Hill, NC 27599

[klrm@email.unc.edu](mailto:klrm@email.unc.edu)

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### **Introduction**

Past research has primarily looked at demographic factors, such as age, household composition and race or ethnicity to understand evacuation decision-making. However, the associations between hurricane evacuation and these demographic factors have been inconsistent, sometimes appearing to encourage evacuation and other times to deter it. For example, studies of Hurricane Bonnie (1998) (Whitehead 2001; Bateman and Edwards 2002) found that female gender of the head of household was a significant predictor of evacuation. However, significant associations were not found in studies of storms of similar magnitude and location. Whitehead and Bateman found no association between gender and evacuation from Hurricanes Dennis (1999) or Floyd (1999) although all 3 made landfall in south-eastern North Carolina as Category 2 hurricanes within a 1 year period. This inconsistency makes it difficult to develop effective interventions based on these factors and to target messages about evacuation to those most at risk. It also makes it difficult to draw conclusions based on these factors that will hold true over multiple events. In addition, many of these compositional variables (e.g., marital status, children in home) are not modifiable by scientists or policymakers, limiting the potential effectiveness of interventions.

In the 2 principal reviews of hurricane evacuation behavior, Quarantelli (1980) and Baker (1991) found no consistent associations between demographic factors and hurricane evacuation. They urged that attempts to relate demographic variables to evacuation behavior cease as they have no predictive capability, address the wrong unit of analysis, and fail to address important questions. However, these factors continued to be included in almost every post-disaster assessment.

Some recent studies have shown significant associations between evacuation and gender (Whitehead 2001; Bateman and Edwards 2002; Morrow and Gladwin 2005; Lindell, Lu and Prater 2005), race (Van Willigen et al. 2005b; Riad, Norris and Ruback 1999), pet ownership (Heath et al. 2001; Whitehead 2001), having children at home (Lindell, Lu and Prater 2005), and special medical needs (Maiolo et al. 2001; Van Willigen 2005a). These more recent results may also have been influenced by changing demographics of coastal areas of the U.S. as they become more urbanized and densely developed. Variability in results may also be attributable to the modification of risk factors for evacuation by population characteristics that change in prevalence over time or differ depending on the location of landfall (Slatterly et al. 2007).

We propose that a reason for these inconsistent associations between demographic characteristics and hurricane evacuation is modification by typically unmeasured social and community factors such as social cohesion, social capital and social control. In order to understand the potential interactions between demographic covariates and social factors, substantive and statistical evidence of effect measure modification on the additive scale can be sought, even for those variables without significant associations in bivariate analyses (Knol et al. 2009). For example, a variable that has a positive effect on evacuation among families with children under age 18 living at home may have a negative effect on families without children at home. Results of no association, likely when strata-specific risks are on opposite sides of the null, reflect average risks that are uninformative for public health and emergency management interventions such as the issuance of evacuation orders. The identification of effect measure modification on the additive scale is appropriate for the targeting of emergency interventions and could explain the inconsistency of previously published results.

## **Methods**

### *Data Collection*

All data were collected as part of a cross-sectional study conducted on October 8 and 9, 2011, in Beaufort County, North Carolina. Hurricane Irene caused widespread damage to the Pamlico Sound and Pamlico River basin, including extensive flooding and wind damage. Digital Flood Insurance Rate Maps (DFIRMs) for Beaufort County were obtained from the Federal Emergency Management Agency (FEMA) and information on damaged areas was provided by local public health and emergency management staff.

In order to ensure inclusion of residents from areas that has been most severely impacted by the storm, 10 blocks in Pamlico Beach, NC, Aurora, NC, and Hickory Point, NC, were purposively sampled. The additional 20 blocks were selected probability proportionate to population as follows: 10 blocks where 95% or more of the total area of the census block was in the 100 year flood plain; 5 blocks where 50% or more and less than 95% of the total area of the census block was in the 100 year flood plain; and 5 blocks where the centroid was located in the 100 year flood plain. Any block with fewer than 10 households as of the 2000 U.S. Census was not eligible to be included in the sample.

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). Interviewers were routed to each location with a Garmin Nuvi GPS unit and attempted an interview at the nearest home. If the interview was refused, the interviewer proceeded to the next nearest home. In-person interviews with 1 adult member of each selected household were conducted using Magellan Mappers (handheld computers), which electronically recorded responses at the time of interview. This research received approval by the Institutional Review Board of the University of North Carolina Gillings School of Global Public Health (Public Health IRB #11-1658).

### *Data Sources*

Evacuation was dichotomous and was measured by asking respondents whether or not they evacuated from their home before Hurricane Irene made landfall on August 27, 2011. Respondents were asked if an evacuation order covered their home, and if so, was this order mandatory or voluntary. To measure preparation, respondents were asked if they prepared their home before Hurricane Irene and if making those preparations played a role in their decision not to evacuate. The number of years a respondent had lived in the home and the county, as well as any past evacuation experience was also recorded.

Demographic information collected on all households included the presence of anyone over age 65, under age 18, pets, and anyone with a disability as well as the type of home and the gender, race and year of birth of the respondent. To measure perceived risk, respondents were asked if they considered their home to be in a high, medium or low risk site for flooding. To measure social capital, respondents were asked to report on involvement in community organizations and attendance at community meetings, including church as well as on volunteerism. Social control and cohesion was represented by 4 questions that asked respondents about their willingness to help neighbors, how close-knit they felt their neighborhood was, and their intentions for intervening if they saw looters or others damaging

property in their neighborhood. Markers of territoriality (e.g., no trespassing signs) were also assessed to measure social cohesion.

### *Data Analysis*

Bivariate analyses were performed in SAS 9.2 (Cary, NC). Generalized linear models were used to identify any associations between hurricane evacuation and demographic variables. Crude risk differences (RD) and continuity corrected 95% confidence intervals (CI) were estimated. Reference categories were selected because they were previously identified or assumed to be the lowest risk level.

Since average risks calculated in the bivariate analysis may obscure significant strata-specific differences, effect measure modification on the additive scale was assessed by calculating strata-specific RDs and 95% CIs. Strata-specific estimates that were considered substantively different (e.g. on opposite sides of the null value) were explored further based on subject matter knowledge, even when 95% CIs overlapped.

### **Results**

Interview teams approached 472 homes and 226 had an eligible resident (over age 18, residing in the area when Hurricane Irene made landfall) at home for a contact rate of 47.9%. Two-hundred and five interviews were conducted for a response rate of 90.7% (205/226).

### *Demographics*

The residences of 138 participants (67.32%) were located in the 100-year floodplain, 21 (10.24%) were in the 500-year floodplain, and the remaining 46 (22.44%) were located in non-flood areas with a low risk of flooding. The majority of residences where interviews occurred were stick-built, single-family homes (n=135), with the remaining residences either multi-unit apartments or townhomes (n=35), or mobile homes (n=34). Over three-quarters of respondents reported owning their home (n=155), while the remaining 23.65% rented their home. The mean age of respondents was 58 years, with a median of 59, and reported living in their current residence for a mean of 15 years, with a median of 10 years. Many homes were occupied by at least one individual over the age of 65 (60.49%), few had residents under the age of 18 (20.98%), and 15.92% reported living with at least one resident with special needs. The majority of those surveyed were female (64.22%), white (72.55%), and owned at least one pet (51.71%) (Table 1).

Bivariate analyses of demographic variables yielded no significant associations at the  $\alpha = 0.05$  level. However, a household with no children under the age of 18 was 15% more likely to evacuate than those with children under age 18 living in the home (RD = 0.15; 95% CI: 0.00, 0.29). Evacuation of households with a resident requiring special needs was 19% higher than the evacuation rate of those without special needs residents (RD = 0.19; 95% CI: -0.01, 0.39) (Table 1).

### *Social Factors*

Bivariate analysis of social factors yielded no significant associations at the  $\alpha = 0.05$  level (Table 2). However, there was evidence of effect measure modification of the RDs based on differences in the strata-specific RD estimates for a number of variables (Table 3). For example, having children under age 18 at home and age of respondent both had differential effects on evacuation depending on the

respondents reported level of social control. Having children under age 18 at home also had a different effect on evacuation depending on the reported level of social cohesion. Having a household member with a disability, having a household member over the age of 65 and respondent race all had differential effects on evacuation depending on whether or not there were markers of territoriality present at the home. Gender had a differential effect on evacuation depending on the respondent's membership in a local organization, such as a church or civic group. Finally, having a household member with a disability, age of respondent and preparing your property prior to hurricane landfall had differential effects on evacuation depending on the respondent's social capital.

## **DISCUSSION**

If social factors modify the associations between demographic characteristics and hurricane evacuation failure, these relationships should be taken into account in the development and implementation of interventions and educational programs that attempt to encourage evacuation (Greenland 2009).

For example, many jurisdictions are currently developing plans and registries to identify vulnerable populations, such as residents with a disability, before a disaster. In this study, households which included a resident with a special medical need were about 19% (-1%, 39%) less likely to evacuate, probably due to the concern that shelters would not be able to accommodate their special medical need or the complexities of leaving home. However, households with high social capital (defined as a higher than average number of local family, friends and acquaintances) and a special medical need were twice as likely to fail to evacuate (RD = 44% (95% CI: 5%, 84%)). In another example, in the bivariate analysis, there was little difference in evacuation reported between male and female respondents (RD = 0.04 (-0.10, 0.18)). However, in the stratified analysis, there was evidence of interaction between gender and belonging to a church or other civic organization. Men who reported belonging to a church or civic organization were 17% (95% CI: -7%, 41%) less likely to evacuate while women reporting belonging to a church or civic organization were 14% (95% CI: -3%, 31%) more likely to evacuate. Although there is overlap in the 95% confidence intervals for these measures, this shows a fairly large difference in the behaviors of men and women which is certainly worth additional attention.

The ability to estimate the influence of demographic factors on hurricane evacuation decision-making depends on the presence of effect measure modifiers. Social factors such as church membership and high social capital may modify risk differences associated with other potentially important risk factors including home type, homeownership, age, race, gender, marital status, and having children under age 18 living at home. Changes in the prevalence of these social factors over time and among different groups of residents will affect risk difference estimates associated with these demographic factors (Rothman, Greenland and Walker 1980).

Stratified data analysis can inform policy makers, planners, and emergency services personnel and guide targeted interventions towards sub-groups that are most important to reach. Relying on population average risk ignores heterogeneity that is fundamental to improving the public health response to hurricanes.

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