Choice and constraint during natural disaster evacuation: the case of Hurricane Katrina

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Introduction

Hurricane Katrina ranks among the most destructive and deadly natural disasters in United States history. The storm is estimated to have inflicted $108 billion in property damage and caused more than 1,800 deaths (Knabb, Rhome, and Brown 2005). With up to 1.2 million people fleeing the storm, Katrina also spurred the largest mass human migration in the United States since the Dust Bowl of the 1930s (Picou and Marshall 2007). The physical damage and demographic displacement wrought by Katrina have had significant implications for evacuees' individual social and economic prospects, as well as those for the affected communities in the Gulf Coast (Groen and Polivka 2010, Groen and Polivka 2008, Finch et al. 2010, Fussell et al. 2010, Hori and Shafer 2010, Zottarelli 2008).

This paper contributes to the growing body of social science research on Hurricane Katrina in particular, and population displacement from natural disasters more generally. By examining the social determinants of evacuation behavior, we provide additional evidence that natural disasters do not 'level the playing field' but rather interact with previously existing social structures to produce unequal outcomes.

We extend previous studies of evacuation behavior prior to Katrina in two respects. First, we produce a more rigorous examination of the effects of race and socioeconomic status by developing models that also account for potentially intervening or extraneous factors, such as participation in social networks, information attainment, and location. This helps clarify the ambiguity among previous studies regarding the relationship between race, socioeconomic status, and evacuation behavior. Second, we distinguish between individuals that chose not to evacuate and those that wanted to evacuate but were unable to do so. This allows us to isolate the constraining factors, and therefore move beyond simply describing inequalities to identifying sources of disadvantage.

Previous literature

Social science literature on natural disasters has demonstrated that the impacts of environmental events are not random, but rather structured by existing patterns of social interaction and organization (Mileti 2001, Morrow 1999). This has helped to 'de-naturalize' disasters and highlight the ways in which the outcomes of such events are socially constructed. Scholars have emphasized that everyday patterns of inequality and disadvantage structure patterns of vulnerability to disasters—that is, the ability to prepare, respond, cope, and recover (Cutter et al. 2003, Wisner et al. 2004). Of course, given that social organization varies across time and space, the exact sources of disadvantage during disasters are context specific. In some locations, caste and religion may be the most important axes of inequality, while income and ethnicity may differentiate affected populations in others.

In the United States context, an extensive body of research has documented racial and socioeconomic status inequalities in vulnerability to natural disasters (Forthergill et al. 1999, Fothergill and Peek 2004). These differences have been observed across multiple dimensions of disasters, from risk perception and preparedness to recovery. This reflects not only unequal

access to material resources (e.g. money, safe housing, transportation), but also social and cognitive processes such as participation in social relationships, risk perception, and information attainment.

Race and socioeconomic status have been shown to be important axes of differentiation in the evacuation process as well.[1] However, the effect of these two factors has varied across the limited number of studies that have examined them. This has left the question of "race versus socioeconomic status" to be addressed on a case-by-case basis.

A number of case studies on Hurricane Andrew addressed this issue. Morrow (1997) and Morrow and Enarson (1996) both highlighted the various difficulties that many low-income residents faced when attempting to evacuate prior to the storm. In a more representative analysis of the population affected by Andrew, Gladwin and Peacock (1997) found that race, but not socioeconomic status, was associated with evacuation behavior. Black and Hispanic individuals were less likely to evacuate prior to the storm than their white counterparts. However, these racial effects disappear when location inside (outside) the evacuation zone, evacuation information attainment, preparation time, and prior hurricane experience are accounted for. This suggests that these variables are the mechanisms through which racial differences in evacuation rates can be explained, and demonstrates the need to include such intervening variables in analyses of evacuation behavior.

With respect to Hurricane Katrina, the intense discussion about race—or the "color of disaster"—that emerged in the wake of the storm was largely about evacuation (Dyson 2006). Journalists and scholars variously suggested that racial inequalities were the root cause of why some individuals and households escaped the storm's path before landfall, while others were left—many forced to their rooftops for rescue or to die. However, social science literature on evacuation during Katrina has been equivocal about the role of race, suggesting that socioeconomic status and other less structural demographic factors (e.g. age and sex) may also help to explain differences in evacuation behavior.

Drawing upon Gallup and Red Cross data[2], Elliot and Pais (2006) found that among indicators of race and socioeconomic status, income was the strongest and most consistent predictor of evacuation timing among New Orleans city residents. Income was positively associated with the odds of evacuating prior to the storm, with lower-income respondents most likely to have stayed until during or after the storm, or never left. Significant racial differences in the city were observed only when predicting the odds of never evacuating, as the small group of non-evacuees was comprised almost entirely of black individuals. In contrast to the New Orleans sample, black respondents were significantly more likely to delay evacuation until during or after the storm than whites in the other affected areas across the Gulf Coast. No socioeconomic status-based differences were observed in the area outside of New Orleans.

In a similar, but non-comparable study, Haney et al. (2007) examined the effects of race and socioeconomic status on household evacuation strategies[3]. Using the same Gallup data, they analyzed data for New Orleans and the other affected areas combined.[4] Haney et al. found that black households were significantly less likely than whites to evacuate in unison before the Hurricane struck. Income also affected evacuation behavior. Poor households were more likely to stay up to or through the storm, or leave at least one family member behind. Notably, Haney et al. found that New Orleans residents were more than four times less likely than others to stay in unison than evacuate in unison. Although the racial disparities in this comparison were observed within both New Orleans and other affected areas, this demonstrates that respondents' overall odds of evacuation were strongly affected by pre-storm location.

These findings suggest that both race and socioeconomic status affected evacuation behavior prior to Hurricane Katrina, but these relationships were contingent upon geographic location and the precise outcome that was being predicted (e.g., evacuation before, during or after; household evacuation strategy).[5]

Since these studies are not methodologically comparable, knowledge of the impact of race and socioeconomic status on evacuation during Hurricane Katrina remains ambiguous at best. In addition to their slightly divergent conclusions, these two studies also fail to answer the question of whether non-evacuation before the storm was the result of constraint or choice. In fact, to our knowledge, no previous study of evacuation behavior prior to natural disasters has differentiated between the factors associated with the choice to stay and those that constrained evacuation.

Our study seeks to reexamine the questions of 'race versus socioeconomic status' and 'choice versus constraint' by drawing upon a dataset that has previously not been used to examine evacuation behavior prior to Hurricane Katrina. In addition to allowing us to re-examine the question of race, socioeconomic status, and evacuation, these data have the advantage of allowing us to determine whether race, socioeconomic status or other factors were associated with constrained evacuation.

Data and methods

We examine these questions with baseline year data (2006) of Harvard Medical School's Hurricane Katrina Community Advisory Group longitudinal study. The purpose of this study is to assess the impact of Hurricane Katrina on survivors' physical and mental health, and provide insight for future natural disaster planning efforts (Kessler 2009).

The study's target population was English-speaking adults (aged 18+) whose pre-Katrina residences were located in FEMA-defined "affected areas"[6], and who were located in either of two sampling frames[7]. The first frame included numbers listed in telephone banks working in the affected areas before the storm; the second included telephone numbers of the approximately 1.4 million families that applied for assistance from the American Red Cross after Katrina. In addition to these two primary frames, the Community Advisory group conducted a supplementary sample of hotels known to be housing FEMA-supported evacuees.

Pre-storm residents of greater New Orleans were oversampled in both frames to facilitate a separate analysis of the metropolitan area's population. The total sample was weighted for systematic differences between participants and respondents that declined to participate during the screening survey. The sample was also weighted for within-household probability of selection and residual differences between the sample and data from the 2000 Census on a range of variables (Hurricane Katrina Community Advisory Group 2006, Appendix I).

The data in Table 1 compare selected characteristics of the sample and 2000 Census data for the affected areas (Hurricane Katrina Community Advisory Group 2006). These data demonstrate that the weighting scheme generally increases the representativeness of the sample, and we therefore use the weighted data in our study.

[See Table 1 in Appendix]

Logistic regression has been the primary analytical method used to study evacuation behavior and post-storm resettlement in the case of Katrina (Elliot and Pais 2006, Groen and Polivka 2010, Haney et al. 2007, Stringfield 2009), as well as many other natural disasters

(Gladwin and Peacock 1997, Stein et al. 2010, Zhang et al. 2004). This technique is also appropriate for the binary outcomes that we model in our study. The relatively unrestrictive assumptions of logit models are also advantageous for analyzing the non-normally distributed data on storm-affected populations.

Our analysis is centered on two series of binary logistic regression models, which are expressed as:

$$z = \log \frac{p(Y_0)}{1 - p(Y_1)} = \alpha_0 + \sum \beta_{mk} x_{ik}$$

where α_0 is a constant and β_{mk} is the effect of a unit change in independent variable x_i on z, the log odds of the dichotomous outcome variable (Hosmer and Lemshow 1989). We report β_k in terms of odds ratios: values greater than 1.000 indicate that the respondents in group *k* were more likely to experience the outcome Y_1 than those in the reference group; values less than 1.000 indicate that those in group *k* were less likely to experience the outcome Y_1 than those in the reference group.[8]

Analytical framework

Our empirical analysis is motivated by the abovementioned literature on race and socioeconomic status inequalities in evacuation behavior during natural disasters, as well as additional literature on hurricane evacuation and human mobility in general. In this section, we describe the variables we include in our analytic models.

Outcome variables:

Evacuation status is our outcome variable in the first series of logistic regression models. Our binary outcome variable distinguishes between respondents who reported: (a) evacuating their residence before the storm and (b) evacuating during or after the storm, or never evacuating at all. This contrasts the optimal response from a policy perspective (evacuating before the storm) with all sub-optimal outcomes. We use pre-storm evacuees as the reference group, and therefore predict the odds that respondents did not evacuate before the storm.

In our second series of models, we examine only the non-evacuee population and compare individuals who: (a) wanted to evacuate prior to the storm but were unable and those who (b) chose to remain in their residence through at least the beginning of the storm. The former group includes respondents who were unable to evacuate due to lack of transportation, money, place to go, job requirements, and/or some "other" reason they considered a constraint. The latter group includes those who chose to stay in order to take care of someone too sick to travel, to protect their home from potential vandalism, because they did not think the storm was going to be severe, and/or for other self-identified "non-constraining" reasons.

Independent variables:

The primary goal of our empirical analysis is to determine the respective effects of race and socioeconomic status on evacuation behavior. This is motivated by the ambiguity of previous studies of evacuation prior to Hurricane Katina (Elliot and Pais 2006, Haney et al. 2007), as well as the body of literature documenting low-income and racial minority

disadvantages in preparation for, response to, and recovery from natural disasters (Fothergill et al. 1999, Fothergill and Peek 2004).

Consistent with Elliot and Pais (2006), we limit our analysis of race to a comparison of self-reported non-Hispanic whites and non-Hispanic blacks. We exclude Hispanics (3.4% of respondents) and "others" (3.0% of respondents) because the small number of respondents in these groups precludes them from inclusion in multivariate analysis. Moreover, the unique social positions of these two groups vis-à-vis blacks and whites make it problematic to utilize a single non-white category.

We use the respondent's education as our primary indicator of socioeconomic status.[9] With respect to the evacuation process, education serves as an indicator of the social and human capital needed to accurately assess the risk and navigate the evacuation process. Given its positive correlation with income, education is also a strong proxy for respondents' ability to acquire goods and services through the market (e.g. hotel rooms, meals, transportation). The variable that we include in the model indicates the highest level of education attained by the respondent, and consists of three categories: (1) did not complete high school; (2) high school diploma or equivalent; and (3) some college or higher.

We also include an indicator of social networks in our analysis. The literature on human migration has demonstrated that social relationships affect mobility decisions in numerous ways, such as providing information on potential destinations, reducing the risks and uncertainty associated with moving, reducing the costs of relocation, and facilitating social integration in the destination (Stark and Bloom 1985, Massey 1990). Previous research on Hurricane Katrina has made a case for the role of social networks during Katrina—particularly in New Orleans. For example, Fussell (2005) argued,

> "among the first to leave were those for whom the costs of leaving were relatively low because their friends and relatives assisted them by providing shelter, food, and other necessities away from the city. Those without such social networks outside of the city were among the last to evacuate and were most dependent upon the city, state, and finally the federal governments to provide transportation, shelter, food, clothing, and medical attention."

Similarly, Barnshaw and Trainor (2007) reported that many affected persons had difficulties evacuating because their entire social network was concentrated within areas hit by Katrina. They cite evidence that a large majority of affected persons did not have a friend or family member they were able to stay with during the storm, contrasting it to those with extended social networks who were able to utilize family and friends to escape the affected area (Barnshaw and Trainor 2007). Such situations were likely widespread across the affected areas—but particularly in New Orleans, where scholars have noted the extremely high nativity rate among the city's population (Campanella 2008, Falk 2004, Falk et al. 2006). Indeed, the social significance of nativity in the city led Campanella to view "nativity as ethnicity" there (Campanella 2008: 270).

These insights suggest that persons with an extensive social network outside of the affected area were more likely to evacuate prior to the storm than those whose social networks did not extend beyond their locality. However, previous studies have lacked the data needed to systematically examine this relationship. We fill this gap by including a social network variable based upon the number of friends and relatives that respondents could confide in, and whether

these relations lived inside or outside of the respondent's home county or parish. This variable[10] distinguishes between respondents who were (a) "locally embedded", with a high number of social ties in their county or parish and a low number of ties outside of that county or parish, (b) "extra-locally embedded", with a low number of local ties but a high number of ties outside of their county or parish of residence, (c) "embedded", with high number of both local and outside ties; and (d) "socially isolated", with a low level of both local and outside ties.

Previous research has shown that information attainment is only one step in a multi-phase warning response process (see review in Dash and Gladwin 2007). However, our study is concerned less with understanding the social psychological aspects of that process than in determining whether information constraints (access) affected the likelihood of evacuation.[11] We therefore include a single measure of the number of times respondents' received evacuation preparedness recommendations. This indicates the degree to which they were aware of the storm's threat and received information about how best to prepare and when to evacuate. This variable consists of three categories: we consider 0-4 recommendations "low" information attainment, 5-15 "medium", and 16 or greater "high".[12]

Descriptive statistics

We begin our analysis by examining evacuation rates across the categories of all independent variables. As shown in Table 2, evacuation rates differed notably by race and education. Black (35.6%) and low-education (31.2%) respondents were less likely to evacuate prior to the storm than white respondents (42.7%) and those with a high school education or more (44.9% weighted average), respectively.

Rates also varied according to respondents' social networks. Those with a high number of relationships outside of their county or parish but few local ties had the highest pre-storm evacuation rate (53.6%). This provides preliminary support for our expectation that social relationships outside of the affected areas decreased the economic and social costs of evacuation. Additionally, the low rates of evacuation among those with high levels of local ties—regardless of their ties outside of their home county or parish—suggest that local social relations had a binding effect, diminishing respondents' propensity to evacuate prior to the storm. Although the effect of social networks on evacuation behavior may have multiple possible mechanisms, the lack of variation in evacuation rates according to respondents' information attainment suggests that information transmission is not one of those.

Lastly, we note that evacuation rates were much higher in the New Orleans metropolitan (77.2%) area than in the other affected areas (30.7%). This, in part, is a reflection of the heterogeneous conditions across the non-New Orleans affected areas, where evacuation orders were not uniformly in place.

[See Table 2 in Appendix]

In Table 3, we report rates of non-evacuation according to whether respondents reported having chosen to stay or wanted to evacuate but were unable to do so. We find that the racial and socioeconomic status differences in overall evacuation rates reported in Table 2 reflected a relatively high probability that black and low-educated non-evacuees were unable to evacuate prior to the storm. Black and low-education respondents were each approximately 20% more likely than their white and higher-educated counterparts, respectively, to report having been unable to evacuate prior to the storm.

With respect to social networks, we find that locally embedded respondents were more likely (79.5%) to report having chosen to stay prior to the storm than those with other arrangements of social networks. This provides additional support for expecting that strong local connections had a binding effect, lowering the propensity of respondents to evacuate. In contrast to the differences shown in Table 2, reported reasons for non-evacuation varied markedly (21%) between respondents who received a low number of evacuation recommendations and those who received medium or high numbers of recommendations. This suggests that information (or lack thereof) served as an instigating (constraining) factor in the evacuation process.

Last, we find we that non-evacuees with a pre-storm residence outside of the New Orleans metropolitan area were much more likely to have reported choosing to stay than those in the metropolitan area. Conversely, among those who did not evacuate prior to the storm, those who lived in New Orleans were much more likely to have done so because they were unable to leave. As discussed above, these differences partially reflect the uneven imperative to evacuate across the non-New Orleans affected areas (e.g. mandatory evacuation orders were not in place everywhere and storm impacts varied).

[See Table 3 in Appendix]

Multivariate analysis

In this section, we examine the determinants of non-evacuation in a multivariate context using logistic regression. We present two series of models. The first examines the determinants of non-evacuation prior to Hurricane Katrina by predicting the odds that respondents did not evacuate prior to the storm compared with those who did. The second series of models examines the non-evacuee population to identify the factors that differentiated persons who were unable to evacuate and those who chose to stay prior to the storm. These models predict the odds that respondents were unable to evacuate prior to the storm compared with those that reported staying in their residence by choice.

Comparing evacuees and non-evacuees

Our first series of models predict the odds that respondents did not evacuate prior to Hurricane Katrina. Given our focus on race and socioeconomic status, we begin with a model that includes only race, and then gradually add education and additional, potentially intervening, variables to determine the persistence of potential race and socioeconomic status effects.

In the first model, we find that black respondents were nearly 35% more likely to stay prior to the storm than their white counterparts. This effect cannot be explained by educational differences between racial groups, as a significant racial effect remains when education is introduced in Model 2. We find that education had an additive effect, with low-educated respondents approximately 50% more likely to have stayed prior to the storm than those with at least some college education. This suggests that both race and socioeconomic status affected evacuation behavior, and that black, low-educated respondents were least likely to evacuate prior to the storm.

In the final three models, we introduce variables that may underlie the observed race and socioeconomic status effects. None of these control variables affect the direction or statistical significance of these effects, indicating that both race and socioeconomic status were significant factors in evacuation dynamics prior to Hurricane Katrina. However, we observe a number of

important effects in addition to race and socioeconomic status, which indicate that both macro-structural and micro-level factors affected evacuation behavior prior to Katrina.

Respondents' social relations had a significant effect on their evacuation odds. Those with few local ties—regardless of the level of distant ties they possessed—were significantly less likely to stay prior to the storm. As suggested in the discussion of our descriptive analysis, this may indicate that a high level of local ties served as a "binding" force that lowered respondents' propensity to evacuate. Our reading of the literature on human migration more generally had also led us to anticipate that distant ties would increase the likelihood of evacuation, and our evidence supports this. We find that those with few local ties and a high number of distant ties were more than twice as likely to evacuate prior to the storm than those who were socially isolated across all geographic space. Evacuation odds did not differ significantly according to respondents' information attainment.

Model 5 includes a control for the location of respondents' pre-storm residence. Given the unique social context of New Orleans, as well as the concentrated environmental risk in that area, this control was necessary to determine whether location-specific effects biased the estimated odds of previous models. We find that this control for location has a strong and significant negative effect on the odds of staying prior to the storm. New Orleans residents were much less likely to stay than those from outside the metropolitan area, where the high probability of choosing not to evacuate found in our descriptive analysis suggests that many respondents were not compelled to evacuate. Including this geographic control does not change the effects of other variables. This indicates that the estimated coefficients in Models 1-4 were not biased by uncontrolled for differences between these two geographic areas.

[See Table 4 in Appendix]

In general, this first series of models indicates that both race and socioeconomic status affected the odds of evacuation, and that respondents' social networks had an additive effect on these odds. Black respondents and those with low-educational attainment were more likely to stay prior to the storm, while those with few social ties in their home county or parish were more likely to evacuate. Among those with few local ties, those with a high number of distant ties were most likely to evacuate prior to the storm. We also find a strong and statistically significant negative relationship between pre-storm residence in the New Orleans metropolitan area and the odds of staying prior to the storm. However, we find that the abovementioned effects of race, socioeconomic status, and social networks persist when pre-storm residence was controlled for. This indicates that the effects observed in Model 4 occurred in both the New Orleans metropolitan area and other affected areas.

Reasons for non-evacuation

The regression models reported in Table 4 describe differences between the evacuee and non-evacuee population. While the variables positively associated with non-evacuation may reflect constraining factors, they may also indicate respondents' choice to stay in their homes prior to the storm. We address this issue in the following series of regression models, which analyze only the non-evacuee population and predict the odds that respondents were unable to evacuate relative to having chosen to stay. Given our continued focus on the question of race versus socioeconomic status, we employ an identical model building strategy as in Table 4.

The first model shows that black non-evacuee respondents were more than two and a half times as likely to have been unable to evacuate than white non-evacuees. This effect persists across all of the models in the series, indicating that black non-evacuees were systematically more likely to have been constrained from evacuating prior to the storm compared to white non-evacuees. Education has an additive effect vis-à-vis race when it is introduced in Model 2. Non-evacuees with less than a high school education were more than twice as likely to have been unable to evacuate prior to the storm than those with at least a high school education. Like race, this effect is not changed by the introduction of additional control variables in subsequent models. We can therefore conclude that both race and socioeconomic status were significant axes of disadvantage during the evacuation process prior to Hurricane Katrina.

In addition to race and socioeconomic status, this series of models indicates that social networks, information attainment, and location of pre-storm residence all had significant effects on the odds that non-evacuee respondents were constrained from evacuating prior to the storm. Locally embedded and socially isolated non-evacuees were significantly more likely to have chosen to remain in their residence prior to the storm than non-evacuees with high numbers of both local and distant ties. The relationship between local social embeddedness and choice to stay is consistent with our expectation that those with strong ties to their local community would have a low propensity to evacuate. While statistically significant, the relationship between social isolation and choice is slightly weaker. Although socially isolated non-evacuees may have been more likely to choose to stay than those with a high number of both local and distant social connections, their lack of strong local social ties made them less likely to have chosen to stay than locally embedded non-evacuees.

We also find evidence that a lack of information constrained respondents' ability to evacuate. Non-evacuees who received a low number of evacuation recommendations were more than twice as likely to have been unable to evacuate prior to the storm than those who received a high number of recommendations.

Finally, the control for location of pre-storm residence has a strong and statistically significant effect on the odds that respondents were unable to evacuate. Among non-evacuees, respondents from New Orleans were more than three and a half times as likely to have been unable to evacuate. This reflects the high proportion of non-New Orleans residents that chose to stay, many because they did not have to evacuate. The significant effect of pre-storm location confirms the importance of introducing this control. Like the first series of models, however, the lack of significant change in the other observed effects between Models 4 and 5 indicates the previous estimates were not significantly biased by uncontrolled for geographic factors.

[See Table 5 in Appendix]

In this second series of models we find evidence that race, socioeconomic status, and low information attainment had constraining effects on evacuation. Among non-evacuees, respondents who were black, had less than a high school degree, and had low information attainment were more likely to have been unable to evacuate than those in their respective reference groups. Although pre-storm location had a strong and significant effect on respondents' odds of being unable to evacuate, the abovementioned factors served as constraints in both geographic areas. In addition to these constraints, we find that among non-evacuees, locally embedded and socially isolated respondents were more likely to have chosen to stay than non-evacuees who had a high number of both local and distant social ties. The relationship

between local embeddedness and choice to stay was particularly strong, which suggests that strong ties to one's local community may decrease the propensity to evacuate.

Discussion and conclusion

In this paper, we present evidence that evacuation behavior prior to Hurricane Katrina varied by race and socioeconomic status, and that these factors were associated with constraints on evacuation. Black respondents and those with less than a high school education were significantly less likely to evacuate prior to the storm and, among non-evacuees, more likely to have been constrained from evacuating than chosen to stay. This is among the first evidence that racial and socioeconomic status-based differences during a natural disaster actually reflected disadvantage—in this case, with respect to the ability to evacuate.

In addition to these structural effects, moreover, we find that social networks, information attainment, and pre-storm location significantly affected the likelihood of evacuating and the reasons for staying. Respondents with few social ties within their county or parish of residence were significantly more likely to evacuate prior to the storm than those with a high number of local ties. Among this group, those with high levels of distant ties were most likely to evacuate prior to the storm. Within the non-evacuee population, socially isolated and locally embedded individuals were more likely to have chosen to stay prior to the storm. Locally embedded respondents were most likely to have chosen to stay among this group.

Considered together, these findings show that within the structural effects of race and socioeconomic status, respondents' bundle of social relationships affected their propensity and ability to evacuate prior to the storm. More specifically, the evidence suggests that local ties had a "binding" effect—lowering individuals' propensity to evacuate—while distant ties made pre-storm evacuation more likely. The observed evacuation behavior of socially isolated individuals is less clearly interpretable. While they had a relatively high probability of evacuating prior to the storm, socially isolated non-evacuees were significantly more likely to have chosen to stay than been unable to evacuate. This may reflect ambivalence about geographic mobility that stems from a lack of any strong relationships or attachments to place.

Information attainment was not a significant predictor of pre-storm evacuation behavior, but it did contribute to the explanation of why non-evacuees stayed prior to the storm. Non-evacuees that received a low number of evacuation recommendations were more than twice as likely to have been unable to evacuate than those who received a high number of recommendations. Our data do not allow us to determine the exact mechanism by which information attainment affects evacuation behavior. However, we can conclude that a lack of information—or being in a situation that limited one's information attainment—constrained evacuation and was therefore an additional source of heterogeneity in evacuation behavior within and between racial and socioeconomic status groups.

Finally, we find that individuals from the New Orleans metropolitan area were much more likely to evacuate prior to the storm than those who lived outside of the metropolitan area. However, among non-evacuees, individuals from New Orleans were more than three times more likely to have been unable to evacuate than those from other affected areas. Both of these findings reflect the high imperative to evacuate from New Orleans relative to other affected areas, which included locations not under mandatory evacuation orders. The significance of geography indicates that this is a critical control variable to introduce in analyses of evacuation behavior, even though it does not significantly diminish the magnitude of other observed effects.

These findings have a number of important implications for policy and research. Regarding policy, our focus on the factors constraining evacuation provides stronger evidence that evacuation aid prior to future hurricanes in the Gulf Coast should be targeted to black and lower socioeconomic status households. These findings also indicate that disseminating information more widely and frequently—including to those without access to mainstream sources of information—is likely to increase pre-storm evacuation rates. Finally, the high propensity of non-evacuee respondents with few distant social ties to have chosen to stay suggests that policy interventions targeting such "holdouts" should consider the social factors that tie individuals to communities and places.

With respect to future research, this paper adds to previous knowledge about race and socioeconomic status differences in evacuation behavior prior to Hurricane Katrina (Elliot and Pais 2006, Haney et al. 2007), and natural disasters more generally (Fothergill et al. 1999, Fothergill and Peek 2004). First, we provide a thorough examination of the question of race and socioeconomic status in the case of Katrina by including a number of potentially intervening variables in our regression models. While many of these variables were statistically significant, they did not diminish the relationships between race, socioeconomic status, and evacuation behavior. They did, however, demonstrate that within the structures of race and socioeconomic status, evacuation behavior is contingent upon individuals' social networks, access to information, and residential location.

We contribute to the literature on population displacement and natural disasters by extending our analysis beyond a comparison of evacuees and non-evacuees to include an examination of why non-evacuees did not leave prior to the storm. Future research should replicate this design, as the inferences drawn from previous literature have been limited by their exclusive focus on comparisons between evacuees and non-evacuees, which does not account for individuals that chose to stay.

Additionally, future research should continue to examine the potential effects of social ties on evacuation behavior. Our findings and the previous literature on human migration more generally suggest that social networks are critical factors in mobility decisions. To better understand this relationship in the context of natural disasters, future research should seek to improve upon the measurement of affected persons' social networks, as our variable was based upon levels of affective social ties only. While these are indeed important, a stronger indicator of social ties would also account for the more utilitarian relationships that respondents perceive to be important in their evacuation decision, such as those who could provide shelter or transportation.

We also believe that future research on evacuation behavior prior to natural disasters should attempt to better collect and analyze spatial data. Our control for pre-storm location within the New Orleans metropolitan area was extremely important, but we believe that more precisely geo-coded data (e.g. tract or ward level) are necessary.[13] This would allow one to understand how neighborhood conditions and relationships affect individual- or household-level evacuation decisions. Additionally, geocoded data would allow one to examine who stayed despite mandatory evacuation warnings, and analyze possible spatial clustering of evacuation behavior.

Given the increasing threat of natural disasters due to climate change, we believe that continued attention to social inequalities vis-à-vis the environment is imperative. Understanding the social and material forces behind individuals' abilities and choices to prepare, respond, and

cope with natural disasters is necessary to pre-empt and respond to potentially destructive environmental events.

Notes

1. An extensive review by Dash and Gladwin (2007) demonstrates that race and socioeconomic status have not been the only focus of research on evacuation behavior. Previous research on this topic has examined the effect of numerous other characteristics of evacuees and non-evacuees (e.g. gender), as well as the social-psychological dimensions of the evacuation process.
2. Gallup Poll #2005-45
3. Household evacuation strategies refer to the timing of evacuation and whether or not household members remained united or divided.
4. Haney et al. controlled for location inside (outside) New Orleans.
5. Both Elliot and Pais (2006) and Haney et al. (2007) report a number of other statistically significant factors in their models. The former find significant gender differences in some comparisons, while the latter observe significant differences in evacuation strategies according to employment, religion, and sex. Because they do not interact with or otherwise affect their findings regarding race and socioeconomic status, we exclude this from our discussion for the sake of brevity.
6. "Affected areas" are defined as those counties and parishes that were declared eligible for "individual assistance" by FEMA.
7. Adjustments were made for overlap in the sampling frames (see Hurricane Katrina Community Advisory Group 2006 for details).
8. To easily interpret odds ratios less than 1.000, one should invert the coefficient ($\frac{1}{\beta}$). The quotient expresses the degree to which respondents in group x_i were less likely to experience outcome Y_1 than those in the reference group of variable x in the same terms as coefficients above 1.000.
9. Although an income variable was also available, we found that education and income were significantly and strongly correlated (.417). Given this, we chose to exclude the income variable for two primary reasons: (1) it was measured at the household level, which was not appropriate for our individual-level outcome; and (2) income is more prone to reporting bias than education.
10. We consider responses of 0-4 to either of the following questions "low" and responses of 5+ "high:" (1) "about how many friends or relatives in the county/parish were you close enough to that you could talk about your private feelings without feeling embarrassed?"; and (2) "about how many friends or relatives who did not live in the country/parish were you close enough to that you could talk about your private feelings without feeling embarrassed?" The median responses to these questions were 5.0 and 4.0, respectively, therefore 4.0 provides a reasonable central point around which to assign respondents to these categories.
11. We also consider the possibility that information attainment reflects the respondent's connection to (isolation from) mainstream society.
12. These thresholds distribute respondents as evenly as possible across the three categories.
13. Due to confidentiality restrictions, we were unable to obtain respondents' zip codes of residence from the Harvard study to link community- and individual-level data. We would have liked to, for example, examine whether living in neighborhoods with high

poverty or nativity rates affected the odds that an individual evacuated and the reason for not evacuating.

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References

Barnshaw, John and Joseph Trainor. 2007. "Race, Class, and Capital amidst the Hurricane Katrina Diaspora". Pp. 91-105. *The Sociology of Katrina: Perspectives on a Modern Catastrophe*. David L. Brunsma, David Overfelt and J. Steven Picou, editors. Rowman and Littlefield.

Campanella, Richard. 2008. *Bienville's Dilemma: A Historical Geography of New Orleans.* Center for Louisiana Studies.

Cutter, Susan L., Bryan J. Boruff, and W. Lynn Shirley. 2003. "Social Vulnerability to Environmental Hazards." *Social Science Quarterly* 84 (2): 242-261

Dash, Nicole and Hugh Gladwin. 2007. "Evacuation Decision Making and Behavioral Responses: Individual and Household". *Natural Hazards Review* 8(3): 69-77.

Dyson, Michael Eric. 2006. *Come Hell or High Water: Hurricane Katrina and the Color of Disaster.* Basic Books.

Elliott, J.R., and J. Pais. 2006. Race, class, and Hurricane Katrina: Social differences in human responses to disaster. *Social Science Research* 35(2): 295-321.

Falk, William W. 2004. *Rooted in Place: Family and Belonging in a Southern Black Community*. Rutgers University Press.

Falk, William W., Matthew O. Hunt, and Larry L. Hunt. "Hurricane Katrina and new Orleanians' Sense of place: Return and Reconstitution or 'Gone with the Wind'?" *Du Bois Review* 3(1): 115- 128.

Finch, Christina, Emrich, Christopher T. and Cutter, Susan L. 2010. "Disaster disparities and differential recovery in New Orleans." *Population and Environment* 31(4): 179–202.

Fothergill, Alice, Enrique G.M. Maestas and JoAnne DeRouen Darlington. 1999. "Race, Ethnicity, and Disaster in the United States: A Review of the Literature." *Disasters* 23(2): 156-173.

Fothergill, Alice and Lori A. Peek. 2004. "Poverty and Disasters in the United States: A Review of Recent Sociological Findings." *Natural Hazards* 32(1): 89-110.

Fussell, Elizabeth. 2005. "Leaving New Orleans: Social Stratification, Networks, and Hurricane Evacuation." *Understanding Katrina*, Social Science Research Council website: http://understandingkatrina.ssrc.org/fussell

Gladwin, Hugh and Walter Gillis Peacock. 1997. "Warning and Evacuation: A night for hard houses." Pp. 52-74. *Hurricane Andrew: Ethnicity, gender, and the sociology of disasters*. Walter Gillis Peacock, Betty Hearn Morrow, and Hugh Gladwin, editors. Routledge.

Groen, Jeffrey A. and Anne E. Polivka. 2008. "The Effect of Hurricane Katrina of the Labor Market Outcomes of Evacuees." *The American Economic Review* 98(2): 43-8.

-- 2010. "Going Home after Hurricane Katrina: Determinants of Return Migration and Changes in Affected Areas." *Demography* 47(4): 821-44.

Haney, Timothy J., James R. Elliot, and Elizabeth Fussell. 2007. Pp. 71-90. *The Sociology of Katrina: Perspectives on a Modern Catastrophe*. David L. Brunsma, David Overfelt and J. Steven Picou, editors. Rowman and Littlefield.

Hori, Makiko. and Mark J. Shafer. 2010. "Social costs of displacement in Louisiana after Hurricanes Katrina and Rita." *Population and Environment* 31(1-3): 64-86.

Hosmer, David W. and Stanley Lemeshow. 1989. *Applied Logistic Regression*. Wiley.

Hurricane Katrina Community Advisory Group. 2006. "Overview of Baseline Survey Results: Hurricane Katrina Community Advisory Group. www.hurricanekatrina.med.harvard.edu.

Kessler, Ronald C. 2009. *Hurricane Katrina Community Advisory Group Study [United States]*. Ann Arbor, MI: Inter-university Consortium for Political and Social Research.

Knabb, Richard D., Jamie R. Rhome, and Daniel P. Brown. 2005. "Tropical Cyclone Report: Hurricane Katrina." NOAA.

Massey, Douglas. 1990. "Social structure, household strategies, and the cumulative causation of migration." *Population Index* 56(1): 3-26.

Mileti, Dennis S. 2001. *Disasters by Design: a reassessment of natural hazards in the United States*. Joseph Henry.

Morrow, Betty Hearn. 1997. "Stretching the Bonds: the families of Andrew." Pp.141- 170. *Hurricane Andrew: Ethnicity, gender, and the sociology of disasters*. Walter Gillis Peacock, Betty Hearn Morrow, and Hugh Gladwin, editors. Routledge.

-- 1999. "Identifying and Mapping Community Vulnerability." *Disasters* 23(1): 1-18.

Morrow, Betty Hearn and Elaine Enearson. 1996. "Hurricane Andrew through women's eyes: Issues and recommendations." *International Journal of Mass Emergencies and Disasters* 14(1): 5-22.

Picou, J. Steven and Brent K. Marshall. 2007. "Katrina as a Paradigm Shift: Reflections on Disaster Research in the Twenty-First Century." Pp. 1-20. *The Sociology of Katrina: Perspectives on a Modern Catastrophe*. David L. Brunsma, David Overfelt and J. Steven Picou, editors. Rowman and Littlefield.

Stark, O. and David E. Bloom. 1985. "The New Economics of Labor Migration." *The American Economic Review* 72(2): 173-8.

Stein, Robert M., Leonardo Dueñas-Osorio and Devika Subramanian. 2010. **"**Who evacuates when hurricanes approach? The role of risk, information, and location." *Social Science Quarterly* 91(3):816-834.

Stringfield, Jonathan D. 2010. "Higher ground: an exploratory analysis of characteristics affecting returning populations after Hurricane Katrina." *Population and Environment* 31(1-3): 43-63.

Wisner, Ben, Piers Blaikie, Terry Cannon, and Ian Davis, editors. 2004. *At Risk: Natural hazards, people's vulnerability, and disasters*, *Second Edition*. Routledge.

Zhang, Yang, Carla S. Prater, and Michael K. Lindell. 2004. "Risk Area Accuracy and Evacuation from Hurricane Katrina." *Natural Hazards Review* 5(3): 115-20.

Zottarelli, Lisa K. 2008. "Post-Hurricane Katrina Employment and Recovery: The Interaction of Race and Place." *Social Science Quarterly* 89(3): 592-607.

Appendix

Table 1: Comparison of social characteristics of the affected area in the weighted and unweighted Community Advisory Group data and the 2000 Census						
	New Orleans Metropolitan Area			Other Affected Areas		
Variable	**Census**	**Weighted**	**Unweighted**	**Census**	**Weighted**	**Unweighted**
Age						
18-39	41.2%	33.7%	26.8%	42.8%	33.3%	34.7%
40-59	36.7%	46.3%	48.2%	34.5%	45.6%	43.9%
60+	22.1%	20.1%	25.1%	22.7%	21.2%	21.4%
Sex						
Male	46.3%	43.7%	45.6%	46.8%	47.6%	46.3%
Female	53.8%	56.4%	54.4%	53.2%	52.4%	53.7%
Family Income						
<1.5 Poverty	28.2%	28.2%	20.2%	38.5%	38.5%	37.4%
1.5-3.0 Poverty	29.0%	25.7%	26.8%	26.6%	26.6%	27.6%
3.0-6.0 Poverty	30.4%	29.2%	33.2%	24.6%	24.6%	23.8%
>6.0 Poverty	12.3%	16.9%	19.9%	10.4%	10.4%	11.1%
Race-Ethnicity						
White	60.7%	62.1%	69.2%	67.0%	62.5%	65.9%
Black	32.7%	31.1%	24.2%	30.3%	29.6%	28.1%
Other	6.6%	6.8%	6.6%	2.7%	7.9%	6.0%
Pre-storm residence						
New Orleans City	33.7%	34.1%	28.1%			
Rest of N.O. Metro	66.3%	65.9%	71.9%			
Rest of Louisiana				35.4%	40.2%	27.0%
Alabama				43.5%	31.7%	32.7%
Mississippi				21.2%	28.1%	40.3%

Table 2: Evacuation rates by individual and family characteristics				
Independent variable	**Evacuated prior to storm**		**Evacuated during or after the storm, or not at all**	
	Rate	N	Rate	N
Race				
Non-Hispanic Black	35.6	111	64.4	201
White	42.7	277	57.3	371
Education				
Less than HS Education	31.2	69	68.8	152
HS Education or GED	43.9	132	56.1	169
Some College+	42.7	221	57.3	296
Social Ties				
Low Local, Low Distant	43.3	196	56.7	257
Low Local, High Distant	53.6	45	46.4	39
High Local, Low Distant	35.1	61	64.9	113
High Local, High Distant	36.6	113	63.4	196
Information attainment				
Low	38	90	62	147
Medium	40.5	148	59.5	217
High	39.8	149	60.2	225
Pre-storm residence				
New Orleans Metro	77.2	169	22.8	50
Other Affected Areas	30.7	252	69.3	568

Table 3: Reported reason for non-evacuation by individual and family characteristics				
Independent variable	**Unable to evacuate**		**Chose to stay**	
	Rate	N	Rate	N
Race				
Non-Hispanic Black	41.0	75	59.0	108
White	20.6	70	79.4	270
Education				
Less than HS Education	45.5	65	54.5	78
HS Education or GED	20.1	32	79.9	127
Some College+	24.4	64	75.6	198
Social Ties				
Low Local, Low Distant	30.7	70	69.3	158
Low Local, High Distant	32.1	9	67.9	19
High Local, Low Distant	20.5	23	79.5	89
High Local, High Distant	30.8	57	69.2	128
Information attainment				
Low	43.8	57	56.2	73
Medium	22.7	47	77.3	160
High	22.1	46	77.9	162
Pre-storm residence				
New Orleans Metro	50.0	21	50.0	21
Other Affected Areas	26.6	139	73.4	383

Table 4: Logit models predicting the odds that respondent did not evacuate prior to Hurricane Katrina					
Independent variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Race					
Non-Hispanic Black	1.346(.037**)	1.305 (.065*)	1.361 (.036**)	1.513 (.009**)	1.827 (.001**)
White[a]					
Education					
Less than HS Education		1.532 (.015**)	1.706 (.004**)	2.284 (.000***)	1.709 (.017**)
HS Education or GED		1.023 (.883)	1.076 (.644)	.966 (.834)	.944 (.752)
Some College+[a]					
Social Ties					
Low Local, Low Distant			.690 (.025**)	.607 (.004**)	.494 (.000***)
Low Local, High Distant			.467 (.004**)	.368 (.000***)	.226 (.000***)
High Local, Low Distant			1.114 (.611)	1.153 (.524)	1.098 (.709)
High Local, High Distant[a]					
Information attainment					
Low				.929 (.692)	1.419 (.101)
Medium				.849 (.323)	.820 (.272)
High[a]					
Pre-storm residence					
New Orleans Metro					.095 (.000***)
Other Affected Areas[a]					
N	972	972	941	868	868
Overall Sig.	.036**	.012**	.000***	.000***	.000***
(-2)Log Likelihood	1291.163	1284.643	1245.771	1139.451	989.118
Cox-Snell R^2	0.005	0.011	0.029	0.054	0.202
Nagelkerke R^2	0.006	0.015	0.038	0.073	0.273
[a]= Reference Category; *=p<.10; **=p<.05; ***=p<.001					

Table 5: Logit models predicting the odds that non-evacuee respondent was constrained from evacuating prior to Hurricane Katrina					
Independent variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Race					
Non-Hispanic Black	2.659 (.000***)	2.794 (.000***)	2.804 (.000***)	2.805 (.000***)	2.885 (.000***)
White[a]					
Education					
Less than HS Education		2.174 (.001**)	2.565 (.000***)	2.352 (.002**)	2.507 (.001**)
HS Education or GED		.707 (.180)	.736 (.251)	.640 (.128)	.616 (.104)
Some College+[a]					
Social Ties					
Low Local, Low Distant			.660 (.101)	.566 (.032**)	.542 (.024**)
Low Local, High Distant			1.261 (.609)	1.218 (.674)	1.273 (.612)
High Local, Low Distant			.359 (.002**)	.377 (.004**)	.345 (.002**)
High Local, High Distant[a]					
Information attainment					
Low				2.550 (.001**)	2.416 (.001**)
Medium				.916 (.747)	.915 (.748)
High[a]					
Pre-storm residence					
New Orleans Metro					3.650 (.001**)
Other Affected Areas[a]					
N	384	384	372	351	351
Overall Sig.	.000***	.000***	.000***	.000***	.000***
(-2)Log Likelihood	593.758	575.308	555.298	513.274	502.614
Cox-Snell R^2	0.044	0.077	0.095	0.123	0.141
Nagelkerke R^2	0.064	0.112	0.137	0.178	0.205
[a]= Reference Category; *=p<.10; **=p<.05; ***=p<.001					