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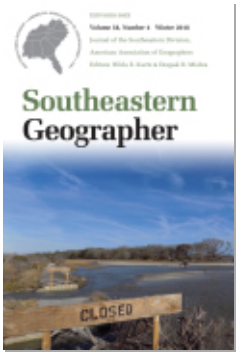

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Southeastern Geographer, Volume 58, Number 4, Winter 2018, pp. 328-347 (Article)

Published by The University of North Carolina Press
DOI: https://doi.org/10.1353/sgo.2018.0034

Social Vulnerability and Perceptions of Recovery from the 2011 Tuscaloosa Tornado

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Environmental hazards and natural disasters disproportionately affect socially vulnerable individuals and communities. However, studies of social vulnerability are often limited to socio-demographic measures of sensitivity to disaster impact without controlling for the effect of social networks on response capabilities. This paper assesses the role of socio-demographic and social network variables when controlling for the preparation for and impact of a disaster using the 2011 Tuscaloosa tornado as a case study. Using the results of a random digit dialing survey of individuals impacted by the Tuscaloosa tornado (n = 115), we model the factors of personal recovery from the disaster. We find that race, age, and education significantly affected one's perceived recovery from the tornado; however, exclusive of religious attendance, social network variables did not affect recovery perception. Time to recovery or to reach their personal "new normal" was longer for older respondents. Moreover, race and education, while statistically significant in degree of recovery, were not factors in speed of recovery. Social capital measures of recovery were consistent for degree and speed, further confirming that further investigation is needed into the role of religious involvement in both degree and speed of recovery.

RESUMEN: *Los peligros ambientales y los desastres naturales afectan de manera desproporcionada a las personas y las comunidades socialmente vulnerables. Sin embargo, los estudios de la vulnerabilidad social suelen ser limitadas a medidas sociodemográficas de sensibilidad al impacto de los desastres sin controlar el efecto de las redes sociales en las capacidades de respuesta. Este ensayo evalúa el papel de las variables sociodemográficas y de las redes sociales controlando la preparación y el impacto de un desastre utilizando el tornado Tuscaloosa del 2011 como un caso de estudio. Usando los resultados de una encuesta de marcado de dígitos aleatorios de individuos afectados por el tornado de Tuscaloosa (n = 115), modelamos los factores de recuperación personal del desastre. Encontramos que la raza, la edad y la educación afectaron mucho la percepción de la recuperación del tornado; sin embargo, excluyendo la asistencia religiosa, las variables de las redes sociales no afectaron la percepción de recuperación. El tiempo de recuperación o de alcanzar su "nueva normalidad" personal fue más largo para los*

SOUTHEASTERN GEOGRAPHER, 58(4) 2018: pp. 328–347

encuestados de mayor edad. Además, la raza y la educación, aunque estadísticamente significativas en el grado de recuperación, no fueron factores en el tiempo de recuperación. Las medidas de recuperación del capital social fueron consistentes para el grado y la velocidad, confirmando además que se necesita más investigación sobre el papel de la participación religiosa tanto en el grado como en el plazo de recuperación.

KEYWORDS: Disaster recovery, social networks, disasters, tornados

PALABRAS CLAVE: Recuperación de los desastres, redes sociales, desastres, tornados

INTRODUCTION

On April 27, 2011, Tuscaloosa, Alabama experienced an EF4 tornado with 190 mile per hour winds. With a ground track of 80.7 miles and a swath of 1.5 miles (NWS, 2011), the tornado resulted in 65 casualties, impacted more than 50,000 residents (NOAA 2014), and damaged or destroyed more than 5,000 homes (Flanagan 2012). Moreover, 12 percent of the structures in Tuscaloosa were severely damaged or destroyed, leaving 7,000 residents unemployed in the community of 80,000 (Rush, Houser, and Partridge 2015). In particular, the neighborhoods of Alberta and Holt were heavily hit, causing the loss of critical community infrastructure, including a nursing home, two elementary schools, a fire station, and the city's emergency operating system (FEMA 2012). The Tuscaloosa tornado was part of a larger storm system that resulted in 62 tornados in Alabama and a total of 247 deaths, rendering it the third deadliest tornado event in recorded United States (US) history (Chiu et al. 2013). Despite the immense community impact, there has been limited academic literature focusing on the social vulnerabilities related to this disaster.

Natural disasters result in an average of 90,000 casualties a year and directly impact the lives of an additional 160 million people internationally (WHO 2013). Moreover, it is expected that natural disasters will only increase in frequency and intensity because of climate change (Bergstrand et al. 2015). The findings of the 2014 National Climate Assessment report definitively conclude that climate change is occurring and that it has and increasingly will result in extreme weather events. Moreover, the report asserts that climate change, including these resulting disasters, threatens human health and well-being. The southeastern US is particularly vulnerable to tornado impact and fatalities (Ashley 2007).

Environmental hazards and natural disasters disproportionately affect the "socially vulnerable," including racial-ethnic minorities and the poor. Social outcomes of disasters are dependent on social vulnerability, adaptive capacity, the usability of scientific information for decision-making, and locally contextualized impact and vulnerability (Morss et al. 2011). Communities may be socially vulnerable to disasters in terms of not having the social capacity to prepare for, respond to, and/or recover from a disaster (Niederkrotenthaler et al. 2014). Specific to tornados, known risk factors are commonly associated with demographics. In particular, poorer communities are more likely to have vulnerable home construction (Daley et al. 2005) and a lack of access to storm shelters. In the South, these communities are disproportionately racial and ethnic minorities. Using the case of the 2011 Tuscaloosa

tornado, we assess adaptive capability through an examination of the relationship between measures of social vulnerability and the ability of individuals to recover from the Tuscaloosa tornado. Using primary survey data, we examine religious attendance, community involvement, and the size of one's social network and control for preparation, impact, education, age, race, income, and gender.

Background

Much of the extant literature on social vulnerability focuses on the intersection of social capital, income inequality, access to resources, and other social and/or political factors (Morss et al. 2011; Eakin and Luers 2006). According to Coleman (1988), social capital is the function by which one accesses resources through a network. The benefits of social capital are well documented in the literature (see Putnam, Leonardi, and Nanetti, 1993); likewise, in the absence of these networks, individuals become excluded from the capital that networks can provide. In disaster response, social capital is necessary to mobilize communities to collective action and promote recovery. To account for these such aspects and differences, Morss et al. (2011) introduced three components of social vulnerability: exposure, sensitivity, and coping/adaptive capacity. While these issues are often presented as disparate fields of research, the study of social vulnerability represents their synthesis (Eakin and Luers 2006). Exposure is based on environmental factors, both natural and built, that would impact vulnerability. More specifically, vulnerability through exposure entails the potential for loss (Cutter, Boruff, and Shirley 2003). Sensitivity is the degree of system affect and is influenced by both socioeconomic and demographic factors. Finally, adaptive capacity is the ability of a system to cope with and adapt to either existing or anticipated risks related to extreme weather. Adaptations are generally considered to be the process of improving how we cope with, manage, or adjust to exposure to vulnerability (Smit and Wandel 2006). Thus, adaptive capacity includes social capital and more specifically, safety nets—social networks through which individuals have access to resources and opportunities (Morss et al. 2011).

Since 1950, the state of Alabama has experienced 608 tornado-related fatalities, and on April 27, 2011 alone, experienced 232 (Simmons and Sutter 2012). Tuscaloosa County specifically has experienced a total of 185 fatalities in its recorded history, 77 of them on April 27, 2011 (NOAA n.d.). See Figure 1 for a map of the three counties included in the sampling frame for this study—Greene County, Tuscaloosa County, and Jefferson County—and the track of the 2011 Tuscaloosa tornado for reference. Tuscaloosa County alone has experienced a total of 73 tornados since 1953 (NOAA n.d.). The Candlestick Park tornado in 1966 also caused over 50 fatalities; however, most of those fatalities occurred outside of Tuscaloosa County (Reed 2016). Tuscaloosa County experienced 34 tornados between 1953 and 1999, yet there have been 42 tornados recorded between 2000 and 2017 (NOAA n.d.). While this trend suggests a rise in the frequency of tornados, this is mostly due to increased tornado observation practices (NOAA n.d.). In addition to disaster vulnerability, Tuscaloosa County is socially vulnerable. Of the 206,102 residents, 65.1 percent are White and 31.8 percent are African-American and the median income is $46,565, with 20 percent of residents living in poverty

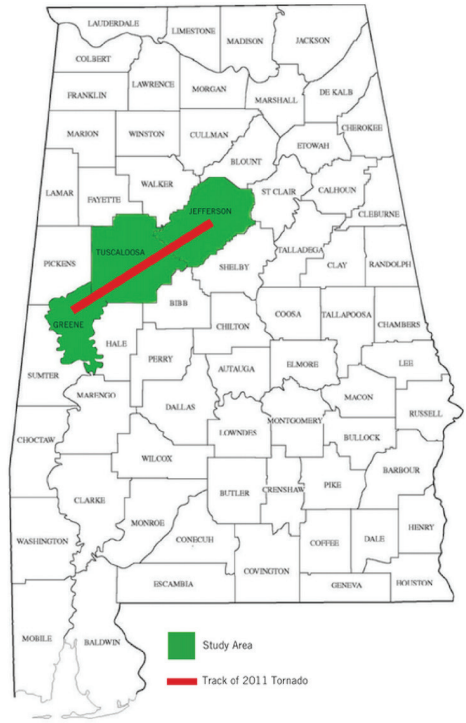

Figure 1. Ground track of the 2011 Tuscaloosa tornado and the counties included in the study.

(Census 2017). This compares to a national median income of $59,039 and a 12.7 percent poverty rate (Census 2017).

Social vulnerability is a complex factor that is embedded in the unique context of a community's geography, political climate, history, and social-cultural environment (Morss et al. 2011) and has been consistently demonstrated to be influenced by personal income, age, physical ability, and one's social support (Ersing and Kost 2012), herein referred to as social capital and measured through networks. Specifically, older, lower-income, and socially disconnected individuals recover more slowly or not as fully even after a considerable amount of time (Ersing and Kost 2012). Socio-demographics have been well documented in the literature to play a significant role in disaster resilience and recovery in which resilience is the community's ability to withstand disruptions and recovery is the process of post-disaster restoration, rebuilding, and reshaping of a household, neighborhood, or community (Cohen et al. 2013). Not only do individuals of different economic classes prepare for, respond to, and generally perceive disasters differently, but they are also differentially impacted, both psychologically and physically (Fothergill and Peek 2004). In the context of a tornado, poverty is a predictor of impact, as lower income residents are less likely to live in structures that could withstand tornadic winds or have reliable transportation to evacuate

(Simmons and Sutter 2012). While tornados are random, communities are racialized. Poorer neighborhoods, which are disproportionately Black and Latinx, are more impacted by tornados due to several compounding factors, including age of the community infrastructure and lack of storm shelters.

To account for the considerable amount of literature indicating that social activity variables also impact recovery (Brunsma et al. 2010), we include variables of social activity in assessing the role of social capital in perception of recovery. To account for differences in access to resources through one's social network, we include variables of social involvement: religious attendance, community involvement, and the size of one's social network.

At the community level, response and recovery are attributed to factors of resource availability, policies, environment, and social context (Lee et al. 2017). Although disaster research is generally considered to be "motivated by a sense of urgency and concern" (Norris, Friedman, and Watson 2002, p. 249), there is value in assessing longer-term recovery because recovery is a process which takes place over months and even years (FEMA 2011). Most tornado research focuses on damage rather than recovery, including reports of tornado damage that detail where the tornado fell on the F-scale, the path of the tornado using GIS or structural damage, and the death toll (Bourque et al. 2007).

Long-term studies of disaster recovery are more often focused on large-scale events, such as Hurricane Katrina (Fothergill and Peek 2016) and the Exxon Valdez Oil Spill (Gill, Picou, and Ritchie 2014). To date, there has been limited research published on the social vulnerabilities of individuals impacted by the Tuscaloosa tornado or the factors that might impact their ability to recover from the event. The closest previous research to the current study is Senkbeil et al. (2014), which examined individual differences in preparedness for and perception of the pre-tornado risk of the 2011 Tuscaloosa tornado between racial and ethnic groups, and if these differences existed when controlling for age, education, and length of residency in Tuscaloosa. Senkbeil et al.'s analysis reveals that there are significant differences in perceptions of preparedness based on race/ethnicity.

To assess the adaptive capacity of individuals impacted by the 2011 Tuscaloosa tornado, we control for socio-demographic sensitivity. Specifically, we address the following research question: What is the relationship between measures of social vulnerability and the ability of individuals to recover from the Tuscaloosa tornado? To this effect, we examine religious attendance, community involvement, and the size of one's social network and control for preparation, impact, education, age, race, income, and gender. In order to present models as parsimonious as possible, we drop some of these variables due to lack of significance as explained below. Community involvement was tested in several permutations of the model, for example, but was never found to be statistically significant. By controlling for preparation levels and impact, we identified the potential channels through which vulnerability affects recovery.

DATA AND METHODS

Data Collection

Data were collected using a random digit dialing (RDD) phone survey consisting

of both landline and cell phone numbers of individuals in communities impacted by the Tuscaloosa tornado: Greene, Tuscaloosa, and Jefferson counties in Alabama (see Figure 1 for the path of the tornado). The sampling frame included individuals living in these counties at the time of the disaster who self-identified as negatively impacted by the event. RDD has been demonstrated to produce data that are as representative as other methods and has been identified as a strategy that should be more broadly used in disaster research to develop a more complete picture of impact, resilience, and recovery (Bourque, Shoaf, and Nguyen 2002). Thus, RDD has been established as a reliable method for data collection in disaster research (Becker-Blease, Turner, and Finkelhor 2010). Yeager et al. (2011) found RDD telephone surveys have higher levels of accuracy than non-probability sample internet surveys. One noted disadvantage of RDD is the large number of unfruitful calls (Fowler 2013), but experimental studies have found this design to decrease standard errors while producing samples with similar demographic profiles (Becker-Blease, Turner, and Finkelhor 2010). Also, technology continues to make the method more cost effective and efficient (Fowler 2013).

In August 2014, the Gulf States disaster survey was conducted to collect information on impact and recovery from the Tuscaloosa tornado. Individuals were called and screened for being at least 18 years old, in the community at the time of the disaster, and having lived in a community near to or affected by the Tuscaloosa tornado. Those who met these criteria and were willing to participate in the survey answered a series of 57 questions about social involvement (i.e., religious, community, political, etc.), socio-demographic variables, and perceived recovery from the storm. To receive 214 completed responses using the aforementioned survey criteria, we made 13,010 calls to numbers in the Tuscaloosa community between July 7, 2014 and July 24, 2014, approximately three years after the tornado. Of these responses, 91 were completed for all variables of interest. Studies of tornado disaster communities have used RDD and received response rates from 11 percent to 33 percent (Houston et al. 2015). However, in these studies, the researchers were collecting data three weeks and six months, respectively, after the disaster, which likely explains the higher response rates than received in this study.

Variable Definitions

Our first dependent variable is the individual's perception of recovery. Measuring recovery from a disaster includes capturing emotions that one experiences about the social world, which vary cross-culturally; thus, capturing such a response is often limited to assessing one's perception of the phenomena given the interrelationships of factors in traumatic events are complex and difficult to capture in survey data (Uskul and Hynie 2014). The existing literature on disaster recovery strongly suggests that there are many problems associated with defining uniform measures of recovery. As recovery is often presented as the least understood phase of the disaster cycle (Chang 2010, Cheng et al. 2015), no consensus exists on how to measure recovery and the multi-disciplinary outlooks further complicate the process (Horney et al. 2016). Yet, scholars emphasize the essential need to define recovery measures to build

a systematic process (Chang 2010) and lament the multitude of single-case and small-scale studies (Horney et al. 2016). Recovery has been presented as a dynamic process lacking a clear endpoint and as a new "stable state" as reconstruction, restoration, rehabilitation, and post-disaster redevelopment progress (Chang 2010). For this reason, we evaluate recovery, both as perception of percent personally recovered and as time to reach current state of personal recovery.

Personal recovery is measured on a scale from zero to 100 percent. Respondents were asked, "Thinking of a percentage where zero percent is not recovered at all and 100 percent is completely recovered, to what extent have you recovered from the Tuscaloosa tornado?" The operationalization of the independent variables—education, age, race, income, gender, religious attendance, social network size, disaster impact, and disaster preparation—was as follows:

[1] Education: "How many years of education do you have?"
[2] Age: "In what year were you born?"
[3] Income: "At the time of the tornado, what was your household's TOTAL ANNUAL income before taxes, not just from wages or salaries, but from all sources?"
[4] Gender: [Phone interviewer: Enter gender of respondent.]
[5] Religious attendance: "In the weeks leading up to the tornado, how often did you attend religious services?"
[6] Social network size: "How many people would you be comfortable discussing important matters related to the tornado with?"
[7] Disaster impact: "How negatively did the tornado affect your well-being? Using a scale from 1 to 7, where 1 is not affected at all and 7 is severely affected, overall, how negatively did the tornado affect your well-being?"
[8] Disaster preparation: "Next, on a scale from 1 to 7, where 1 is not prepared and 7 is very prepared, how prepared did you feel you were for the tornado before it occurred?"

We operationalized socio-demographic variables in our models as follows: we include a variable for age (in years), a dummy variable for female (female = 1, male = 0), an indicator having at least a baccalaureate degree (1 = baccalaureate degree or more, 0 = some college or less), yearly household income (in thousands of dollars) and a dummy variable for race (Black = 1, all others = 0). We use two variables for religious attendance. The first variable used here, weekly religious attendance, is all those who attend religious services at least once a week (attend once a week or more than once a week = 1, all others = 0). The second variable is provided to separate out those who do not attend at all. If someone reports attending "never" or "less than once a month" then our variable "No religious attendance" = 1 and all others are coded as 0. The social network variable is the size of (number of people in) the network. Our final two variables are used as controls to see the specific channel through which social vulnerability may manifest itself. First, we attempt to control for the degree to which vulnerable communities are less prepared by including a scaled variable for the degree to which an individual felt prepared for the disaster beforehand.

DESCRIPTIVE STATISTICS

Descriptive statistics are provided in Table 1. Respondents reported an average level of 90.8 percent recovery from the tornado three and a half years after the disaster. While this shows a substantial degree of recovery, one should note that 20 percent of the sample stated that they were less than 80 percent recovered. Seventy-two percent of our respondents lived in Tuscaloosa County, 21 percent lived in Jefferson County, and 7 percent lived in Greene County. The respondents were not representative of the population ratios of the counties, but Tuscaloosa County was more impacted than Jefferson or Greene counties. Half of the respondents (52.2 percent) had a Bachelor's degree or more education, indicating that the sample is more educated than the population, as 28.5 percent of Tuscaloosa County residents, 10.9 percent of Green County residents, and 20.8 percent of Jefferson County residents have a Bachelor's degree or more education (Census, 2017). The mean age in the Gulf States survey in our sample was 57.8, significantly older than the average age for these three counties: 43.0 percent of our sample is over the age of 65, compared to 12.4 percent in Tuscaloosa County, 19.5 percent in Greene County, and 15.1 percent in Jefferson County (Census, 2017). In our sample, 16.5 percent were African American[i] (compared to the census figures of 31.8 percent in Tuscaloosa County, 80.6 percent in Greene County, and 43.4 percent in Jefferson County), and 67.0 percent were female (51.5 percent in Tuscaloosa County, 52.5 percent in Greene County, and 52.6 percent in Jefferson County). Thus, our sample is limited in demographic representation.

In our sample, 65.2 percent of the respondents reported going to religious services at least once a week and the average network size was 9.4 and the standard deviation was 3.32. Most individuals felt an average level of preparedness with a mean of 4.05 (almost exactly at the midpoint on the range). We also include a variable for the impact of the storm. The mean for this variable was 3.90, indicating that respondents had an average effect. While respondents were screened for having been affected by the tornado, the question about individual impact and the screening question were different. For the screening question we asked the following: "Were you living in a neighborhood or community near to or affected

Table 1. Descriptive statistics of survey sample used in analysis.

Variable	Obs	Mean	Std. Dev.	Min	Max
Recovery (%)	115	90.8	18.2	1	100
Income ($1000s)*	91	69.9	58.8	1.4	300
Weekly Religious Attendance	115	0.7	0.5	0	1
No Religious Attendance	115	0.2	0.4	0	1
Social Network	115	9.4	3.3	0	11
Prepared	115	4.1	2.1	1	7
Disaster Impact	115	3.9	1.9	1	7

Source: Authors' calculations using the Gulf States disaster recovery data set.

by (the tornado)?" Thus, while they might not have been affected personally, they did live in the affected community or near it, so they were included in the survey.

Method 1: Ordinary Least Squares Regression

Our first statistical method of analysis was ordinary least squares regression, which was chosen due to its simplicity in terms of reporting and interpreting results, though maximum likelihood estimates produced qualitatively similar results. While the data technically did not meet some of the Gauss-Markov assumptions for OLS, the robustness between OLS and nonlinear models indicates that any biases from these models are likely minimal, with a gain in an ease of interpretation.[ii]

Method 2: Survival analysis

While estimating the degree of recovery is one useful way to measure which factors are correlated with disaster recovery, a second approach is to consider how quickly individuals achieved that level of recovery. Although recovery means rebuilding and getting things back to normal, most communities will experience such fundamental changes to their characteristics that many people will never claim that recovery has been 100 percent. Individuals will have the tendency to compare the current state of the community to the previous state and connect any differences in the communities to lack of full recovery. Thus, the idea is to reach some degree of a "new normal" and not necessarily to recover back to the original state (Olshansky, Hopkins and Johnson 2012).

When the dependent variable is the time it takes to reach a certain state of being, the statistical approach used involves survival analysis using months as the time scale. One specific form of survival analysis similar to the linear regression models used above is the Cox proportional hazard model, which is employed here.

The hazard function is a function of the probability of the event happening in a given time period, conditional on the fact that it has not yet happened. The Cox proportional hazard model and ordinary least squares regression produce results that have a similar interpretation, except in Cox's method, the dependent variable is the hazard function at a given point in time. Thus, the interpretation of the coefficients is the change in the probability of recovering in any given period due to a one-unit change in the independent variable.

In the Cox proportional hazard, the hazard model that is estimated is compared to the baseline hazard, which is the probability of recovery at any time when all the independent variables are set to zero. One way of thinking of the baseline hazard is that it is analogous to the intercept term in an OLS regression model. A positive coefficient indicates a better chance of recovering, while a negative coefficient indicates the opposite. Thus, a positive (and larger) coefficient indicates that the variable is associated with faster recovery.

EMPIRICAL RESULTS

Our first statistical approach to look at the impact of socio-vulnerability and social networks on disaster recovery is an ordinary least squares regression model of selected covariates on disaster

Table 2. Effect of socio-demographic and social capital variables on perceived recovery.

	(1)	(2)	(3)	(4)
VARIABLES	Recovery (%)	Recovery (%)	Recovery (%)	Recovery (%)
Bachelor's Degree	9.590***	10.58***	10.84***	10.16***
	(2.815)	(3.178)	(3.176)	(3.373)
Age	−0.201***	−0.185**	−0.179**	−0.180*
	(0.0738)	(0.0746)	(0.0852)	(0.0936)
Black	−10.86**	−12.54**	−13.53***	−12.93***
	(4.436)	(4.907)	(5.159)	(4.901)
Weekly Attendance	14.65***	13.56**		
	(5.240)	(5.400)		
No Attendance	17.33***	17.09***		
	(5.238)	(5.318)		
Social Network		−0.330	−0.454	−0.435
		(0.464)	(0.520)	(0.505)
Prepared				0.796
				(0.760)
Disaster Impact				−0.816
				(0.848)
Constant	86.56***	88.77***	102.0***	102.0***
	(6.351)	(7.682)	(5.799)	(6.506)
Observations	128	116	116	115
R-squared	0.240	0.251	0.170	0.184

Source: Author's calculations using Tuscaloosa tornado recovery data set. Results are from and ordinary least squares regression model of covariates on the percent that individual reports that he or she has recovered from the 2011 Tuscaloosa tornado. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

recovery, as measured by the percent recovered (Table 2). Table 2 includes four separate model specifications (in columns 1 through 4) to try to see if any regression results are being obscured by independent variables that are highly correlated and to be sure that our results are not artifacts of the inclusion or exclusion of certain candidate variables. Presenting the results from several models in one table serves two purposes. First, it allows one to see whether potential collinearity between similar variables may drown out the effect of one variable when another related variable is included. Secondly, it presents a robustness check for the results to assure the reader that the results are not merely a statistical artifact of one particular selection of covariates (Hamermesh 2000).

Our results indicate that several socio-demographic groups did recover from the

tornado more quickly or more slowly than others when accounting for other factors.[iii] The estimated R^2 of these models are relatively low, but the F-test on each model was significant at the 0.001 level. Those individuals with at least a bachelor's degree recovered 9.6 to 10.8 percentage points more than those who had less education. Age is statistically significant in the models presented here, but the effect is small. Specifically, a 20-year age difference only leads to a 3.5 to 4.0 percentage point lower level of personal recovery. Unlike previous studies (see Eshel, Majdoob, and Goroshit 2014), we find that income was not a significant predictor of the degree of recovery. In fact, due to its lack of importance, we chose final models presented here that did not include income or a dummy variable for female. We used forward stepwise bootstrap methods on a variety of models and those that were consistently chosen less than 20 percent of the time were excluded in the final models presented in Table 2. More specifically, we conducted stepwise bootstrap procedure with 50 repetitions and any variable that was regularly not selected for 20 percent (at least 10 of 50 repetitions) was excluded from the model. In practice, this only led to the removal of the dummy variable for sex (female = 1) and our income measure. By eliminating these variables, the sample size did increase as missing values for income had reduced our overall number of responses. Also, in results not reported here, we find that women did not show a tendency to recover less than men (see Ashraf and Azad 2015). The most important demographic variable affecting the degree of recovery was race. African Americans were 10.9 to 12.5 percentage points less recovered than Whites when controlling for all other factors.

We found rather limited evidence for social networks being an important determinant of degree of recovery. The size of one's social network ("network") was negative and not statistically significant in the models displayed in Table 2. The one social network variable that does appear to have an effect is attendance at religious services. Individuals who attend at least once a week are 13.6 to 14.7 percentage points more recovered than individuals who attended less often, but at least once a month. While this seems to indicate that religious attendance is correlated with greater recovery, those who never attend religious services were also more recovered than the omitted category (one to three times per month). The effect was relatively large as those who never attend religious services recover 17 percentage points more than those in the category of occasional attendance. Finally, in column four we show that we find no evidence that either the degree to which an individual reports being prepared for the disaster or the level of impact from the disaster affected the degree of recovery.

Table 3 shows the results from a Cox proportional hazard model of recovery from the 2011 Tuscaloosa tornado. The list of independent variables is the same as those in Table 2. Interestingly, age is negatively related to speed of recovery as older respondents attained the current state of recovery more slowly than others. Other demographic variables, such as education and race, did not affect the speed of recovery, while they did affect the degree of recovery shown in Table 2. In the

Table 3. Effect of Socio-demographic and social capital variables on probability of recovery.

	(1)	(2)	(3)	(4)
VARIABLES	Probability of Recovery	Probability of Recovery	Probability of Recovery	Probability of Recovery
Bachelor's Degree	0.169	0.283	0.263	0.209
	(0.188)	(0.206)	(0.206)	(0.209)
Age	−0.0116**	−0.0127**	−0.0125**	−0.00846
	(0.00545)	(0.00560)	(0.00581)	(0.00620)
Black	−0.0127	−0.155	−0.253	−0.196
	(0.273)	(0.298)	(0.288)	(0.290)
Weekly Attendance	0.397	0.324		
	(0.292)	(0.294)		
No Attendance	0.876**	0.886**		
	(0.340)	(0.345)		
Social Network		−0.0390	−0.0439	−0.0394
		(0.0324)	(0.0315)	(0.0317)
Prepared				0.0353
				(0.0481)
Disaster Impact				−0.109*
				(0.0582)
Observations	117	105	105	104

Source: Authors' calculations using Gulf states disaster recovery data set. Results are from a Cox proportional hazard model where the dependent variable is the probability that an individual reports completing his or her disaster recovery from the 2011 Tuscaloosa tornado in a given month. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

hazard model, we find that attending religious services at least once a week did not lead to faster recovery compared to those who attended less regularly. However, similar to the findings from Table 2, those who never attended religious services recovered more quickly than those who attended services occasionally. Our other social network variable, the size of one's social network, did not affect the speed of recovery. When we include how prepared an individual was before the disaster, this variable is also not statistically significant in the model. We did find that level of impact affected recovery: those who were more severely impacted (Disaster Impact) from the disaster recovered more slowly. Since we find that this is true even without race or education being significant (even in models where the Disaster Impact variable is not included), it does not appear that greater impact is the channel through which vulnerability is manifesting itself.

DISCUSSION

The findings of this study present that both socio-demographic variables and social capital variables impacted recovery from the Tuscaloosa tornado. Specifically, regarding percent recovered three and half years post event, we find that: (1) those with at least a Bachelor's degree recovered 9.6 to 10.8 percentage points more than those with less education; (2) age was marginally significant in some models, but had a relatively small impact with a 20-year age difference yielding a three to four percentage point difference; (3) income and gender are not significant when controlling for other factors; and (4) African Americans were 10.8 to 12.9 percentage points less recovered than others when controlling for all other factors in the model. In related work, Senkbeil et al. (2014) found that the only racial significance in early impact was between non-Hispanic Whites and Hispanics/Latinx, but there is limited comparison that can be made here. The current survey did not have a large enough number of Hispanic/Latinx respondents to be able to include this variable.

Although we find that socio-demographic variables explain much of the variation in recovery from the Tuscaloosa tornado, more research is needed on the finding that income is not a significant factor when controlling for other factors. Another limitation to our study is that our sample was older than the resident population. Therefore, income is less likely to reflect access to resources than a variable such as total wealth, that we do not have. Total wealth is also strongly correlated with race and ethnicity, so part of the reason for less recovery for African Americans is the lower wealth and weaker access to financial assets, such as loans, that could facilitate recovery. Although Morss et al. (2011) notes that sensitivity—the degree of socioeconomic and demographic influence on the system—is one of three components of social vulnerability and that income is a key component of sensitivity, it is also important to note that income is one of many measures of sensitivity. For instance, education, which closely correlates with income, was found to be a significant predictor of recovery. Indeed, we argue that it is not merely income limiting access to resources needed for recovery, but that there are communities that are relatively limited, which are more likely to be minority communities (Daley et al. 2005; Niederkrotenthaler et al. 2014). This was confirmed in our study. Further research is needed to understand the differences by race and ethnicity impacting recovery. The African American population is 31.8 percent for Tuscaloosa County, 80.6 percent for Greene County, and 43.4 percent for Jefferson County (Census, 2017). Moreover, it is emphasized that race, as a factor in recovery, is not a biological factor, but rather a socio-economic measure of vulnerability. Thus, the finding that minorities are less recovered indicates that race is significant as a measure of socio-economic access necessary for resilience and recovery. As we noted, minority populations were distinctly underrepresented in this study. The Hispanic population is relatively low (3.5 percent in Tuscaloosa County, 1.2 percent in Greene County, and 3.7 percent in Jefferson County). Given potential language barriers to reaching this population, further research should include methods that target

small-population ethnic minority groups, including translation, to understand the unique resilience and recovery barriers experienced by minority populations in these communities.

The third component of Morss et al.'s (2011) framework, coping/adaptive capacity, highlights the role of social capital and related safety nets in social vulnerability. Despite the numerous calls in the literature for increased inclusion of social capital measures in the study of disaster recovery (Brunsma et al. 2010; Aldrich and Meyer 2015), we found limited evidence for social networks as important determinants of disaster recovery in the case of the Tuscaloosa tornado. Specifically, the size of one's social network was not statistically significant in any of the models tested.[iv] The effect of religious attendance warrants further investigation as individuals who attend at least once a week were 13.6 to 14.7 percentage points more recovered than those who attend less often. However, those who never attend religious services were 17.0 to 17.3 percentage points more recovered than those that attend less than once a week. As religious institutions are important network components for both social relationships and access to organizational resources, this finding is worthy of further investigation. One possible avenue is that the effect of attendance is linear once non-attenders are excluded. For example, Lewis, MacGregor, and Putnam (2013) find that while religious attendance increases charitable and civic activities, it is not the beliefs, but the strength of the friendships developed that lead to this activity. With the increase in religious polarization in the US (see Putnam and Campbell 2010), those who decide to become non-attenders depend upon other (non-religious) friendships for their networks. Occasional attenders, however, still mostly have their connections through religious institutions, albeit weaker ones than frequent attenders.

As recovery is measured within this research as a perception—a cognitive process of recognizing the reinstatement of the status quo—recovery was both captured as a percent and an ephemeral process with an end (Leitch and Bohensky 2014). This end, however, is not always full recovery. As so, we have used survival analysis to capture the month and year at which respondents believe they reached their personal "new normal," regardless of what the level of recovery is relative to their pre-disaster state. Although the results in Table 1 clearly demonstrate that there are differences in when respondents reached their personal "new normal," the results of the survival analysis presented in Table 3 control for socio-demographic and social capital variables. The results reveal that there are some common factors between degree of recovery and speed of recovery. Age, however, has a minimal effect on degree of recovery and on speed of recovery. Specifically, older respondents reached their new normal state slower than others. Moreover, race and education, while statistically significant in degree of recovery, were not factors in speed of recovery. Social capital measures of recovery were consistent for degree and speed, further confirming that further investigation is needed into the role of religious involvement in recovery.

Low levels of social vulnerability correlate to high levels of community resilience, but the Southeast (and Gulf States

of Louisiana, Mississippi, and Alabama in particular) consistently demonstrate low resilience levels (Bergstrand et al. 2015). Thus, as this research finds, African Americans, those with lower educational attainment, and those who attend religious services less than once a week have lower degrees of recovery, and that older individuals experience a slower recovery. Thus, we find that those who are least able to attain recovery and those who are most often demonstrated to be most vulnerable in society based on socioeconomic status. Knowing these factors of vulnerability allows for policy makers and community reaching organizations to promote programs that provide resources and opportunities to these populations in an effort to promote resilience and recovery. More research is needed to understand how these vulnerabilities can be addressed to promote resilience within the Tuscaloosa population. Furthermore, it is recommended that this study is reproduced across more communities impacted by tornados, and other natural and man-made disasters, to understand in what ways these findings are unique to the Tuscaloosa tornado, and to tornados and disasters more broadly.

Finally, this research allows us to better understand the mechanism by which being poorer, of a racial/ethnic minority, and less educated affects disaster recovery. In our analysis, we were able to control for both the level of preparedness and overall impact of the disaster. We find that even when controlling for preparedness and disaster impact, African Americans and less-educated respondents recovered less than Whites and those with a Bachelor's degree. Thus, social vulnerability arises not only from being less able to prepare for and respond to a disaster threat, but also comes from having fewer resources to be able to recover from the disaster.

CONCLUSION

This research has looked at the 2011 Tuscaloosa tornado to assess the effect of social capital when accounting for perceptions of impact and recovery, as well as for socio-demographic variables. Following Morss et al.'s (2011) framework of social vulnerability to disasters, we highlighted Tuscaloosa as a disaster-prone community (exposure). Next, we collected survey data from individuals impacted by the tornado to model sensitivity and coping/adaptive capacity as the second and third components of the framework, respectively. Through these steps, we address the relationship between social vulnerability, occurring through the intersection of exposure, sensitivity, and coping/adaptive capacity, and the ability of individuals to recover from the Tuscaloosa tornado. Based on the results of this analysis, we conclude that race, age, and education significantly affected one's perceived recovery from the tornado; however, exclusive of religious attendance, social network variables did not affect recovery perception.

Given the increased likelihood and intensity of natural disasters, research on social vulnerability is increasingly important as this knowledge can be used to improve disaster preparation and response (Bergstrand et al. 2015). This research advances the study of social vulnerability through the inclusion of measures of social capital, as indicators of the third component of Morss et al.'s (2011) framework. As noted by Aldrich and Meyer (2015), social

cohesion and social networks are underutilized in disaster research, planning, and management simply because scholars have agreed on few appropriate metrics for social capital variables other than economic and demographic factors. However, despite responding to calls in the literature for further analysis of the Tuscaloosa tornado and the inclusion of socio-demographic and social capital variables in disaster research (Lee et al. 2017), this research finds little evidence that social capital variables affect disaster recovery.

The lack of a significant effect from the social capital variables raises an important question in this area of research. While Klinenberg (2002) and Putnam (2000) and other researchers (e.g. Aldrich and Sawada, 2015) have shown the importance of social capital for surviving a natural disaster, few researchers have been able to show the importance of social capital in the recovery process. When researchers do find a role for social capital (see Aldrich 2011), researchers often use indirect measures of the overall level of social capital is in the community to explain differences in community-level outcomes. Since these community-level measures of social capital (e.g. voting behavior) could be the result of other institutional differences in communities, they do not provide an unambiguous measure of the impact of social capital. The lack of an impact of standard measures of social capital (network size and density) means that there needs to be more research to explain this disconnect.

Despite the lack of consistent findings on social network variables, this paper does provide support for the argument that social vulnerability affects disaster recovery in the long run. Education, age, and race are three demographic factors that are strongly correlated to access to resources for the recovery process, especially in the Southeast. Disaster managers and government officials should do more to help facilitate these socially vulnerable individuals as current official and community support is not sufficient to overcome these vulnerabilities.

ACKNOWLEDGEMENTS

Research supported by NIH-NIMHD grant #U54MDD008602 at Gulf States Health Policy Center, BayouClinic, Inc. We would like to thank the Gulf States Health Policy Center for providing review of this manuscript, as well as all the individuals who completed the survey to provide data for this research.

NOTES

i. Issues of recruitment and retention of African Americans in research of all modalities is well documented and often attributed to distrust of research and research institutions (Young et al. 1996).

ii. Technically, due to skewness and kurtosis in the error terms, these data do not meet the Gauss Markov assumptions for efficient, unbiased results in the OLS framework. However, the authors used several non-linear models to as a sensitivity test and produced qualitatively similar results. We also ran a probit model, which assumes normality of the underlying latent variable and not normality of the errors. The dependent variable in the probit model took on a value of 1 if the individual was fully recovered and 0 otherwise. This model produced qualitatively similar results as the OLS model. Likewise, conducting a quantile regression at the 20th percentile and ordered logit and ordered probit models all resulted in qualitatively similar results. Thus, we believe the OLS models are appropriate due to their advantages in ease of interpretation.

iii. One helpful reviewer was concerned about potential collinearity between the independent variables in the model. The basic robustness checks contained within the running of multiples specifications did not indicate any potential candidates. By calculating variance inflation factor diagnostics on all specifications, this was confirmed as none of the variables yielded a VIF of over 4: the highest VIF was only 2.4 and most were close to 1. A full report of VIF results is available upon request.

iv. Also, in results not reported here, we included whether or not someone was "active" or "very active" in community organizations in various permutations of the models presented. This variable was not statistically significant in any of the estimated models.

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