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## Katrina and Vulnerability: The Geography of Stress

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*Abstract:* The immediate aftermath of Katrina focused the world's attention on the vulnerability of the urban poor and racial/ethnic minority groups in New Orleans. This vulnerability can be viewed in terms of *site*, the proximity of a neighborhood to a hazard, and *situation*, the social context of that neighborhood. Vulnerabilities, associated with demographic characteristics such as being poor, being a member of a racial/ethnic minority group, and being female, will strengthen the force of a disaster. This paper uses a *site* and *situation* approach to show how maps of the five main sources of disaster-related stress in New Orleans can be used to predict where counseling resources should be targeted.

*Key words:* Geographic Information System, GIS, vulnerability, stress, disasters, hazards.

**H**urricane Katrina was a catastrophe in terms of structural damage, loss of life, and disaster-related morbidities, both at the time of landfall and for months afterwards. This paper focuses on the links between morbidity, stress, and social vulnerability. The authors will draw from their experiences during the response and recovery to the catastrophe to show how geography and the mapping of stress-related phenomena might be used to understand and predict areas of elevated post-Katrina stress morbidity in New Orleans. This paper in no way suggests it has achieved such a complex mapping, as many of the needed data sets are not readily available. It will show, however, how researchers can begin to move towards such a geographic prediction of stress-related risks with existing information.

The authors of this paper were part of the Louisiana State University (LSU) team providing geospatial support to the Louisiana Office of Homeland Security and Emergency Preparedness Emergency Operations Center (EOC) during Hurricanes Katrina and Rita. Two of the authors (AC, JM) were a constant presence in the EOC, as part of a larger LSU-based volunteer team, performing tasks that included creating navigation

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maps for search and rescue teams, providing larger maps for briefing sessions and media releases, mapping the daily inflow of data (such as 911 calls or the latest flood imagery) and using online geospatial software such as *Google Earth* to provide coordinates for Public Health Service helicopter and ground missions. These tasks were performed under immense pressure. Stress arose from the importance of requests, often originating from high-ranking officials, including the President of the United States, and from the need for immediate results. We worked in a noisy and highly charged atmosphere, with official and unofficial reports about New Orleans diffusing through the EOC, while occasionally a misplaced phone call would be routed to the desk from someone attempting to find a missing relative.<sup>1-2</sup> One of the authors of this paper (AC), in addition to performing these tasks, played a more supervisory role coordinating the EOC, the Office of Public Health EOC, and LSU. This coordination included brainstorming sessions designed continually to improve geospatial response. Finally, all authors have been involved in the post-response phase of the catastrophe through the *LSU Geographic Information System Clearinghouse Cooperative* ([www.katrina.lsu.edu](http://www.katrina.lsu.edu)), the world's largest geospatial data clearinghouse associated with a disaster. This clearinghouse has been widely used by local and national researchers, non-profit organizations, government contractors, state agencies and FEMA. The projects using the *LSU GIS Clearinghouse Cooperative* include both physical and social vulnerability investigations, ranging from how best to educate rural coastal communities about disaster mitigation and preparedness, to understanding the resilience of neighborhoods affected by Katrina and Rita.

Vulnerability to a disaster, or even to day-to-day societal risks, encompasses a great many characteristics worthy of analysis, and far more than can be addressed in this paper. The authors of this paper draw from all their experiences with Katrina, and especially their understanding of the spatial aspects of the catastrophe, to focus on the geography of stress as experienced by Katrina-affected cohorts.

## **The Geography of Vulnerability, The Geography of Stress**

Vulnerability to the effects of a disaster arises from a combination of factors, including physical proximity to a threat (e.g., living in a floodplain), the characteristics of the home (including construction and ownership), lack of a political voice, financial constraints, and choices made by an individual.<sup>3-4</sup> It is widely accepted that high-risk groups vulnerable to a disaster include those with lower incomes, the very young and the elderly, the disabled, women living alone, and female-headed households. Therefore, the social and economic cost of a disaster usually falls unevenly on different populations.<sup>3,5-8</sup> Such vulnerability can be expressed geographically in terms of *site* (proximity of a neighborhood to the hazard) and *situation* (the social context of that neighborhood). During Katrina, the site of many indigent neighborhoods made them vulnerable to flooding due to their proximity to a flooding source (such as a levee break), and the elevation of their homes (Figure 1).

The *situation* of a Katrina neighborhood is a construct encompassing the ability of residents to cope with the disaster. In an analysis of traditional socioeconomic vulnerability indicators and flood depth in Orleans Parish, conducted by LSU researchers, it was found that both heavily White and non-White neighborhoods were severely

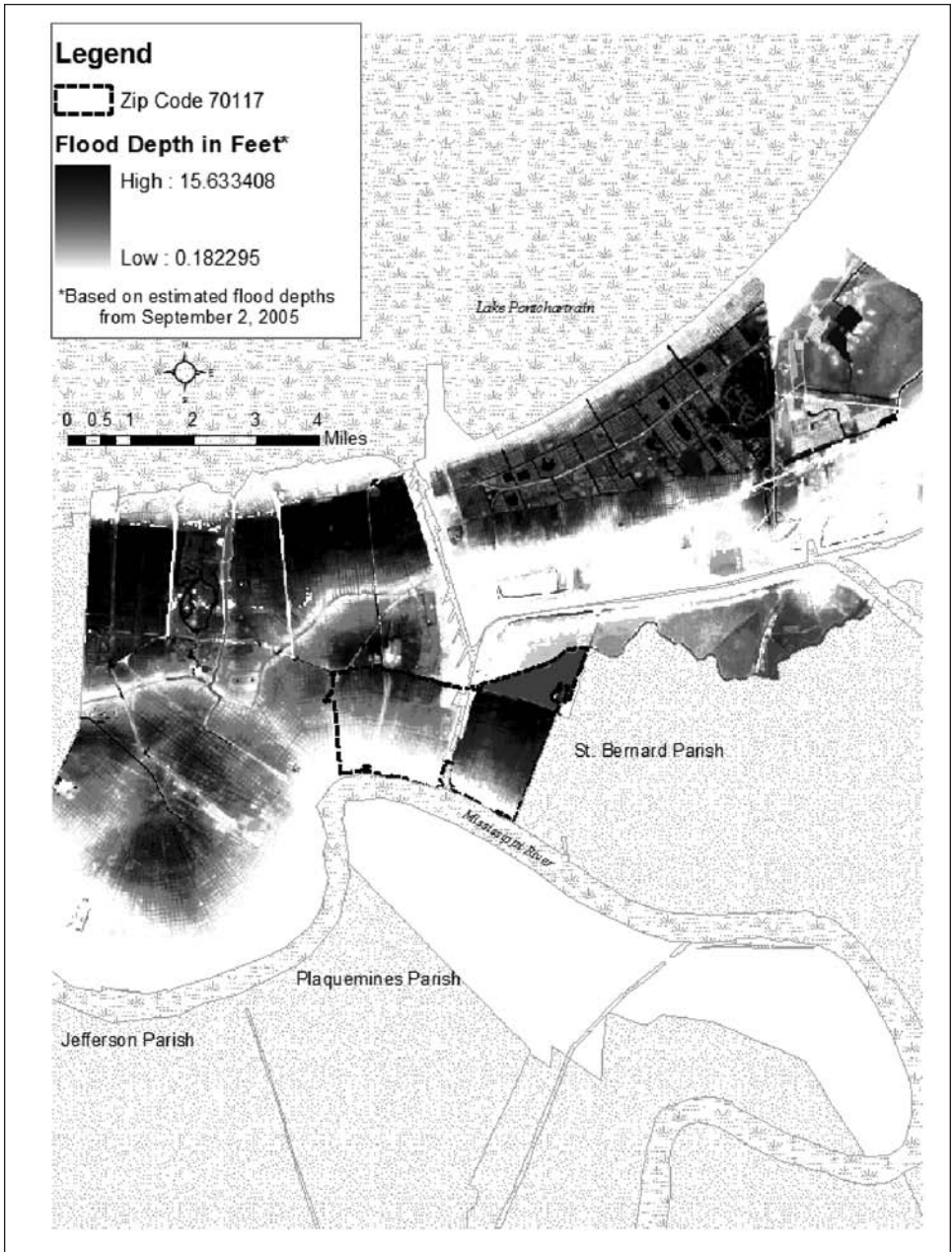


Figure 1. Map of flood depth for all of Orleans Parish.

flooded. (See Curtis A, Pine J, Marx B, Li B. A multiple additive regression tree analysis of social vulnerability and Hurricane Katrina: implications for psychopathology and a disproportionate impediment to recovery; paper under review.) However, non-White residents were more likely to have remained behind, resulting in increased stresses from actually experiencing the hurricane.<sup>8</sup> In addition, non-White residents of New Orleans

had a greater likelihood of having existing chronic health conditions.<sup>9-10</sup> These chronic health conditions, in addition to other poverty-related impediments resulted in people from these neighborhoods having the least ability to rebound and these communities having the worst prospects for recovery. In these fundamental ways, Katrina disproportionately affected non-White populations. The combination of site and situation can be used to estimate future patterns of stress-related morbidities and mortalities.

Multiple stressors accumulated as a result of Katrina, especially during the first few days in New Orleans and the evacuation.<sup>11</sup> Several experiential papers provide insights into the stresses faced by those in the storm.<sup>12-18</sup> It is not surprising that these experiences have translated into health problems. Berggren and Curiel use the crude indicator of death notices reported in the *Times-Picayune* to show a 25% increase in deaths during January 2006 (compared with the previous year), an increase they partly attribute to stress.<sup>19</sup> Post-traumatic stress has also resulted in increases in suicidal thoughts as well as suicidal attempts among children.<sup>11</sup> All of these stresses have a geography (residential address, pre-Katrina neighborhood characteristics, evacuation and relocation routes) whose parts can be mapped and overlaid on each other to estimate total stress load. Unfortunately such data are not readily available and we are left to piece together information from disparate sources as we build a geographic stress surface.

In a formal analysis of the geography of Katrina-related stress, the *site* is where the greatest damage occurred. It has previously been shown that post-traumatic stress is related to the degree of the disaster. Looking at things this way, Figure 1 (other things being equal) can be used as a proxy for neighborhood stress levels. As previously discussed, the situation of some communities made them more vulnerable because their residents were more likely to have experienced hurricane landfall, and to have other characteristics that magnify post-disaster stresses. In order to create a geographic stress surface, the geography of situation must be added to the geography of site. By combining these surfaces, community-level post-Katrina strategies can be prioritized. The maps that appear later in the paper, which are used to illustrate these geographies, focus on the Lower 9th Ward, by highlighting the ZIP Code that encompasses that section of the city. These maps can be broadly grouped into five categories of geographic stress:

1. The geography of experiencing the storm
2. The geography of evacuation and relocation stress
3. The geography of pre-Katrina stress
4. The geography of pre-Katrina health outcomes
5. The geography of rebound and recovery potential

**The geography of experiencing the storm.** There are many reasons why a segment of the population of New Orleans did not heed either the evacuation advisory or the subsequent mandatory evacuation order. In a survey of evacuees in a Texas shelter, 61% did not originally evacuate, with 29% not leaving because they underestimated the storm.<sup>20</sup> Hurricanes threatening Louisiana not long before Katrina led to evacuation advisories for residents of New Orleans even though no disaster ensued. Considering evacuation from New Orleans to Baton Rouge, a journey that usually takes between 1 and 1.5 hours, but took approximately 8 hours during the evacuation, many would have balanced the uncertain risk of the storm based on previous experience against



a certain evacuation discomfort. Of course these are not the only reasons that people stayed behind; others included not wishing to leave their animals and having faith in the city's levee defense system.<sup>20</sup> All these reasons, however, can be viewed as choices. For indigent populations, however, there are reasons not to evacuate that cannot be overridden, such as the lack of any practical means of leaving the city. According to the 2000 U.S. Census, approximately 250,000 people in New Orleans did not have access to a private vehicle; of these 250,000, city buses could have evacuated only 10% (a means that was not, in any case, offered by the bus system).<sup>21</sup> In the Texas shelter survey mentioned above, the largest portion who did not evacuate (36% of all those interviewed) did not leave because they had no means to evacuate.<sup>21</sup> Even for those from poor neighborhoods with vehicles, the costs of evacuation (gas and motel stays) may have been prohibitive. These stranded residents have been likened to the underclass on the Titanic for whom there were not enough lifeboats.<sup>22</sup> Given all of this, it seems clear that people living close to or below the poverty line are forced to rely on the competence of evacuation planners,<sup>23-24</sup> who, if effective, must take such poverty-based traps into account in order to craft effective evacuations. Importantly, the understanding that a sizeable portion of the city's residents would not evacuate had been documented before Katrina by the Center for the Study of Public Health Impacts of Hurricanes at Louisiana State University.<sup>25</sup>

Although having individual level data showing who stayed behind is preferable, neighborhood-level maps can be created showing the lack of the ability to evacuate. For example, Figure 2 displays the spatial pattern of housing units wherein the occupant is without access to a vehicle. It has previously been shown that surviving or suffering through a human-created rather than a natural disaster exaggerates post-event mental health problems.<sup>26</sup> For many victims of Katrina this feeling of being left behind, as they didn't have the ability to evacuate, in combination with the length of time waiting for rescue, either from the floods or from the shelters in New Orleans, may have shifted their understanding of the disaster away from being a natural event to being humanly, even politically, caused. Therefore, maps such as the one presented in Figure 2, in combination with Figure 1, might help in estimating the geography of elevated stress from experiencing the storm. Two further maps (Figures 3a and b) represent census block groups of the population in poverty, and where residents are predominantly African American; these can be used to further develop our understanding of the geographic surface.

**The geography of evacuation and relocation stress.** Volunteers at one Texas shelter were struck by the smell when evacuees disembarked after their multiple hour journey from New Orleans, the smell having developed after several days spent inside the Superdome, standing for several hours in the Louisiana sun waiting for pick-up, and finally riding the bus to Texas.<sup>27</sup> This reflects something of the trauma of experiencing the storm, awaiting rescue, and being evacuated. The geography of this stress is best illustrated by a spider map, with the origin and destinations being portrayed as points, and the victims' journey between these locations being linked by lines. Figure 4 shows a sample of paths taken by people from the Lower 9th Ward. This information was extracted from a dataset provided by the Louisiana Department of Social Services (DSS) and represents a post-Katrina change in address for child support payments wherein

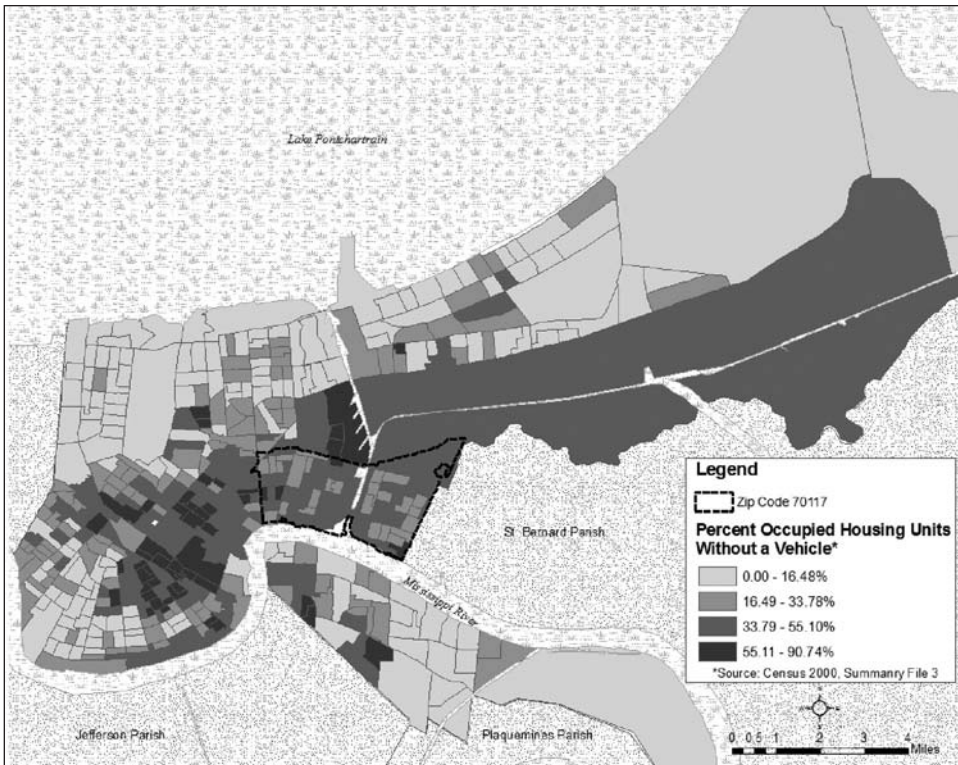


Figure 2. Census block groups displaying housing units without access to a vehicle.

the original address of the custodial or non-custodial parent is in the Lower 9th Ward. Each line represents the initial evacuation away from New Orleans. Stresses could be attached to these lines and nodes based on the known conditions of the evacuation route, combined with descriptions of the shelters; the more points and lines for each evacuee, the greater the stress loads irrespective of the conditions. Although more comprehensive representations of this information exist, most notably FEMA Individual Assistant (IA) application data, they have so far proved difficult to acquire.

Stress associated with disaster-caused relocation was well documented prior to Katrina.<sup>11,28</sup> Evacuees from Katrina-affected areas, like other disaster evacuees before them, were confronted with the uncertainty of when they would be able to return home, the loss of their communities, and even the loss of known and trusted caregivers (and medical facilities) for those suffering from a chronic illness.<sup>29</sup> Such evacuation stress can be either moderated or intensified by the official handling of the disaster.<sup>11,30</sup>

Children, like adults, can suffer posttraumatic stress. Previous disasters have shown that children have the ability to rebound more quickly than adults if they are quickly returned to normalcy.<sup>31</sup> However, an insensitive handling of the relocation process, with children being moved repeatedly without information, can intensify their distress.<sup>11</sup>

The final destination, or rather the last temporary residence before the return home, is another layer in stress geography. After Katrina, problems emerged in temporary

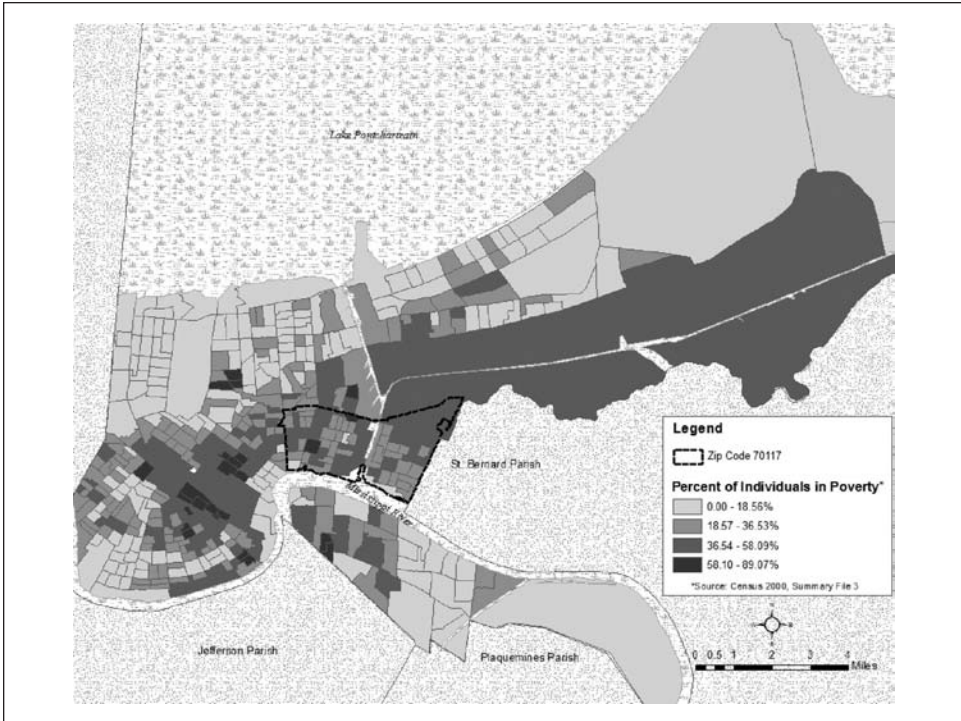


Figure 3a. Census block groups displaying population below the poverty level.



Figure 3b. Census block groups displaying African American population.





Figure 4. Sample evacuation routes away from the Lower 9th Ward.

FEMA villages, the individual not only facing the stress of being in a strange city, and being separated from the support structure of his or her home community, but also facing increased risk from crime.<sup>32</sup>

**The geography of pre-Katrina stress.** Disaster-related vulnerability is complex, comprising both community-level response and individual decisions.<sup>33–34</sup> Many of these vulnerabilities also extend into normal living conditions and are manifest in neighborhoods with limited employment opportunities, high crime rates, low educational attainment, and poor health outcomes. Problematic outcomes include elevated stress levels, which in turn can predispose a disaster victim to mental health problems such as posttraumatic stress, chronic health problems, which will be discussed in the next section, and a general inability to recover and rebound. Mapping vulnerable neighborhoods prior to a disaster (for example by drug arrests) can indicate where people, with all other things being equal, will experience the effects of the disaster to a disproportionate extent.

Further geographic detail can be added to these surfaces by considering the sub-populations most at risk. For example, women often suffer post-disaster stresses disproportionately as they often have to spend more time in the (contaminated) home.<sup>35–36</sup> Furthermore, a major upheaval can cause irreparable damage to a marriage,<sup>37</sup> with the loss of normalcy and the memories associated with the relationship (in combination with stress) resulting in conflict and even abuse.<sup>38</sup>

Of particular importance to low-income African American women in New Orleans is the loss of a neighborhood support structure, which often extends beyond females in the household (mother and grandmother) to include immediate neighbors and community elders.<sup>39</sup> Louisiana, and especially New Orleans, is renowned for its culture and community, with many neighborhoods having distinct character. Within these neighborhoods, community ties, often based around churches, are especially strong. In the Lower 9th Ward, for example, there are two or three churches on every road. The thought of leaving the safety of this community could act as a deterrent to leaving New Orleans, and would be a source of depression once evacuated, especially with no known point of return. Neighborhood social structure is often viewed as being more important than losing personal possessions, including one's house.<sup>38</sup>

One female subpopulation that can be mapped is female as head of the household with young children in the home.<sup>3</sup> In this case, the woman might be without family other than her children, relying on close neighbors for support. She might not have the ability to evacuate with her children. All the previously described stresses will apply to her situation, though in addition she might have to face the physical needs of evacuation, or the stresses of caring for her children through the storm by herself. Figure 5 displays the surface of women as head of household with young children in the home. By comparing this pattern with maps of poverty, race/ethnicity, and neighborhood stressors such as crime, a pre-Katrina stress surface can be generated. All that is needed is to add the actual Katrina damage map (Figure 1).

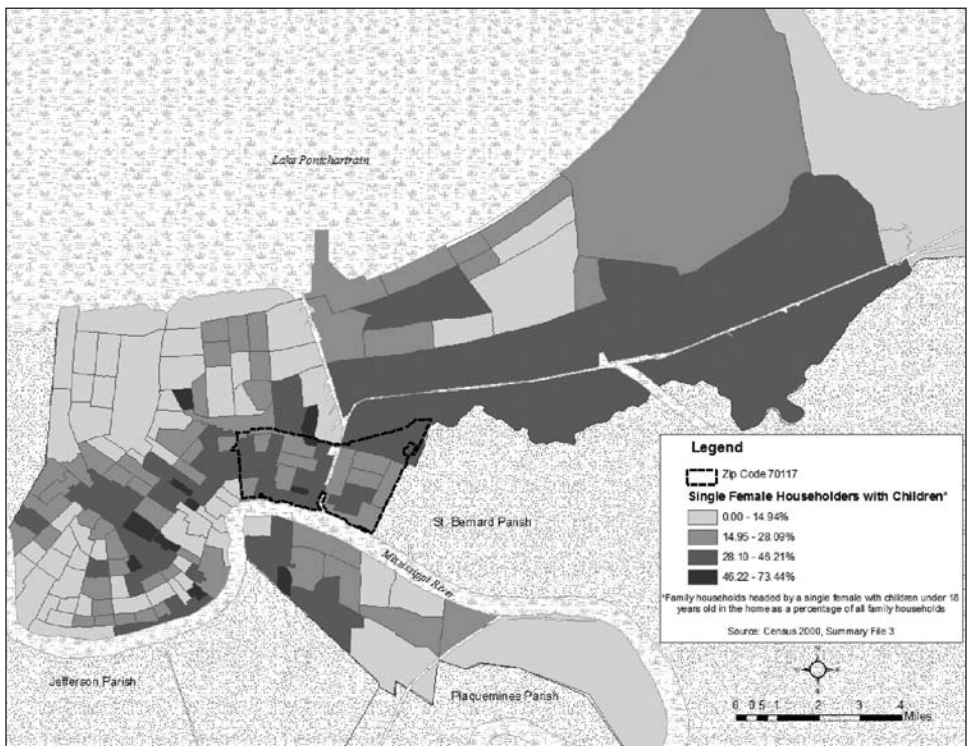


Figure 5. Women as head of household with young children in the home.

**The geography of pre-Katrina health outcomes.** Approximately 11% of the residents of Orleans and Jefferson parish had diabetes,<sup>29</sup> a number skewed higher in poorer cohorts. Furthermore, approximately 7,000 residents of New Orleans were HIV-infected prior to Katrina.<sup>19</sup> According to the daily surveillance system initiated by the Louisiana Department of Health and Hospitals Office of Public Health (LAOPH), the American Red Cross and the U.S. Public Health Service, 31% of medical interactions between shelter workers and evacuees was for chronic illness, most of these contacts being to replace medications or resume treatment.<sup>40</sup> In one shelter, over half the evacuees had chronic health problems.<sup>22</sup> It has been estimated that some diabetics went as long as six months without insulin.<sup>19</sup> Diabetic concerns also extended to the diet provided at the shelters and limited opportunities for appropriate exercise. Hyperglycemia could make the evacuee susceptible to other medical conditions, including severe depression, which in turn might affect diabetes, and skin infections, the later showing up regularly in shelter surveillance tools.<sup>29,40</sup> Other chronic illnesses common among evacuees were hypertension and gout.<sup>27</sup>

Additional stressful situations were caused by the loss of an evacuee's medical records. This resulted in doctors having to rely on a patient's memory in order to refill prescriptions.<sup>29</sup> As children began to attend school in their new locations, school caregivers were faced with a similar situation regarding vaccination status; in some cases, this was compounded by a lack of a guardian to recount the child's history.<sup>11</sup>

The geography of these chronic illnesses can be mapped as neighborhood rates. For example, Figures 6a and b display the infant mortality and low birth weight delivery surfaces for Orleans Parish for the period 2002 to 2004. New Orleans had severe problems with poor pregnancy outcomes in African American neighborhoods, where a large number of births were to single mothers. After Katrina, this population is most likely to have experienced and to continue to experience the greatest stress load. Although other health conditions can be triggered by elevated stress,<sup>41-42</sup> poor birth outcomes, especially low birth weight deliveries (less than 2500 grams), have been strongly linked to anxiety and poor mental health.<sup>43</sup> In addition, many coping mechanisms associated with stress are also harmful to pregnant women and their fetuses, including smoking,<sup>44-45</sup> alcohol,<sup>46</sup> and drug use.<sup>47-50</sup> Unfortunately, this is one area where the legacy of Katrina will likely be felt by vulnerable populations for, literally, a lifetime to come. An increased chance of a low birth weight will persist as long as the mother continues to experience stress.

As previous poor birth outcomes can be used to predict similar future outcomes, the maps in Figure 6 can be used to give an indication of where the greatest risks will be faced in post-Katrina New Orleans. In addition, by combining these maps with the evacuation spider map in Figure 4, the diffusion of these pre-Katrina risks to other neighborhoods outside of New Orleans, and even outside of Louisiana, can be predicted.

**The geography of rebound and recovery potential.** The first set of stresses associated with the return home arise from confronting the devastation: a destroyed home, removing possessions from inside the house and leaving them on the street outside, taping the refrigerator shut to keep the decaying food inside, possibly having a spray painted marking from animal rescue on the exterior of the house stating that the pet inside had died, the corpse left to be found and removed by the owner. The second set

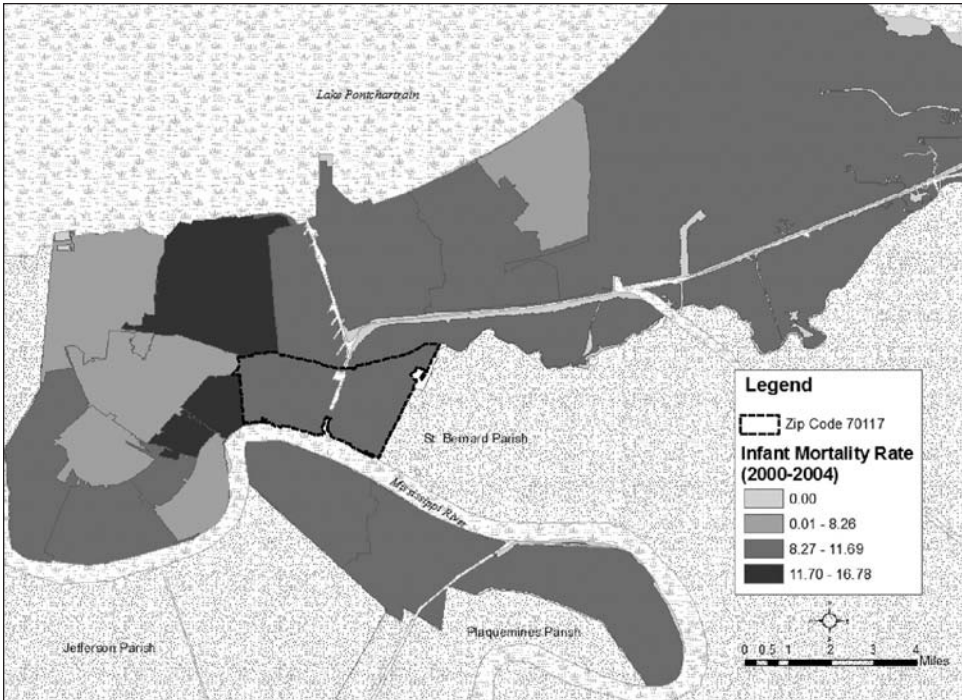


Figure 6a. Infant mortality in Orleans Parish 2002–2004.

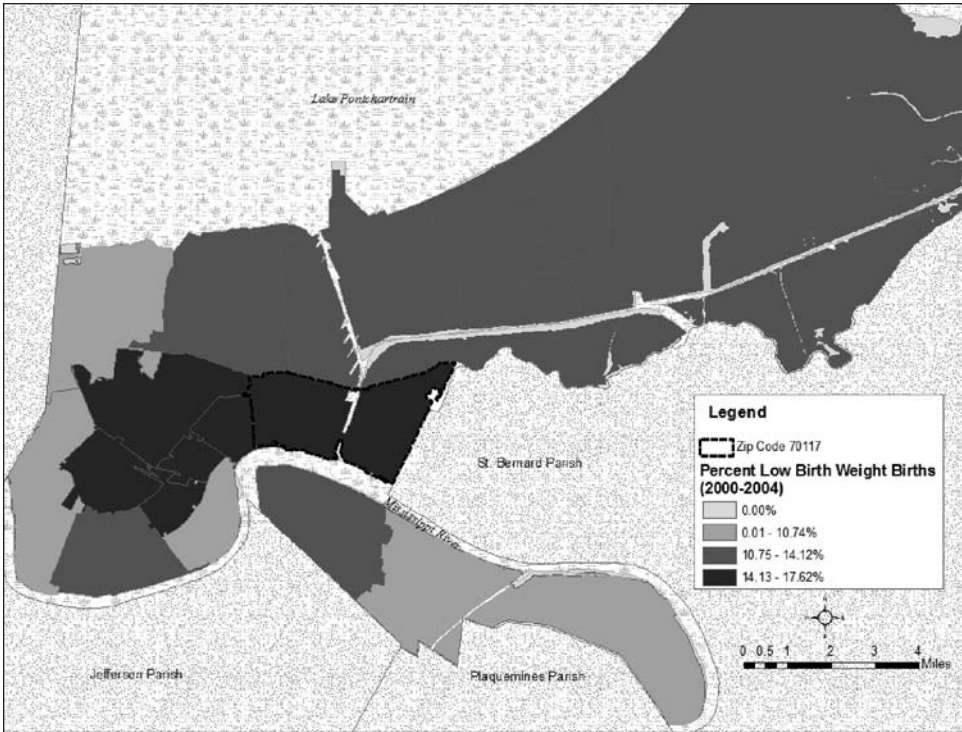


Figure 6b. Low birth weight deliveries in Orleans Parish 2002–2004.



arises during rebuilding, amidst uncertainty about whether the damaged house can still serve as a safe living environment. In a joint survey by the Centers for Disease Control and Prevention (CDC) and the Louisiana Department of Health and Hospitals during October 22–28, 2005, 45.5% of properties had visible mold, while 17% had heavy mold, which is defined as one interior wall having at least 50% coverage.<sup>51</sup> In a second survey, 96.2% of returning residents believed that there was a health risk associated with mold growth, even though 42.1% had already cleaned mold, with 68.7% not always using respirators because of either discomfort or unavailability.<sup>51</sup> The returnee would also be uncertain about several other environmental hazards and health risks reported in the media. For example, continued exposure to damp interior spaces can lead to both upper and lower respiratory problems, and may result in the fabled *Katrina cough*.<sup>51–52</sup> Further uncertainties involved the neighborhood interdependence of cleaning: if there was no rebuilding next door, was there a developing toxicity in the neighborhood? The third series of stresses arises from the perceived futility of rebuilding, as returnees ask such questions as what the point of rebuilding the home is if the rest of the neighborhood, or even just a large proportion of the neighborhood, remains devastated; and whether the state of the entire neighborhood would result in the home eventually being compulsorily torn down anyway. According to one theory connected with disaster mitigation, the theory of interdependency, the actions of neighbors are almost as important as one's own actions.<sup>19</sup>

The stressors associated with first return and rebuilding are likely to affect all classes and races to some degree but, as previously discussed, socioeconomic groups differ in their ability to cope with these stresses in a post-disaster environment.<sup>26,53</sup> The geography of the environmental health risks can be displayed as neighborhood toxicity survey maps. For example, at the New Orleans Area Healthy Disparities meeting (held at the Hilton New Orleans Riverside on June 12, 2006), organized by the Poverty and Race Research Action Council (PRRAC), the Alliance for Health Homes, and the Health Policy Institute of the Joint Center for Political and Economic Studies, maps were displayed on the wall showing the spatial distribution of different environmental sensors and their toxicity readings.

Maps can also display the state of neighborhood return by showing the proportion of inhabited houses or locations of FEMA trailers. These data can come from door-to-door surveys, or even be extracted from high-resolution aerial photography. A cheaper and more dynamic data collection system is a video camera linked to a global positioning system (GPS). A car can drive the neighborhood (one GPS route is seen on the left side of the display in Figure 7), recording neighborhood activity. A second team can view the video and extract information from it, such as the level of rebuilding activity. These maps can be used to gauge neighborhood stress if we assume it is a function of returning residents to abandoned houses.

Finally, post-Katrina stress is developing in New Orleans, which had its roots in the problems of the city prior to the storm. A map displaying the location of murders was printed in the *Times Picayune* as part of an article entitled, "Murders so far," published on June 20, 2006. This not only shows neighborhoods where stress is likely to be elevated because of the fear of the emerging crime threat, but the map itself may actually create stress by revealing to returning residents where these new problems were emerging.





Figure 7. The Digital Video/GPS display.

## Discussion

Vulnerability is closely linked to poverty, which is compounded in New Orleans by race. Members of racial and ethnic minorities often feel left behind by society, sometimes literally so, as during the Katrina disaster.<sup>54</sup> An estimated 84,000 African Americans die per year because of health care deficiencies, the net result of which is widespread community distrust of “the system.”<sup>22,55</sup> In a shelter survey of hurricane evacuees in Texas, 79% believed the official response was too slow, 68% feeling this was because the people stranded were both poor and minority group members, and 61% thought the government did not care.<sup>21</sup>

If we are to learn something from Katrina, it is that—in their circumstances and their resources—all people are not equal in the United States, and that there is both a geography and a social character to vulnerability. Living in New Orleans, living in certain neighborhoods of New Orleans, being African American, having limited income, being female, being a head of household, having young children in the home, suffering from chronic illnesses, and being pregnant can all contribute to vulnerability. As we drill down through these risks, it is easy to see how spatially and socially complex vulnerability is. It is not enough to map poverty; we have to understand the social dimensions within our maps.

The maps presented in this paper can all be used to predict where post-Katrina stress load, and stress-related health outcomes, are likely to be worst in New Orleans.

These surfaces can be supplemented by individual information (which is preferred on a case-by-case basis). However, in the absence of individual counseling, and in the knowledge that poor and minority populations often do not seek help for disaster-related depression, the approach presented in this paper can be used to prioritize community level outreach. This is especially appealing as most of these datasets are either publicly available, or can be obtained with minimal effort as they do not contain confidential information.

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