Measuring Cost Burden of Hurricane Repairs on Socially Vulnerable Households

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Shifting Focus in Emergency Management

A growing body of research has shown that natural hazards disproportionately affect disadvantaged communities. Recently, this fact has influenced recent Federal policy.[i ii iii] The U.S. Federal Emergency Management Agency (FEMA) and the U.S. Census Bureau have launched online dashboards which compare population characteristics and levels of exposure to natural hazards like hurricanes and wildfires.[iv] While such tools make it easier to access crucial data, they do not provide estimates of hazard risk for disadvantaged communities.

In fact, no previous work (outside of a few case studies)[v] has provided a systematic, quantitative look at how hazard risks are distributed across disadvantaged communities. Our study begins to bridge this gap by quantifying how hurricane cost burden is distributed across individual households when climatological, structural, and social risk factors compound.

Key Takeaways:

- Federal agencies are increasing spending to alleviate social inequity, but metrics used to inform decisions fall short.
- A novel framework for loss estimation captures how hurricane risk varies spatially and across demographics.
- Findings show that impoverished and socially vulnerable households are much more likely to be cost burdened by hurricane repairs.
- By mitigating 14% of homes strategically, Miami-Dade could relieve 70,038 households from cost burden and prevent $1.78 billion of monetary damage annually.

Silver Palm Mobile Park in Miami was devastated by Hurricane Andrew. After hurricanes, mobile home residents experience outsized losses and excessive cost burden compared to residents of multistory apartment buildings. Photo credit: Bob Epstein of FEMA News

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A More Complete Picture of Hurricane Vulnerability

Hurricane vulnerability is typically represented as emerging from a combination of only two factors: **climatological vulnerability** (living in areas prone to natural hazards) and **structural vulnerability** (living in structures susceptible to damage).

However, a growing body of work recognizes that the impacts of natural hazards fall disproportionately on disadvantaged communities.[vi] Specifically, this literature has introduced a third risk factor: **social vulnerability**, the inability to "anticipate, confront, repair, and recover from the effects of a disaster."[vii]

Based on a review of the literature, no study to date has quantified the connection between hazard loss risk and social vulnerability. To address this gap, we aim to quantify the hurricane vulnerability of socially vulnerable groups by combining a high-resolution loss estimation approach with demographic and socioeconomic models.

Our method provides a high-resolution look at hazard risk. By accounting for **neighborhood texture**, the configuration of structures in an area, we capture previously overlooked variations in wind loads and related losses at the building level.

With this approach, we can simulate hurricane repairs on the level of individual homes and, therefore, individual households, allowing us to observe how hurricane risks vary spatially and across demographics.

Bridging Present Tools and Data

HAZUS, the multi-hazard loss estimation tool developed and implemented by FEMA, focuses on climatological and structural risk factors in evaluating hurricane vulnerability.[viii] In considering which populations are vulnerable to hurricane damage, it does not account for social risk factors. Instead, it estimates the number of households that are likely to require shelter or to be displaced following a storm based on projected physical damage.

Neighborhood texture is the configuration of the structures in a given area. In this city map, the areas in dark blue have structures arranged in an especially orderly pattern.

We sought to quantify socially-driven hurricane vulnerability by drawing on the U.S. Census Bureau's American Community Survey (ACS), which offers a database with microdata on the physical characteristics of housing alongside demographic and socioeconomic characteristics of households.

The ACS also offers census tract information which allows us to create localized relationships between structures and households, and tie these relationships to the climatological stressors in their neighborhood.[ix] Combining these datasets makes it possible to highlight relationships between climatological, structural, as well as social risk factors driving hurricane vulnerability.

Using this data and information about neighborhood texture, we simulated expected losses for every residence in the Gulf States and developed demographic and socioeconomic characteristic models for them.[x]

To identify socially vulnerable households, we focused on household characteristics that serve as indicators within the U.S. Centers for Disease Control and Prevention (CDC's)

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Social Vulnerability Index (e.g., household income, employment status, and minority status).[xi]

We aim to assess whether there is a relationship between household characteristics and the exposure of that household to hazard losses. We examined whether socially vulnerable groups are overrepresented among households facing significant hurricane cost burden, which we define as incurring losses exceeding three months of household income.[xii]

Case Study: Miami-Dade County, Florida

Miami-Dade is the most populous county in hurricane-prone South Florida[xiii] and has been devastated by hurricanes in the past, such as the infamous Hurricane Andrew, making it a valuable candidate for our case study.[xiv]

For the county, we simulated expected hurricane damages and losses for 937,957 households.[xv]

Of these households, 65% live in single-family homes, 30% in multi-unit housing, and 5% in mobile homes. The median expected annual losses were found to be $2,266 per household, or 4% of average annual income (this and all following results are in 2018 dollars).

Expected annual losses were found to differ greatly between housing types. These median losses are as high as $10,352 per household (41% of annual income) for mobile homes while low-to-mid-rise multi-unit housing has a median loss of $1,155 per household (4% of annual income).

We found that 88,421 households are likely to be significantly cost burdened by hurricane losses and repairs. In Miami-Dade, almost every socially vulnerable group is overrepresented among these households.

An aerial photograph of the city of Miami, Florida.

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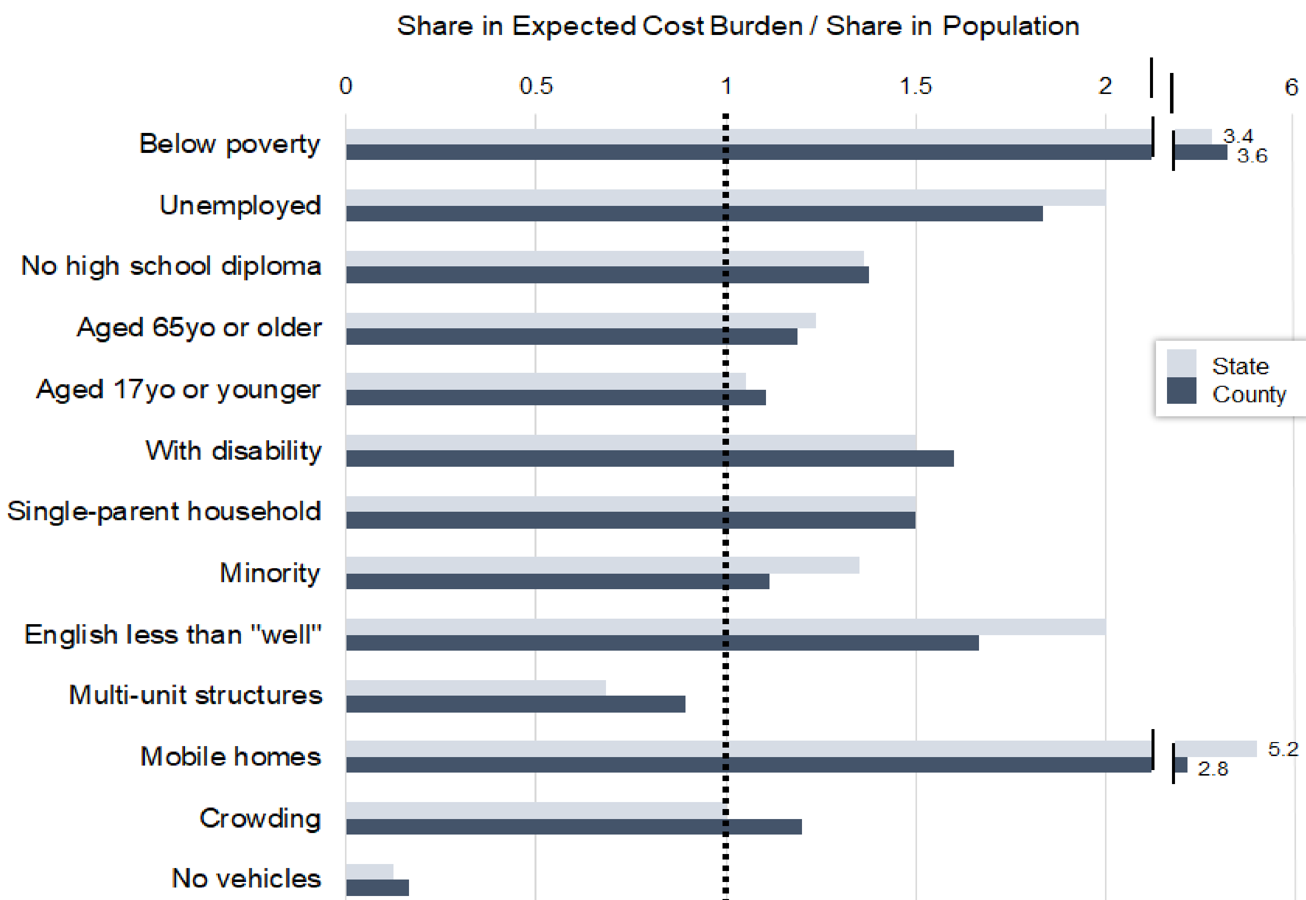
The below figure shows ratios between the percent prevalence of socially vulnerable groups among cost burdened households and their percent prevalence among the population of all households. A ratio greater than 1.0 implies that a group is overrepresented among the cost burdened population than among the whole population.

As an example, single parent households represent 15% of cost burdened households, even though they only represent 10% of the county population. These values work out to a reported ratio of (15%)/(10%)=1.5.

Overrepresentation among the cost burdened population is highest for households that are below the Federal poverty line, that have members who are unemployed, that have members with disability, that are single-parent households, that speak English less than "well," and/or that live in mobile homes. Each of these groups has a ratio greater than or equal to 1.5.[xvi]



Ratio between percent prevalence of each group in expected cost burden and their overall percent prevalence for Florida (light blue) and for Miami-Dade (dark blue).

Policy Implications

Currently, FEMA evaluates mitigation grant applications in terms of a benefit-to-cost ratio for the property. However, in a recent report, FEMA noted that grant funds "are not distributed to individuals that most need assistance." There is an opportunity for alternative metrics to "ensure that the needs and considerations of different communities are met."[xvii]

While we do not have data on the cost of mitigation, we can assume that projects with the highest benefit likely also have high benefit-to-cost ratios and, therefore, on average would be prioritized over mitigation with lower benefit. Below, we present model results for Miami-Dade comparing a strategy prioritizing the mitigation of homes based on the value of their expected annual damage alone (**Strategy 1**) to one which prioritizes homes based on the value of damage normalized by household income (**Strategy 2**).

Roughly a quarter of Miami-Dade residences were found to already incorporate hurricane mitigation measures.[xviii] The expected losses that remain in the county include 51% of avoidable cost burden as well as 46% of avoidable monetary damage.[xix]

Applying Strategy 1, focusing on the most expensive repairs first, to mitigate 122,000 additional homes (13% of all homes) can cover 75% of avoidable monetary damage. However, 25,000 households would remain cost burdened.

Conversely, applying Strategy 2 to mitigate 56,000 homes (6%) would cover all avoidable cost burden. But, a downside to this strategy is that a total of 178,000 homes (19%) would need to be mitigated to cover 75% of avoidable monetary damage.

A combination of these strategies could yield economically and socially effective results. In mitigating 131,000 additional homes (14%) by first addressing the 56,000 most cost burdened homes and then addressing the 75,000 remaining homes with the most expensive repairs, it is possible to cover all avoidable cost burden as well as 75% of avoidable monetary damage.

By mitigating 1% more homes than Strategy 1, the

Hurricane Katrina took over 1,800 lives and caused over $108 billion in damages. The hurricane was particularly devastating to New Orleans, Louisiana, where it displaced millions of people. Photo credit: U.S. Coast Guard.[xx]

combined approach can achieve the same level of hurricane damage prevention while shielding more households from being priced out of hurricane repairs.

In the end, these results provide the first prospective analysis that socially vulnerable groups are subject to heightened financial risk from hurricane-related hazards. Fortunately, if mitigation grants are distributed carefully, it may be possible to mitigate the outsized cost burden faced by these groups. This can be achieved without significant investment beyond what is needed to reduce the overall financial risk faced by a given community. Stakeholders should begin to invest in stronger construction both for the financial health of the community as a whole but also for the financial health of their most vulnerable households.

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Related Links:

- MIT News, "Mitigating hazards with vulnerability in mind"
- MIT News, "Hurricane-resistant construction may be undervalued by billions of dollars annually"

Endnotes

i. The types of federal investment include "climate change, clean energy and energy efficiency, clean transit, affordable and sustainable housing, training and workforce development, remediation and reduction of legacy pollution, and the development of critical clean water and wastewater infrastructure." See White House https://www.whitehouse.gov/environmentaljustice/justice40/.

ii. See The Washington Post https://www.washingtonpost.com/climate-environment/2022/08/25/hurricane-harvey-climate-change-study/.

iii. See FEMA https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities.

iv. Two such dashboards are the National Risk Index for Natural Hazards and the Community Resilience Estimates dashboards. See FEMA https://hazards.fema.gov/nri/. Also see U.S. Census Bureau https://www.census.gov/programs-surveys/community-resilience-estimates.html.

v. Case studies which consider social, structural, and climatological vulnerability include (among others):

1. Flax, L.K., Jackson, R.W. and Stein, D.N. (2002) Community Vulnerability Assessment Tool Methodology, Natural Hazards Review, 3, 163-176;
2. Wood, N. J., J. W. Good, and R. F. Goodwin. 2002. "Vulnerability Assessment of a Port and Harbor Community to Earthquake and Tsunami Hazards: Integrating Technical Expert and Stakeholder Input." Natural Hazards Review 3 (4): 148–57; and
3. Wu, S., Yarnal, B. and Fisher, A. (2002) Vulnerability of Coastal Communities to Sea-Level Rise: A Case Study of Cape May County, New Jersey, USA. Climate Research, 22, 255-270.

vi. Pertinent papers include (among others):

1. Cutter, S.L., Boruff, B.J. and Shirley, W.L. (2003), Social Vulnerability to Environmental Hazards. Social Science Quarterly, 84: 242-261. https://doi.org/10.1111/1540-6237.8402002.
2. Flanagan, B. E., E. J. Hallisey, E. Adams, and A. Lavery. 2018. "Measuring Community Vulnerability to Natural and Anthropogenic Hazards: The Centers for Disease Control and Prevention's Social Vulnerability Index." Journal of Environmental Health 80 (10): 34–36.

vii. See NIH National Library of Medicine https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7179070/.

viii. See FEMA https://www.fema.gov/flood-maps/products-tools/hazus.

ix. See U.S. Census Bureau https://www.census.gov/programs-surveys/acs.

x. Alabama, Florida, Georgia, Louisiana, Mississippi, and Texas.

xi. See CDC https://www.atsdr.cdc.gov/placeandhealth/svi/index.html.

xii. In reality, this threshold may be much lower. A survey by Bankrate found that "more than half of Americans (or 51 percent) have less than three months' worth of expenses covered in an emergency fund," with one in four Americans having no emergency savings. See Bankrate https://www.bankrate.com/banking/savings/emergency-savings-survey-july-2021/.

xiii. See University of Florida https://www.bebr.ufl.edu/wp-content/uploads/2022/01/census_summary_2020.pdf.

xiv. Miami-Dade was infamously devastated by Hurricane Andrew in 1992, which destroyed about 49,000 homes, damaged 108,000 homes, and resulted in 15 direct and 28 indirect deaths. See NWS https://www.weather.gov/mfl/andrew.

xv. We used data for 781 census tracts, 3,736 census blocks, and more than 300,000 building footprints.

xvi. In contrast, households that occupy multi-unit structures and/or that have no vehicles have ratios smaller than 1.0. These characteristics may relate to living in densely built-up areas, which are mostly comprised of mid-to-high-rise multi-unit housing that typically have better hazard performance than single-family homes and mobile homes.

xvii. See FEMA https://www.fema.gov/sites/default/files/documents/fema_nac-2021-report-211216.pdf.

xviii. Such measures may include strengthened roof-to-wall connections and roof deck attachment. Across Miami-Dade, hurricane mitigation measures have the potential to remove 70,038 households from cost burden annually and prevent $1.78 billion in monetary damage annually.

xix. In other words, there is potential to remove an additional 36,000 households annually from cost burden and prevent $820 million in annual monetary damage.

xx. See National Ocean Service https://oceanservice.noaa.gov/podcast/aug15/dd62-katrina.html.

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