Have We Adapted? Hurricanes and Excess Mortality in the United States

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Extended Abstract

Hurricanes trigger decimating losses to human communities around the globe (World Bank and United Nations, 2010).[1] A well known finding is the negative correlation between income and hurricane mortality, so much so that it is commonly thought that rich countries have almost completely "adapted away" fatalities to this environmental risk (Kahn, 2005; Bakkensen and Mendelsohn, 2016). For example, the United States averaged just 19 deaths per year by hurricanes from 2014-2023 (NOAA, 2023). However, hurricane mortality records are typically based on official estimates of direct fatalities.[2] Indirect fatalities are also captured in some official event data, with some estimates of indirect fatalities almost equaling direct fatalities (Rappaport and Blanchard, 2016).[3] Both direct and indirect fatalities are typically recorded based on careful analysis of death records that can be attributed to either direct or indirect factors. Yet, it is likely that disasters may also increase deaths by causes not easily attributed to the disaster in individual death records. Advanced statistical methods can isolate these "excess fatalities" occurring beyond the no-disaster baseline without need for individual attribution of each death record.[4] Similar approaches have been applied to estimate excess mortality from the COVID-19 pandemic when death certificates may not attribute a death to the COVID-19 virus but mortality was nonetheless elevated (Msemburi et al., 2023). However, it remains unclear to what extent more routine disasters, such as hurricanes, may lead to excess mortality and by how much official estimates may be under-counting these harmful impacts.

This paper causally estimates the excess mortality from hurricanes in the United States and examines various mechanisms associated with differences in the level of excess fatalities. We estimate

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[1] Tropical cyclones are the weather phenomena known as a hurricanes in the North Atlantic, central North Pacific, and eastern North Pacific, and cyclones or typhoons in other parts of the world.

[2] NOAA defines direct fatalities as "a fatality... directly attributable to the hydrometeorological event itself, or impact by airborne/falling/ moving debris" (NOAA, 2016).

[3] Indirect fatalities are defined by NOAA as "occurring in the vicinity of a hydrometeorological event, or after it has ended, but not directly caused by impact or debris from the event (weather event was a passive entity)" (NOAA, 2016). National Oceanic and Atmospheric Administration's (NOAA) Storm Events Database includes estimates of indirect fatalities and injuries.

[4] Excess fatalities are defined as "the difference in the total number of deaths in a crisis compared to those expected under normal conditions" (Msemburi et al., 2023) and can encompass many types of mortality from, e.g., disruptions in access to medical care, physical and psychological stress, accidents, or other factors.

a county-by-month panel fixed effects model using the complete history of U.S. mortality records from 2005 through 2016 at the individual level, including place of death, day of the week, manner of death, and decedent sociodemographic information (age, gender, race, ethnicity, education). We merge mortality data at the county-by-month level with detailed wind field estimates for all hurricanes during the same time period modeled by the NOAA. In order to examine additional mechanisms that may alter local vulnerability to hurricanes, we augment these data with information on climate beliefs from the Yale Climate Opinions Survey, Google Trends data on climate attention, political ideology vote shares from the MIT Election Lab, previous federal post-disaster aid from FEMA, healthcare capacity data complied by Social Explorer (originally from Area Health Resource File from the American Medical Association), and county-level sociodemographic information including race, ethnicity, and income from the National Institute of Health's Surveillance, Epidemiology, and End Results Program.

Preliminary results highlight that hurricanes trigger elevated mortality for several months relative to locations that do not receive them. Based on mortality data from the Insurance Information Institute, direct U.S. hurricane deaths from 2006-2016 totalled 228.[5] Based on the results of our empirical analysis, our preliminary estimates predict total mortality from hurricanes was 2,926, more than 11 times the official estimates. We highlight that the income elasticity of disaster mortality that we estimate is still negative, even for excess mortality, as income remains an important protective force in saving lives. However, we caution that these sources of "hidden" hurricane mortality expose the vulnerabilities remaining even in one of the wealthiest countries in the world. Using the EPA's official Value of Statistical Life (VSL) estimate of $11.72 million ($2024USD), mortality valuation, based on official fatality numbers, of $242.9 million during the 2006-2016 period is drastically understated compared to our estimate of $2.874 billion when excess mortality is accounted for.[6] In addition, we find a significant number of these excess fatalities occur from accidents and natural causes, and occur in counties with a higher fraction of residents with an education of high school or less. Finally, we find some (limited) evidence of a "harvesting" effect, or a decrease in mortality in the six to twelve months following a hurricane, given the higher mortality that just preceded it (Deschênes and Greenstone, 2011).

In our preliminary results, we also find that multiple mechanisms significantly mediate the relationship between hurricanes and excess mortality across space and time. In particular, counties with stronger belief in climate change and counties that have a higher percentage of democratic voters have significantly fewer fatalities in the months following the hurricanes, potentially signalling greater preparedness among these locations. In addition, we still find evidence of a negative income elasticity of fatalities, evidence that higher income locations are better able to protect themselves from hurricane mortality. We also find that the immediate impact of hurricanes is less harmful in areas with a higher percent of female and Hispanic residents, in contrast to traditional concepts of disaster vulnerability (Cutter et al., 2012).

In soon-to-be-completed work, we will also estimate mortality regressions at the county-by-month-by-age-group level in order to examine how hurricanes may heterogeneously impact excess mortality across key groups, e.g., young children, older adults, etc. We will also investigate more specifically the role of race, ethnicity, gender, age, income, and education of the decedent in driving excess mortality as these are commonly cited as correlates of vulnerability (Cutter et al., 2012). Examining how much these factors increase the probability of fatality and how they interact will add value for more specific policy recommendations and solutions (Bakkensen et al., 2017).

[5]Official direct hurricane deaths listed by the National Weather Service was even lower - just 104 during this time period (NOAA, 2023).

[6]The EPA recommends a VSL estimate of $7.4 million ($2006USD) per statistical life updated to the year of analysis (EPA, 2024).

This paper has key contributions to the literature and policy implications. First, to our knowledge, we are the first to causally estimate excess fatalities from U.S. hurricanes and key mechanisms associated with heterogeneity in these excess fatalities.[7] Second, we move beyond existing vulnerability and resilience indicator research to empirically validate their underlying components in a real-world, policy-relevant context of mortality. Finally, we highlight the role of climate beliefs and ideology in impacting real world outcomes that are relevant both today and for decades to come (Peduzzi et al., 2012).

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[7] We note that Parks et al. (2022) examine the association between hurricanes and county-level U.S. mortality, but utilize a Bayesian conditional quasi-Poisson model, similar to a case-crossover analysis, that arguably does not account for omitted variables as well as our panel fixed effects approach and only examines few mechanisms. They also do not estimate total excess fatality over their data period.

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