

Tropical cyclones and human health

Exploring evidence of associations using environmental epidemiology tools

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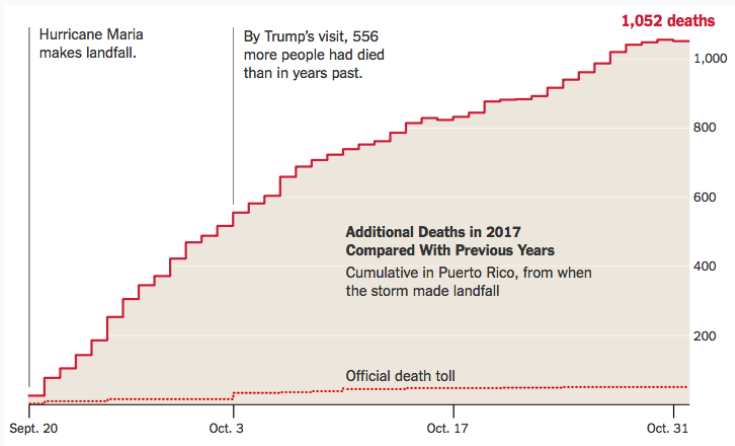
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🔗: github.com/geanders

Impacts in excess of official death tolls

Evidence from Hurricane Maria in Puerto Rico of extensive mortality impacts.



Counting tropical cyclone fatalities

Exposure to forces of nature: ICD-10 X30—X39	
X30	Exposure to excessive natural heat
X31	Exposure to excessive natural code
X32	Exposure to sunlight
X34	Earthquake
X35	Volcanic eruption
X36	Avalanche, landslide, and other earth movements
X37	Cataclysmic storm
X38	Flood
X39	Exposure to other forces of nature

Reporting cause of death

CAUSE OF DEATH (See instructions and examples)			Approximate interval: Onset to death
<p>32. PART I. Enter the <u>chain of events</u>—diseases, injuries, or complications—that directly caused the death. DO NOT enter terminal events such as cardiac arrest, respiratory arrest, or ventricular fibrillation without showing the etiology. DO NOT ABBREVIATE. Enter only one cause on a line. Add additional lines if necessary.</p> <p>IMMEDIATE CAUSE (Final disease or condition -----> resulting in death)</p> <p>Sequentially list conditions, if any, leading to the cause listed on line a. Enter the</p> <p>UNDERLYING CAUSE (disease or injury that initiated the events resulting in death) LAST</p> <p>a. <u>Crushed chest</u> Due to (or as a consequence of): _____</p> <p>b. <u>Shed collapsed during hurricane</u> Due to (or as a consequence of): _____</p> <p>c. _____ Due to (or as a consequence of): _____</p> <p>d. _____</p>			<p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p>
<p>PART II. Enter other <u>significant conditions contributing to death</u> but not resulting in the underlying cause given in PART I.</p> <p>Head trauma</p>		<p>33. WAS AN AUTOPSY PERFORMED? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p> <p>34. WERE AUTOPSY FINDINGS AVAILABLE TO COMPLETE THE CAUSE OF DEATH? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p>	
<p>35. DID TOBACCO USE CONTRIBUTE TO DEATH?</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> Probably</p> <p><input checked="" type="checkbox"/> No <input type="checkbox"/> Unknown</p>	<p>36. IF FEMALE:</p> <p><input type="checkbox"/> Not pregnant within past year</p> <p><input type="checkbox"/> Pregnant at time of death</p> <p><input type="checkbox"/> Not pregnant, but pregnant within 42 days of death</p> <p><input type="checkbox"/> Not pregnant, but pregnant 43 days to 1 year before death</p> <p><input type="checkbox"/> Unknown if pregnant within the past year</p>		<p>37. MANNER OF DEATH</p> <p><input type="checkbox"/> Natural <input type="checkbox"/> Homicide</p> <p><input checked="" type="checkbox"/> Accident <input type="checkbox"/> Pending Investigation</p> <p><input type="checkbox"/> Suicide <input type="checkbox"/> Could not be determined</p>

Source: https://www.cdc.gov/nchs/data/dvs/hurricane_certification.pdf

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a. <u>Acute respiratory failure</u>	Due to (or as a consequence of):		4 hours
b. <u>Severe emphysema</u>	Due to (or as a consequence of):		
c. <u>Heat and loss of air conditioner power from hurricane</u>	Due to (or as a consequence of):		
d. _____			
<p>PART II. Enter other <u>significant conditions contributing to death</u> but not resulting in the underlying cause given in PART I.</p>			<p>33. WAS AN AUTOPSY PERFORMED? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p> <p>34. WERE AUTOPSY FINDINGS AVAILABLE TO COMPLETE THE CAUSE OF DEATH? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p>
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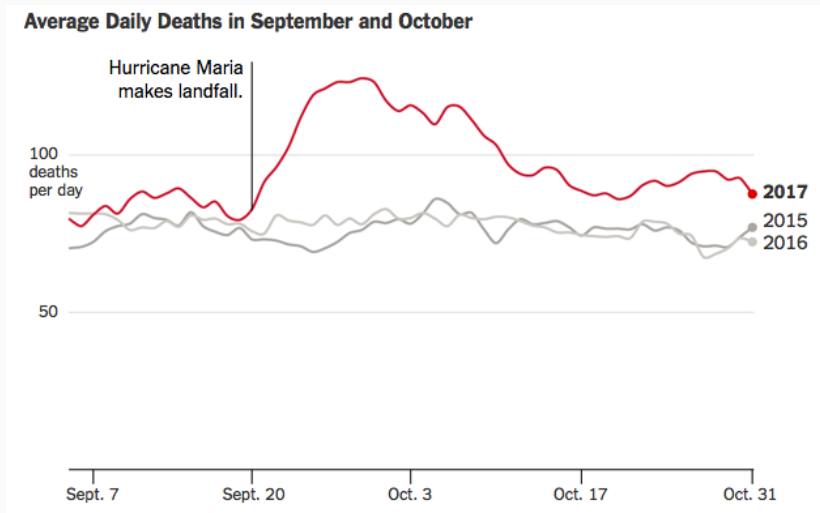
Source: https://www.cdc.gov/nchs/data/dvs/hurricane_certification.pdf

Reporting cause of death

CAUSE OF DEATH (See instructions and examples)				Approximate interval: Onset to death
<p>32. PART I. Enter the chain of events—diseases, injuries, or complications—that directly caused the death. DO NOT enter terminal events such as cardiac arrest, respiratory arrest, or ventricular fibrillation without showing the etiology. DO NOT ABBREVIATE. Enter only one cause on a line. Add additional lines if necessary.</p> <p>IMMEDIATE CAUSE (Final disease or condition resulting in death) → a. <u>Massive head trauma</u> Due to (or as a consequence of): _____</p> <p>Sequentially list conditions, if any, leading to the cause listed on line a. Enter the UNDERLYING CAUSE (disease or injury that initiated the events resulting in death) LAST b. <u>Car collides with falling tree</u> Due to (or as a consequence of): _____</p> <p>c. _____ Due to (or as a consequence of): _____</p> <p>d. _____</p>				<p>_____</p> <p>_____</p> <p>_____</p>
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<p>38. DATE OF INJURY (Mo/Day/Yr) (Spell Month)</p> <p>August 29, 2005</p>	<p>39. TIME OF INJURY</p> <p>1130</p>	<p>40. PLACE OF INJURY (e.g., Decedent's home; construction site; restaurant; wooded area)</p> <p>In decedent's car on road</p>	<p>41. INJURY AT WORK?</p> <p><input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p>	
<p>42. LOCATION OF INJURY: State: Mississippi</p> <p>Street & Number: 800 block of Sylvan Road</p>		<p>City or Town: near Pas Christian</p> <p>Apartment No.: _____ Zip Code: 39571-1234</p>		
<p>43. DESCRIBE HOW INJURY OCCURRED:</p> <p>Car collided with falling tree</p>			<p>44. IF TRANSPORTATION INJURY, SPECIFY:</p> <p><input checked="" type="checkbox"/> Driver/Operator</p> <p><input type="checkbox"/> Passenger</p> <p><input type="checkbox"/> Pedestrian</p> <p><input type="checkbox"/> Other (Specify)</p>	

Impacts in excess of official death tolls

Evidence from Hurricane Maria in Puerto Rico.



Source: The New York Times

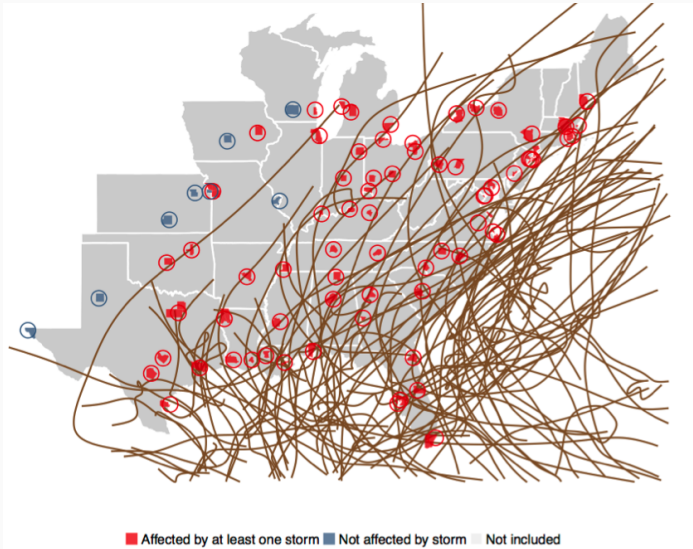
Relative risk of mortality associated with storm exposure

Relative risk of mortality associated with storm exposure

We aimed to measure the *relative risk* (RR) of mortality during the storm compared to what would have been expected the same days if there had not been a storm:

$$RR = \frac{\# \text{ deaths during storm}}{\text{Expected } \# \text{ of deaths without storm}}$$

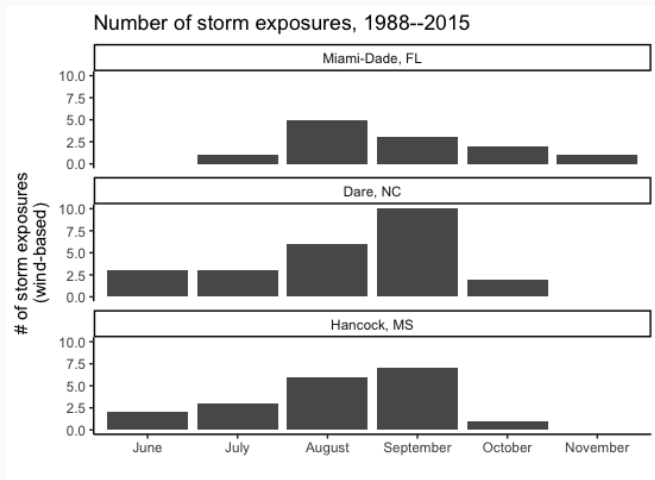
Study storms and communities



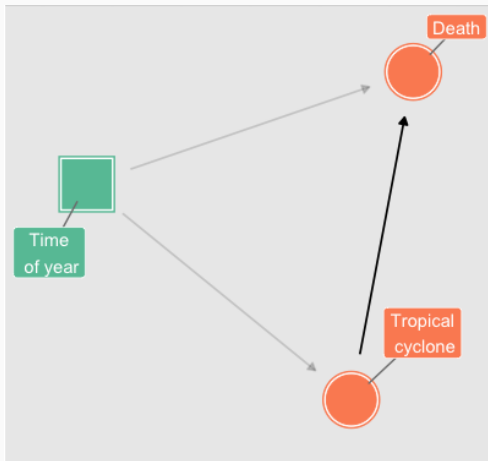
Source: Preliminary results, Yan et al.

Seasonality in tropical cyclones

Storm occurrence by month for three high-risk US counties.

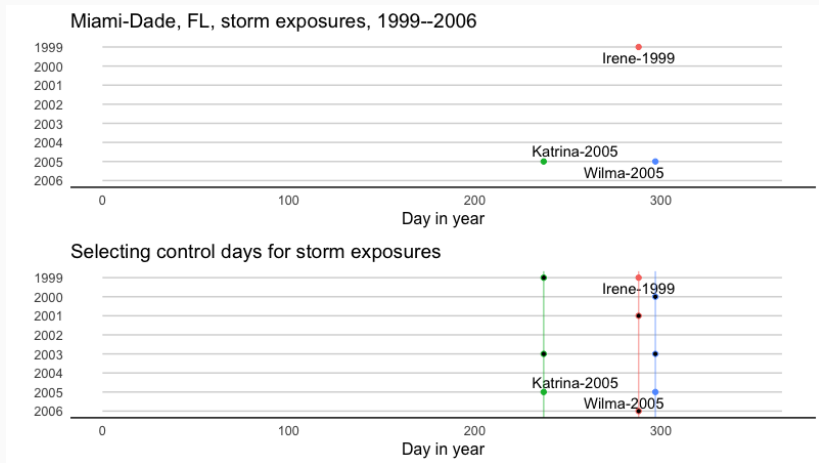


Seasonal confounding



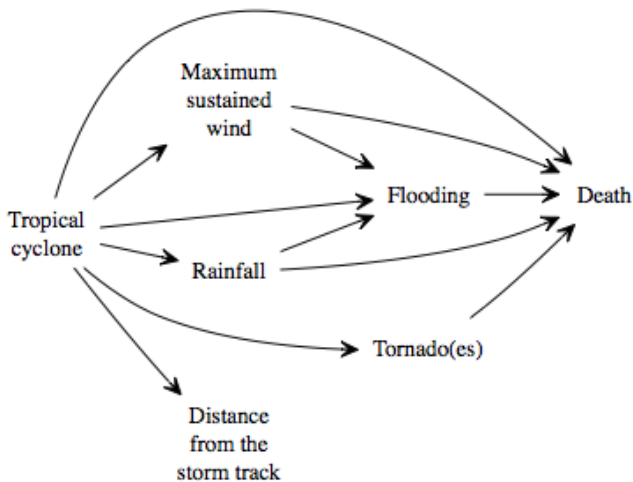
The probability of both tropical storms and mortality vary by season, opening the potential for season to confound measurements of the relationship between tropical storm exposure and mortality risk.

Matching to control for seasonality

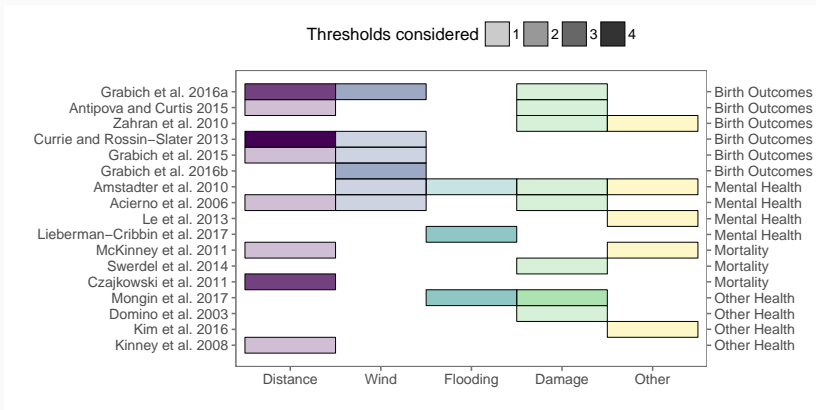


We selected unexposed days in each community, matched to each storm exposed day, ensuring all matches are on similar days of the year.

Potential pathways through which tropical cyclone exposure might increase mortality risk



Metrics of tropical cyclone exposure used previously



Distance as a surrogate measure of tropical cyclone exposure

Increase in West Nile Neuroinvasive Disease after Hurricane Katrina

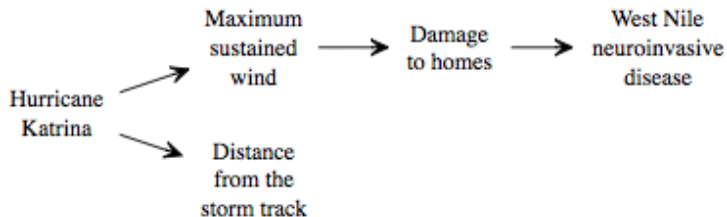
Kevin A. Caillouët,* Sarah R. Michaels,* Xu Xiong,* Ivo Foppa,* and Dawn M. Wesson*

After Hurricane Katrina, the number of reported cases of West Nile neuroinvasive disease (WNND) sharply increased in the hurricane-affected regions of Louisiana and Mississippi. In 2006, a >2-fold increase in WNND incidence was observed in the hurricane-affected areas than in previous years.

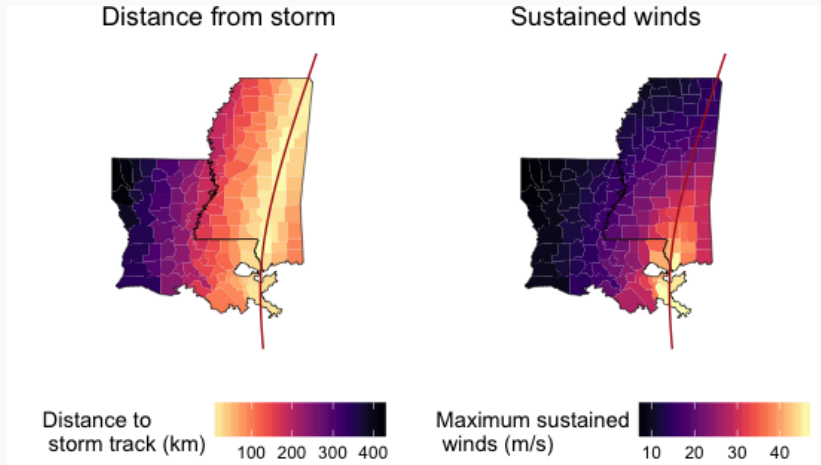


Figure 1. Hurricane Katrina track and hurricane-affected Louisiana parishes and Mississippi counties. Affected parishes and counties (gray) were defined as those in which >50% of the total area was ≤ 50 miles of the hurricane track coordinates.

Potential pathway for effects of Katrina on West Nile risk

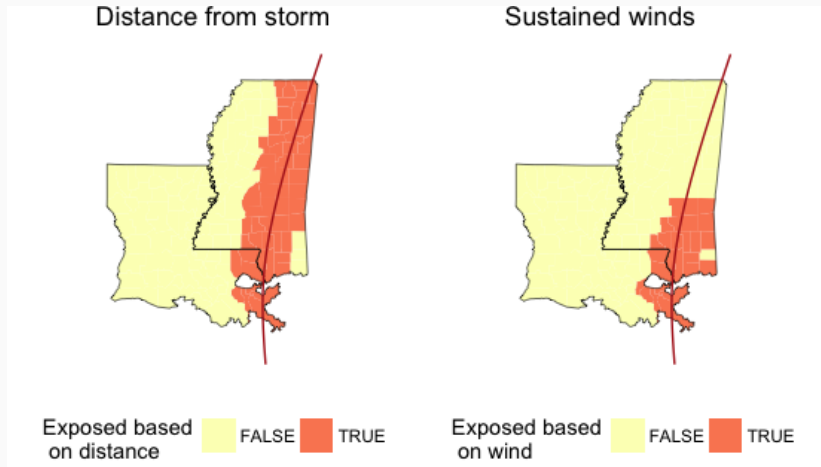


Katrina wind exposure vs. distance from storm track



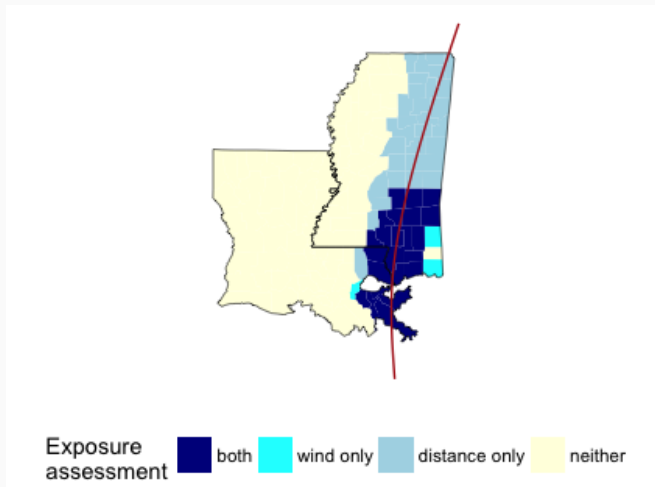
For each county in Louisiana and Mississippi, we measured the distance of the county's population mean center from the storm track (left) and modeled the maximum sustained windspeed associated with the storm (right).

Katrina wind exposure vs. distance from storm track



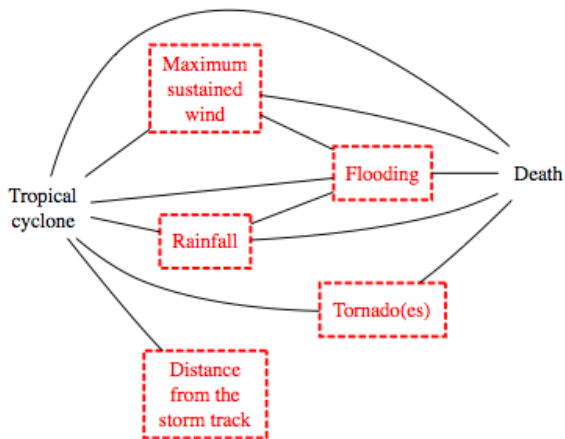
Binary storm exposure classifications based on distance from the storm track (left) and maximum sustained wind (right) for Hurricane Katrina.

Katrina wind exposure vs. distance from storm track



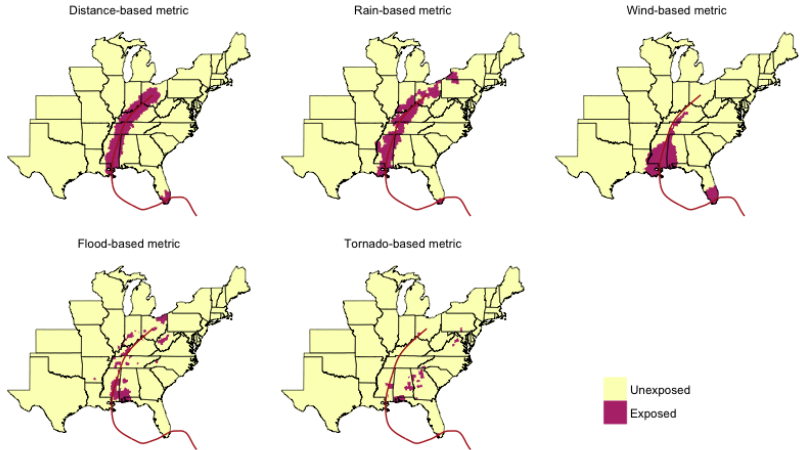
Differences between storm exposure classifications when using distance versus maximum sustained winds.

Relationships among tropical cyclone hazards

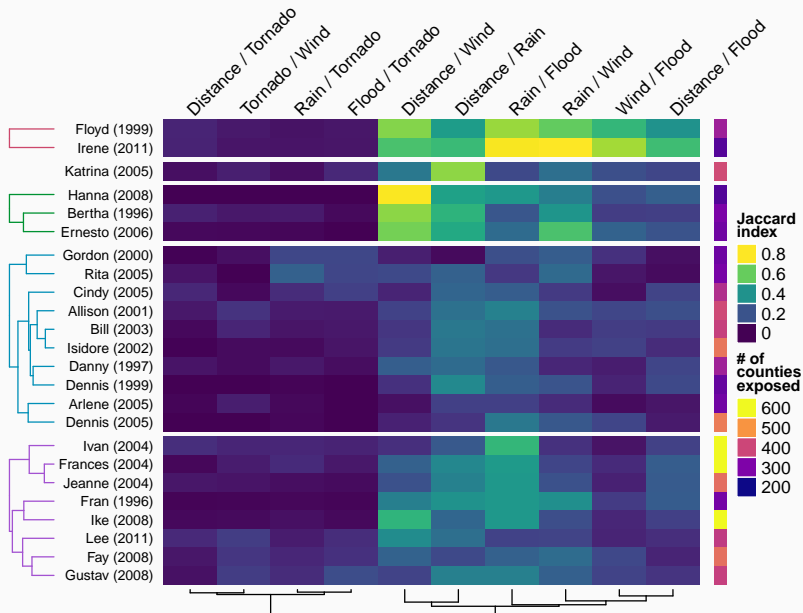


Tropical storm exposure classifications for Hurricane Katrina

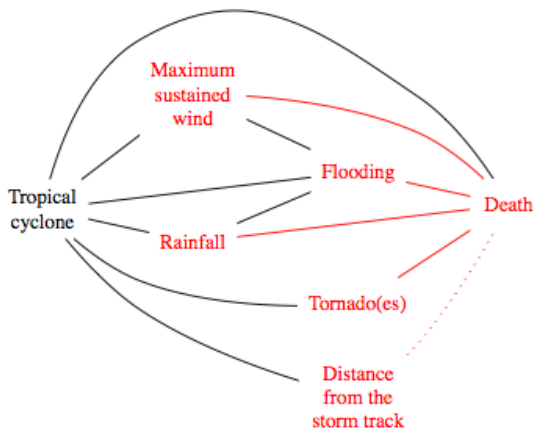
Katrina (2005)



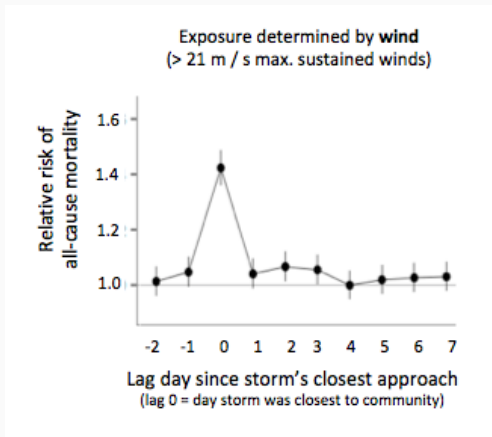
Similarity among tropical cyclone hazards



Associations between storm hazards and mortality



Mortality risks by day during storm period

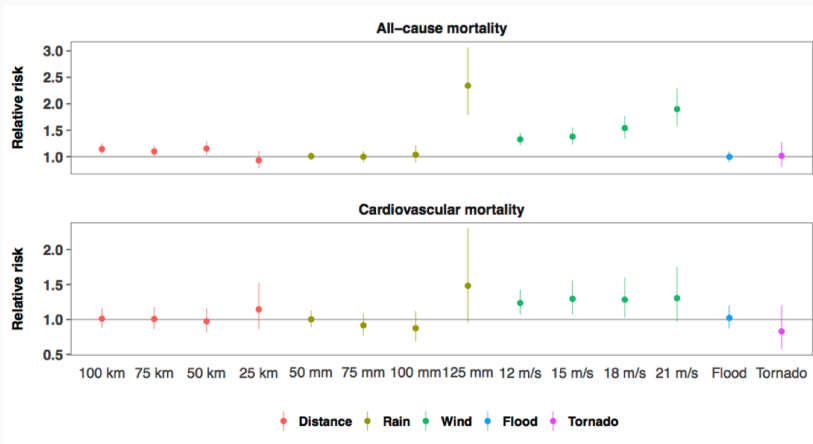


Risks by day

- For all-cause deaths, RRs were highest on storm's closest day
- There was some evidence of elevated risk before and after the storm
- Lag patterns were similar for cardiovascular and accidental deaths

Source: Preliminary results, Yan et al.

Mortality risk by exposure metric



Source: Preliminary results, Yan et al.