Tropical cyclones and human health

Exploring evidence of associations using environmental epidemiology tools

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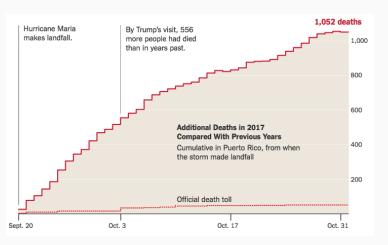
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Impacts in excess of official death tolls

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



Source: The New York Times

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

			Approximate interval:				
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 areas, respiratory arrest, or ventricular fibrillation without showing the etiology. DO NOT ABREVIATE. Enter only one cause on a line. Add additional lines if necessary.							
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disease or condition							
Sequentially list conditions, if any, leading to the cause listed on line a Lenter he							
UNDERLYING CAUSE (disease or injury that initiated the events resulting initiated of the vents resu							
in death) LAST d							
PART II. Enter other significant conditions co	ntributing to death but not resulting in the underlying cause given in F	PART I. 33. WAS AN AUTOPSY PERFO	RMED?				
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34. WERE AUTOPSY FINDING COMPLETE THE CAUSE OF D							
35. DID TOBACCO USE CONTRIBUTE TO DEATH?	36. IF FEMALE: □ Not pregnant within past year □ Pregnant at time of death	37. MANNER OF DEATH					
☐ Yes ☐ Probably	☐ Not pregnant, but pregnant within 42 days of death	■ Accident □ Pending Investigation					
■ No □ Unknown	Not pregnant, but pregnant 43 days to 1 year before death Unknown if pregnant within the past year	□ Suicide □ Could not be determined	d				

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

Reporting cause of death

			Approximate interval:		
CAUSE OF DEATH (See instructions and examples)					
 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. 					
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35. DID TOBACCO USE CONTRIBUTE TO DEATH?	36. IF FEMALE: ☐ Not pregnant within past year ☐ Pregnant at time of death	37. MANNER OF DEATH ■ Natural □ Homicide			
Yes Probably	Not pregnant, but pregnant within 42 days of death Not pregnant, but pregnant 43 days to 1 year before death	□ Accident □ Pending Investigation □ Suicide □ Could not be determined			
□ No ■ Unknown	☐ Unknown if pregnant within the past year				

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

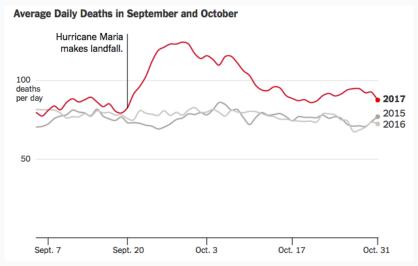
Reporting cause of death

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■ No □ Unknown □ Unknown if pregnant within the past year 38. DATE OF INJURY 39. TIME OF INJURY 40. PLACE OF INJURY (e.g., Decedent's home; construction site; restaurant; wooded are) 1130 In decedent's car on road 12. INJURY AT WORX? 42. LOCATION OF INJURY: State: Mississippi City or Town: near Pas Christian Street & Number: 500 block of Sylvan Road Apartment No.: Zip Code: 39571-1234 43. DESCRIBE HOW INJURY OCCURRED: 44. IF TRANSPORTATION INJURY, SPECIFY:	□ Yes □ Probably		☐ Not pregr					
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August 29, 2005 1130 In decedent's car on road 42. LOCATION OF INJURY: State: Mississippi City or Town: near Pas Christian Street & Number: 800 block of Sylvan Road Apartment No.: Zip Code: 39571-1234 43. DESCRIBE HOW INJURY OCCURRED: 44. IF TRANSPORTATION INJURY, SPECIFY:		39. TIME O	INJURY		onstructio	on site; restaurant;	41. INJUR	Y AT WORK?
Street & Number: 800 block of Sylvan Road Apartment No : Zip Code: 39571-1234 43. DESCRIBE HOW INJURY OCCURRED: 44. IF TRANSPORTATION INJURY, SPECIFY:	August 29, 2005 1130		In decedent's car on road		□ Yes I	■ No		
43. DESCRIBE HOW INJURY OCCURRED: 44. IF TRANSPORTATION INJURY, SPECIFY:	42. LOCATION OF INJURY: State: Mississippi City or Town: near Pas Christian							
	Street & Number: 800 block of Sylvan Road Apartment No : Zip Code: 39571-1234							
	43. DESCRIBE HOW INJURY OCCURRED: 44. IF TRANSPORTATION INJURY, SPECIFY:							
Car collided with falling tree	Car collided with falling tree					□ Pedestrian		

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

Impacts in excess of official death tolls

Evidence from Hurricane Maria in Puerto Rico.



Source: The New York Times

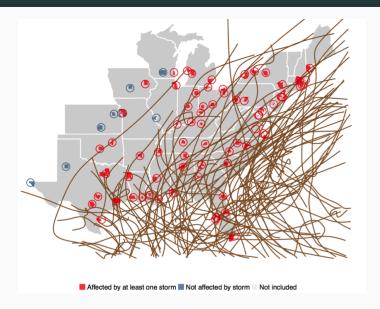
Relative risk of mortality associated with storm exposure

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:

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

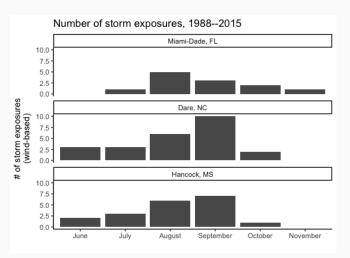
Study storms and communities



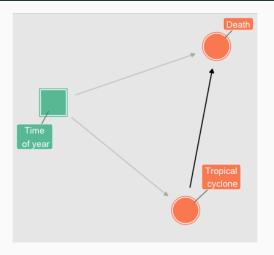
Source: Preliminary results, Yan et al.

Seasonality in tropical cyclones

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

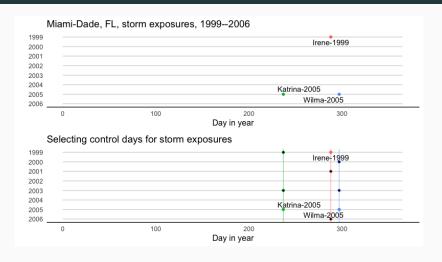


Seasonal confounding



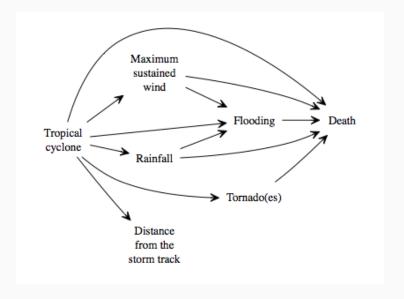
The probability of both tropical storms and mortality vary by season, opening the potential for season to confound measurements of the relationship between tropical storm exposure and mortality risk.

Matching to control for seasonality

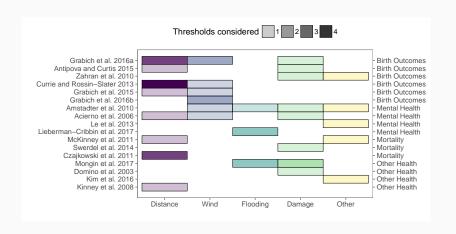


We selected unexposed days in each community, matched to each storm exposed day, ensuring all matches are on similar days of the year.

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

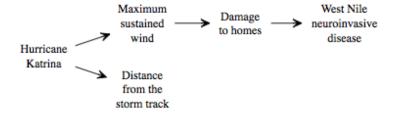
Kevin A. Caillouët,* Sarah R. Michaels,* Xu Xiong,* Ivo Foppa,* and Dawn M. Wesson*

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.

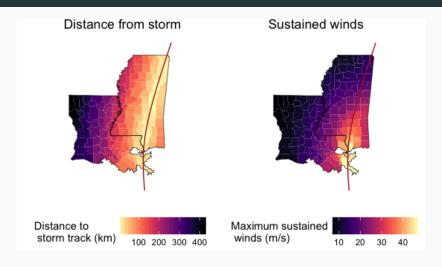


Figure 1. Hurricane Katrina track and hurricane-affected Louisiana parishes and Mississippi counties. Affected parishes and counties (gray) were defined as those in which >50% of the total area was <50 miles of the hurricane track coordinates.

Potential pathway for effects of Katrina on West Nile risk

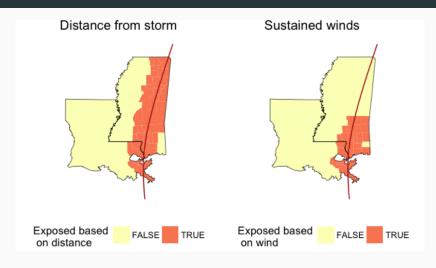


Katrina wind exposure vs. distance from storm track



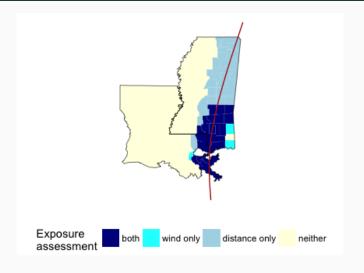
For each county in Louisiana and Mississippi, we measured the distance of the county's population mean center from the storm track (left) and modeled the maximum sustained windspeed associated with the storm (right).

Katrina wind exposure vs. distance from storm track



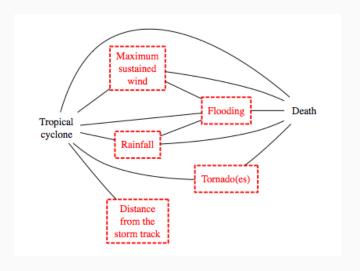
Binary storm exposure classifications based on distance from the storm track (left) and maximum sustained wind (right) for Hurricane Katrina.

Katrina wind exposure vs. distance from storm track

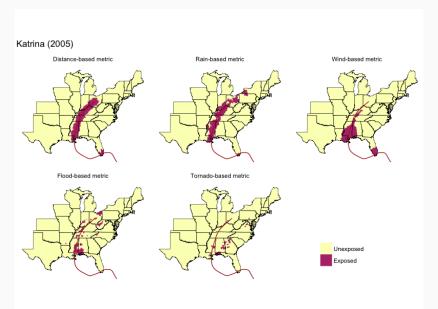


Differences between storm exposure classifications when using distance versus maximum sustained winds.

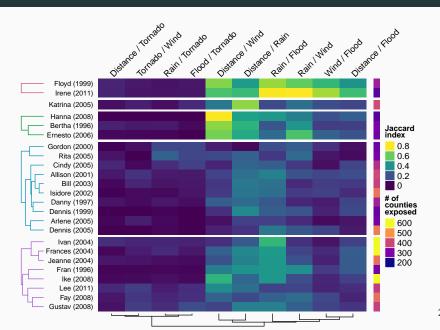
Relationships among tropical cyclone hazards



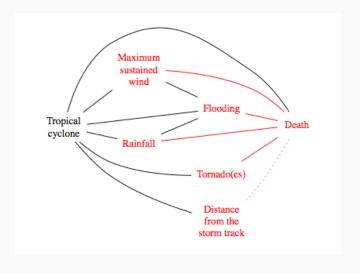
Tropical storm exposure classifications for Hurricane Katrina



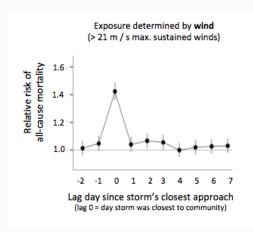
Similarity among tropical cyclone hazards



Associations between storm hazards and mortality



Mortality risks by day during storm period

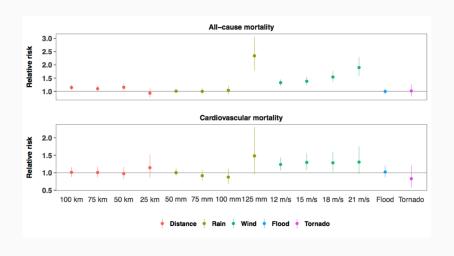


Source: Preliminary results, Yan et al.

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

Mortality risk by exposure metric



Source: Preliminary results, Yan et al.