Tropical Cyclone Bibliography

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Spatial levels

- Point location (latitude / longitude or address) of each subject (e.g., household, individual)
  - (Bayleyegn et al. 2006)
- Fine spatial resolution, but not individual level (e.g., tree mortality in small areas measured by remote sensing)
  - (Bianchette et al. 2009)
- ZIP code
  - (Bevilacqua et al. 2020) [double-check]
  - (Lane et al. 2013)
- County / parish
  - (Kinney et al. 2008)
  - (S. C. Grabich et al. 2016) [double-check]
  - (S. Grabich et al. 2016) [double-check]
- State
  - (Jaycox et al. 2010) [double-check]
- Country (e.g., Puerto Rico)
  - (Scaramutti et al. 2019) [double-check]

Time scales

Either the specific time scale used, or the finest resolution that would likely be helpful given the study's outcome data.

- Day
  - (Bayleyegn et al. 2006)
  - (Pugatch 2019)
- Between day and week
  - (Hagy, Lehrter, and Murrell 2006)
- Week (often pregnancy outcomes, where gestational week is a factor)
  - (Kinney et al. 2008)
  - (S. C. Grabich et al. 2016) [double-check]
  - (S. Grabich et al. 2016) [double-check]
- Cumulative measure across storm event
  - (Jaycox et al. 2010)
  - (Scaramutti et al. 2019)
  - (Bianchette et al. 2009)

(Kinney et al. 2008)

This study tested a hypothesis that the risk of autistic disorder increases in a dose-response manner relative to the intensity of prenatal storm exposure, and that sensitive periods of gestation exist where these exposures are more likely to increase the risk of autistic disorder. The study was conducted in Louisiana parishes that had been hit by the storm centers from 1980 to 1995.

Temporal Scale

- Severe storms between 1980 and 1995 were identified.
- "To investigate how timing of storm exposure affected prevalence, the normal 40-week term of gestation was divided into five equal periods, each period being 8 weeks (or two four week"months"). Although the use of shorter gestational periods would have been desirable, it would have yielded too few AD cases in each period to provide adequate statistical power. Moreover, data on individual gestation lengths were not available, so 40-week gestations were assumed when estimating gestational age during storms." (Kinney et al. 2008)

Spatial Scale:

- "National Weather Service maps of storm tracks were used to identify the parishes that were hit by the centers of each storm, and thus were likely to have experienced the most intense effects of the storm" (Kinney et al. 2008)
- Parishes hit by the center of the storms were assumed to have withstanded the most intense effects of the storm.
- Storms that were considered severe were identified using data from the National Weather Service on all hurricanes, tropical storms and floods that included the storms' dates, tracks, and degrees of destruction.
- Three levels of storm exposure were assessed: High, Intermediate, and Low/Control exposure to the storm. Each level was assessed based on whether the exposure included both, one, or none of the exposure factors (Storm intensity, and storm vulnerability).

Exposure:

- Severity of prenatal storm exposure assessed two ways: intensity of storm's impact on parish, and how vulnerable residents would be if storm hit their parish. (Intensity and Vulnerability).
- Three levels of storm exposure were assessed: High, Intermediate, and Low/Control exposure to the storm. High exposure meant that both severity factors were present (both Intensity AND Vulnerability), Intermediate exposure meant only one of these factors was present (either Intensity OR Vulnerability), and Low/Control exposure meant that neither of the factors were present.
- Using data from NCHS, 40 week gestations were assumed to estimate the gestional age of babies during the storm, so that the researchers could count backwards from the date of birth.

Results/Outcomes:

- AD (Autistic Disorder) had significantly higher prevalence in those with higher prenatal storm exposure. AD Prevalence also depended on Prenatal Period of Storm Exposure (what gestational period the baby was in when the storm exposure occured)

(Bayleyegn et al. 2006)

This study was a rapid needs assessment conducted in Santa Rosa and Escambia counties in the Florida Panhandle shortly after Hurricane Ivan in September 2004. It was done using a survey, with the goal of seeing what critical needs residents had following the storm, in terms of utilities.

Temporal scale

- Survey instruments administered over 3 days, 6 days after Hurricane Ivan made landfall. Since they measured this in days, they probably were looking at the specific day that the storm passed as the "day 0," and then looking at needs at specific day-level time points from that initial day, so they would need a daily temporal scale for other exposure data.

Spatial Scale:

- Escambia and Santa Rosa counties were identified as those most impacted by Hurricane Ivan by Florida Department of Health. ###[Was this based on a qualitative assessment, or on any type of measurements? If the latter, let's include any quantitative measurements they used here.]### Probability Proportional to Size Sampling (modified from the WHO), was used to obtain a sample of 30 clusters within these counties, which were put on maps given to interview teams.
- 7 households interviewed per cluster, for a total of 420 households interviewed.
- Interviews administered asking for demographic info, housing info, damage info, etc.

Exposure

- Hurricane Ivan making landfall on the Florida panhandle was the exposure. The Florida Department of Public Health then made a determination of several of the hardest hit areas to study (and also the determination that the storm was severe enough to consider parts of Florida as exposed to a severe event and so in need of assessment for current needs). ###[No further analysis was used to quantify the intensity of exposure in the study areas?]###

Results/Outcomes

- Most commonly reported "Greatest needs" were garbage pickup and restoration of electricity, after that it was access to medical care, medications, home repair, and ice.
- Interviews and surveys were intended to look at what the health and safety impacts were after the hurricane, it turned out to be a wide variety of factors including poor environmental hygiene, living in damaged homes, sleep disturbance, respiratory problems, and the aformentioned "Greatest Needs."

(Hagy, Lehrter, and Murrell 2006)

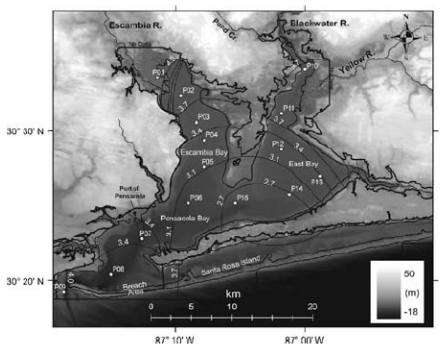
This study investigated the evolution of water quality in Pensacola Bay in Florida following Hurricane Ivan in 2004. The studies were conducted monthly for several years following the storm.

Temporal Scale:

- Water quality surveys conducted monthly from 2000 to 2004, the final of these 48 surveys before the storm happened 15 days before it made landfall. Post Hurricane Ivan surveys were taken October 6 and November 5, or 20 and 50 days after the storm, and compared to the survey taken 15 days before the hurricane made landfall. The paper didn't mention anything about when or if the water quality tests went back to a monthly schedule, but teh 20 and 50 day surveys seemed to be intended entirely for assessing the hurricane's impact. ###[Could you clarify? Is it that there was this tighter schedule right after the storm, and then it moved to a monthly schedule for the following few years?]###

Spatial Scale:

- Water quality surveys conducted at up to 15 sites located on two transects within the Pensacola Bay system. These sample site shad recorded Latitude and Longitudinal coordinates.



- The water quality surveys were really a series of tests described in the quotes: "Hydrographic data were collected at each stationusing a Seabird SBE25 CTD measuring water temperature, salinity, dissolved oxygen, PAR, chlorophyll a fluorescence, and turbidity. Profile data were binned at a 0.25-m interval. Surface and bottom water samples were collected with either a Van Dorn bottle or a low pressure submersible pump. Samples for dissolved nutrients were filtered in the field using a syringe filter system with combusted GF/F filters. Additional 2-l water samples were collected in a clean polyethylene bottle and processed for chlorophyll a and particulate carbon and nitrogen in the laboratory within 2 to 3 h." (Hagy, Lehrter, and Murrell 2006)
- If sample sites are given with lat./long., having point-level exposure data could help inform a study like this. Otherwise, watershed-level data (as well as, perhaps, data on a spatial scale linked to the water system, like "bay," "inlet," "river") might be more helpful.
- "River flow data were obtained from U.S. Geological Survey gauging stations on the Escambia River at Molino, Florida, Blackwater River near Baker, Florida, Yellow River near Milligan, Florida, and Big Coldwater Creek near Milton, Florida, accounting for 74% of the watershed area. Runoff from ungauged watershed areas adjacent to Pensacola Bay was computed from the discharge per unit of watershed area in the Pond Creek watershed, a small gauged watershed immediately adjacent to Pensacola Bay" (Hagy, Lehrter, and Murrell 2006)
- The location and heights of high water marks around the perimeter of Pensacola Bay were used to estimate the extent of inundated land and the maximum height of the tidal surge.

Exposure:

- Exposure of interest in this study was the storm surge from Hurricane Ivan when it made landfall
- Extent of inundated land and maximum height of tidal surge were estimated by directly observing locations and heights of high water marks around perimeter of Pensacola Bay.
- Total Prism Model used to estimate the magnitude of exchange associated with storm surge.

Outcome/Results:

- Hurricane Ivan caused water to rise continuously for 31 hours.
- Storm surge inundated 165 km^2 of land, which increased the Bay's surface area by 50% and it's volume by 230%.
- Based on Total Prism Model, storm surge flushed a maximum of 60% of the Bay's water out to sea as it retreated—this must have increased salinity of the Bay substantially.
- Using Navy's model estimate of offshore salinity in the Tidal Prism Model, Ivan's surge was computed to have increased the mean salinity of the Bay from 23.4 to as high as 30.0.
- Tidal surge replaced Bay waters with low-nutrient, well-oxygenated, oligotrophic Gulf waters
- Post-storm freshwater input stimulated an increase in phytoplankton biomass, which persisted for several weeks.
- Hypoxia was intensified relative to the seasonal norm.

(Lieberman-Cribbin et al. 2017)

This study investigated how exposure to flooding during Hurricane Sandy in 2012 was associated with mental health in New York City and Long Island, NY. Self reported flooding exposure was compared to flooding exposure data from FEMA after Hurricane Sandy and this then an association was determined between the flooding exposure and depression, anxiety, and PTSD.

Temporal Scale

- Surveys were all administered after Hurricane Sandy, and the mean time elapsed since Hurricane Sandy was 20.16 months.

Spatial Scale:

- A residential address for each study subject was then geocoded to a latitude and longitude (point location) for each study subject.
- Street level geo-coding in SAS using datasets generated from U.S. Census Bureau TIGER/Line shapefiles. Process matches street, city, and zip-code from survey dataset with lookup dataset to produce a coordinate
- Point-level, it sounds like (or at least street level)
- "In conjunction with community and governmental partners, the recruitment team traveled to libraries, community centers, senior centers, gyms and faith-based institutions across Queens, Staten Island, Nassau, and Suffolk in both heavily and less affected areas, and accepted all the volunteers who offered to participate in the study." (Lieberman-Cribbin et al. 2017)

Exposure:

- Extent of flooding at the study subject's residential address as a result of Hurricane Sandy in 2012
- Flooding was the main factor for assessing hurricane exposure
- FEMA dichotomous and FEMA continuous flooding models were used to map the flooding exposure in New York City and Long Island
- Self-reported flooding exposure was also assessed and compared to the FEMA models. There were discrepencies between the two of these.
- "Public macro-level flood data was obtained from the FEMA Modeling Task Force (MOTF) Hurricane Sandy Impact Analysis" (Lieberman-Cribbin et al. 2017)
- New York State 3-meter spatial resolution storm surge product downloaded and imported into licensed version of ArcGIS to provide water depth above ground in New York City and Long Island
- They also assessed the degree of exposure based on self reports of flooding water height.
- Participants who did not provide an address were excluded from the study.
- "The presence and height of flooding were gathered from the overall hurricane exposure measure. Instances where participants recorded that there was no flooding in their home during Sandy (n = 63) were correspondingly assigned a flood height of 0 feet in order to be incorporated in a continuous measure of flood exposure. Instances where participants recorded flooding in their homes but did not record a numerical water height (n = 66) could not be included in analyses involving the continuous measure of flood exposure. A maximum water height of 15 feet reported on questionnaires was chosen as a cutoff to be included in this study to remove unreasonable flood heights. This choice excluded 4 participants." (Lieberman-Cribbin et al. 2017)
- Self-reported flood data was collected, meaning that the subjects were asked to assess their own flood exposure. The address they provided was used to create a a point location using latitude and longitude
- It sounds like they ideally wanted to match exposure to a point location (subject's home). They used a very fine-scale (3-m resolution) estimate of storm surge to try to do this (as well as asking the subject to assess their own flood exposure).

Results/Outcomes:

- Mental health variables considered based on scores of a questionaire were anxiety score, depression score, and PTSD score
- Self reported flood exposure and FEMA flood exposure data showed significant discrepencies in the associations between flooding and mental health outcomes.
- Self reported dichotomous flooding showed significant associations with all mental health outcomes, whereas dichotomous FEMA flooding only showed significant associations with PTSD.
- Macro-level flooding data is less expensive and faster, but potentially underestimates mental health outcomes.

(S. C. Grabich et al. 2016)

This study investigated the association between risk of pre-term birth and hurricane exposure in Florida.

Spatial Scale:

- Births to (only) Florida residents linked to address to link to hurricane exposure
- Hurricane risk assessed at county level
- Florida Department of Health, Vital Statistics Department was the source of data on births from 2003 to 2005.

Temporal Scale:

- Risk period begins at 20 weeks of gestation
- Pregnancy divided into exposed time and unexposed time after 20 weeks
- Study population included births with estimated date of conception between October 24, 2003 and September 26, 2004.
- "The authors used county-level Vital Statistics data obtained from the Florida Department of Health to calculate county-specific rates oflow birth weight and preterm births for women who were pregnant during the 2004 hurricane season. Women included in this calculation had an estimated date of conception based on last menstrual period between October 2003 and September 2004. These women would be at risk of hurricane exposure during pregnancy." (S. C. Grabich et al. 2016)

Exposure:

- Hurricane exposure classified as maximum wind speed in specific Florida county extracted from NOAA's Hurricane Research Division public database.
- "Wind speeds were extracted from NOAA's Hurricane Research Division (HRD) public databases." (S. C. Grabich et al. 2016)
- "The geographic spatial buffer exposure method yielded different results than either the disaster declaration method or the binary maximum wind-speed-exposure classifications. For all hurricanes except Hurricane Ivan, the 60 and 100-km buffer identified a similar number of counties as the binary 63-km=h (39-mi=h) windspeed categorization. For Hurricane Ivan, the number of counties exposed to both the 60 and 100-km buffer was less than any of the other methods. Compared with the counties exposed using the dichotomous 119-km=h (74-mi=h) maximum wind speed, there was a 138% difference in the number of counties exposed. Although the spatial buffer categorized a similar number of counties exposed as the binary wind speed methods, the heterogeneity across storms is apparent, particularly for Hurricane Ivan."(S. C. Grabich et al. 2016)

###[Could you check on this—did they use the wind field value for the county, for example from H*Winds, or did they use the central wind of the storm as the approximation, which they would have gotten from HURDAT?]### - Exposure defined as >= 39 mph and >= 74 mph

Results/Outcomes

- Outcome of interest was to see if there was an association between hurricane exposure and the risk of a preterm birth.
- Two outcome standards: extremely preterm delivery < 32 weeks gestation, and overall preterm delivery < 37 weeks gestation.
- Overall positive association observed between exposure to Hurricane Harvey and hazard of extreme preterm delivery (not overall preterm delivery however)

(Scaramutti et al. 2019)

This study investigated mental health outcomes in Puerto Ricans in both Puerto Rico and Florida following Hurricane Maria through a survey-based study.

Spatial Scale:

- Major cities in Florida and Puerto Rico were coded as urban with 0, and all other areas were coded as rural/suburban with a 1.
- Word of mouth and outreach to community leaders and community centers in Central and South Florida and Puerto Rico
- Online surveys available through Qualtrics, respondants asked to refer 3 additional respondants
- ###[Do we know if they had the exact address of each participant? Or did they only know that they were in Puerto Rico and whether they were in the city or a rural area, without knowing which city or area?]### It doesn't appear that the exact address of the respondants was provided, and seems unlikely given that the identities of the participants were not even verifiable.

Temporal Scale:

- Assessing mental health of Puerto Ricans in Florida and Puerto Rico 6 months after Hurricane Maria.
- There was a single time point when outcomes were measured, so coarser time resolutions (e.g., week, month, single value for the storm as a whole) would probably be useful in this type of study.

Results/Outcomes:

- Linear regression models used with site and urbanacity as predictors for depressive symptoms, anxiety symptoms, and PTSD symptoms
- Binary logistic regression analysis for clinical vs non-clinical anxiety, depression, and PTSD as criterion variables, and site or urbanacity as predictors
- Mental health outcomes of interest were anxiety, depression, and PTSD
- Results showed significant associations between urbanacity and anxiety, approaching statistical significance for association between urbanacity and depressive symptoms, and significant association between urbanacity and PTSD intrusive reexperiencing and PTSD hypervigilance.
- Overall, rates of depression and PTSD were higher in Puerto Ricans who migrated to Florida after Hurricane Maria.
- Puerto Ricans outside major cities were more likely to meet criteria for depression and PTSD
- Puerto Ricans in Puerto Rico had significantly fewere clinical symptoms than those in Florida, but rates were high overall for both Florida and Puerto Rico.

(Bianchette et al. 2009)

This study investigated the ecological impacts (particularly in terms of tree mortality) in a coastal area in Alabama following Hurricane Ivan in 2004.

Temporal Scale:

- Post hurricane images of vegetation take 9.5 months after hurricane to ensure that vegetation damage observed was permanent.

Spatial Scale:

- Study area was three coastal lakes known as the Shelby Lakes in Gulf State Park, Alabama.
- Remote sensing using Landsat 5 images coupled with ground surveys of tree mortality were used.
- "Two Landsat 5 images (30 m resolution, path 020, row 039, GeoTiff format), dated 20 July 2004 (pre-Ivan) and 7 July 2005 (post-Ivan), were used for this study." (Bianchette et al. 2009)

Exposure:

- Hurricane Ivan brought 120 mph winds and a storm surge of 10-12 feet, which inundated all of the coastal plane around the Shelby Lakes.
- ###It sounds like the full study area was assumed to be exposed based on the fact that the whole area around it was inundated by the surge of this storm?###

Results/Outcomes:

- Ecological impacts were the main concern of this study, primarily measured by tree mortality.
- Trees at lower elevation showed greater mortality than those at higher elevations.
- Results suggested that saltwater intrusion and storm surge flooding were the main reasons for tree mortality in forests around Shelby Lakes, rather than wind damage.

(S. Grabich et al. 2016)

This study investigated the association between hurricane exposure and birth outcomes in Florida. In particular, it investigated different ways of assessing exposure to the storm. At the time of publishing, the most accepted methods for assigning disaster exposure: FEMA presidential disaster declarations and spatial data on the specific storm track trajectory. The authors of this paper propose a new method that uses meteorological data to define exposure to hurricanes.

Spatial Scale:

- Preterm birth and low birth weight rates collected from the county level of exposed areas
- "The authors' novel meteorological method uses the hurricane intensity by the county's maximum wind speed. Wind speeds were extracted from NOAA's Hurricane Research Division (HRD) public databases." (S. Grabich et al. 2016)

Temporal Scale:

- In other birth outcome studies, it seems like gestational week might be used a lot? So, this study might not need a higher resolution than week? It's interesting, since they have three different exposure metrics, they really have two different time resolutions on those. The winds and storm track could be determined to about the hour (and certainly the day), while the FEMA disaster declarations will be a single, storm-long measurement (the storm resulted in one or it didn't).

Exposure:

- Hurricane disaster exposure 3 methods, FEMA Presidential disaster declarations, spatial data on specific storm trajectory (storm tracks with a symmmetrical buffer around them), novel meteorological measure based on Saffir-Simpson hurricane intensity scale [i.e., including wind speeds experienced locally].

Table 1. Description of Methods for Determining Hurricane Exposure

Method	Description
FEMA disaster declaration	
Binary classification with declared counties considered exposed	Classification determined if a county was given a declaration to receive financial assistance for the specific hurricane
Spatial symmetrical buffer	
Binary classification with exposed counties within 30 km of storm track	Classification determined when the county boundary touched within the symmetrical buffer distance; then a given county would be considered exposed
Binary classification with exposed counties within 60 km of storm track	
Binary classification with exposed counties within 100 km of storm track	
Maximum wind speed	
Continuous measure of maximum wind speed in kilometers per hour	Maximum-wind-speed categories were based on the tropical storm wind and the Saffir-Simpson hurricane wind scale: tropical storm wind speed [<63 km/h (<39 mi/h)], tropical storm wind speed [63–118 km/h (39–73 mi/h)], category 1 hurricane [119–153 km/h (74–95 mi/h)], and category 2 or higher hurricane [153 km/h (>95 mi/h)]
Categorical classification: <63 km/h (<39 mi/h), 63–117 km/h (39–73 mi/h), 119–153 km/h (74–95 mi/h), ≥153 km/h (>95 mi/h)	
Binary classification with exposure counties ≥ 63 km/h (39 mi/h)	
Binary classification with exposure counties ≥ 119 km/h (74 mi/h)	

Results/Outcomes:

- All three of the different exposure methods showed noticeably different results. The FEMA disaster declaration consistently assigned the highest number of counties as exposed, and the authors speculate that it could be overassigning.
- Using the disaster declaration method, the authors could not find any statistically significant associations between the whether the county was exposed, and low-birth weight and pre-term births, but these null findings support the idea that exposure misclassification is occurring.

(Bevilacqua et al. 2020)

This study investigated associations between exposure to Hurricane Harvey in 2017, and mental health symptoms in the Greater Houston Area.

Spatial Scale:

- The Greater Houston Area was the study area and spatial scale of this study. Recruitment events were organized in different neighborhooods of Houston to get participants to enroll.
- Efforts were made to recruit a sample of participants that reflected the racial/ethnic makeup of Houston.
- ggmaps package in R was used to generate distribution of zip codes of the participants

Temporal Scale:

- Study began 5 months post-Hurricane Harvey in January of 2018, and survey participants were recruited and took the survey between from January 25 to January 29, 2018.

Exposure:

- Hurricane exposure was quantified using a hurricane exposure score that was calculated from tallying the number of hurricane exposures checked on a survey. The survey included 30 Yes/No questions about hurricane experiences that included the death of a friend or family member, damage to property, etc.

Results/Outcomes:

- Multivariable logistic regression models showed that an increased Hurricane Exposure Score was significantly associated with an increased odds for probable depression, anxiety, and PTSD.

(Lane et al. 2013)

This study investigated a review of the literature pertaining to health outcomes after hurricanes. The purpose was to use the review to inform climate adaptation planning efforts, especially pertaining to New York City.

Spatial Scale

- "Based on vulnerable subgroups identified in the literature, potential indicators of population vulnerability for which data are available were identified and mapped within the 42 NYC United Hospital Fund (UHF) neighborhoods located within any NYC hurricane evacuation zone. UHF neighborhoods

are zip code-aggregated areas within all five boroughs. For each indicator, prevalences were categorized into quartiles by neighborhood."

Temporal Scale:

- No clear temporal scale was used as this was a literature review.

Exposure:

- "Health outcomes can occur through multiple pathways (see Figure 1) including (1) hazards from exposure to storm impact; (2) evacuation; (3) post-storm hazards from utility outages and sheltering in place in inadequate housing; (4) exposure to secondary hazards including contaminated drinking water, contact with contaminated floodwaters, and mold and moisture in housing; (5) population displacement and disruption of services; (6) mental health effects from traumatic or stressful experiences during and after the storms and (7) health and safety risks from clean-up and recovery activities." (Lane et al. 2013)

Results/Outcomes:

- "A wide range of potential acute and long-term health impacts were identified in the literature, from injury and death resulting from a failure to evacuate safely, physical and mental health problems in displaced populations because of disruption of care or stress, and injury and illness risk during repair and recovery, as well as a range of potential health impacts fromexposures in damaged housing and fromsheltering in place.Mental health problems were some of the most frequently cited health consequences of major storms. For several dimensions of public health vulnerability to coastal storms, NYC neighborhoods with elevated poverty levels may be at increased risk for lasting impacts." (Lane et al. 2013)

(Schwartz et al. 2018)

This study investigated the mental health needs of Houston residents in the aftermath of Hurricane Harvey in 2017.

Spatial Scale:

- Convenience sampling from the Greater Houston area

Temporal Scale:

- Research team arrived in Houston less than 3 weeks after Hurricane Harvey made landfall to administer the survey.

Exposure:

- "Having probable PTSD, anxiety or depression was the primary outcome in the logistic regression statistical models, and was treated as a dichotomous variable (yes or no) based on the clinically relevant cutoffs described above. The number of personal, property-related or chemical exposures was used as a continuous variable to investigate how an increase in any type of hurricane exposure affected mental health. Logistic models were adjusted for covariates including age, gender and a prior history of a mental health condition, including anxiety disorder, depression, PTSD, schizophrenia, bipolar disorder, substance abuse disorders (alcohol or prescription drug related) or some other mental health disorder that was diagnosed by a physician." (Schwartz et al. 2018)

Results/Outcomes:

- Overall Hurricane Harvey was positively associated with mental health outcomes especially PTSD and anxiety in Houston residents.
- Displacement was associated with a higher risk of PTSD and depression.
- A positive association between perceived exposure to chemicals and toxins was also associated with an increased risk of PTSD and depression 3 weeks after Hurricane Harvey.

(Pugatch 2019)

This study used objective meteorological data and vital statistics records to quantify the effects of tropical storm frequency and mortality in Mexico.

Spatial Scale:

- "I use data on tropical storm exposure and mortality in all 31, Mexican states, plus Mexico City, for each month during 1990–2011 (I chose the starting period based on the availability of microdata on mortality)." (Pugatch 2019)
- Deaths came from the Mexican state level.
- "Mortality data are from the universe of Mexican Vital Statistics records. Beginning with 10.3 million individual recorded deaths, I aggregate by state, month, and year. To construct mortality rates, I divide the deaths in each state-month-year cell by the population in that cell, using the Mexican Census from 1990, 2000, and 2010 and the Mexican Conteo (a large population survey conducted between Census years, comparable to the American Community Survey) from 1995 and 2005. I assume constant population growth to impute population values between surveys, and annualize monthly mortality rates by multiplying by 12." [pugatch2019tropical]

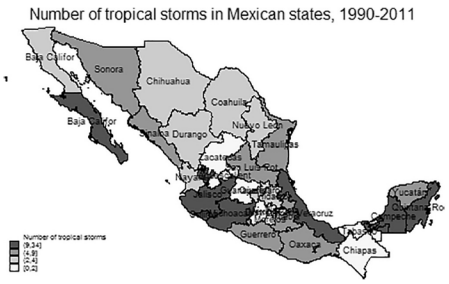


Fig. 2. Geographic distribution of tropical storms in Mexico, 1990–2011.

Temporal scale

- Deaths are aggregated by month and year in each Mexican state. The deaths are then divided by the population using the Mexican census in 1990, 2000, and 2010.
- Storms are also recorded by month.

Exposure:

- "I use windspeed data on tropical storms originating in the Atlantic and eastern North Pacific oceans (the regions relevant to Mexico), available from the National Oceanic and Atmospheric Administration (NOAA) Tropical Prediction Center, a U.S. government agency. NOAA analyzes data from reconnaissance aircraft, ships, and satellites to create "best tracks'' of individual storms: positions (latitude and longitude) of storm centers at 6-hourly intervals, combined with intensity information (windspeed and barometric pressure; Jarvinen, Neumann, & Davis, 1993; Davis, Brown, & Preston, 1984; Chu, Sampson, Levine, & Fukada, 2002). Complete records for both ocean regions are available since 1949. Fig. 1 maps storm best tracks making landfall in Mexico" (Pugatch 2019)

- The researchers divided Mexico into a series of grids and used storm best track data, which is a model of windspeed decay from the hurricane eye by predicting the radius of the hurricane, found the distance between each affected gridpoint and the nearest point along the storm best track, then finally inserting the predcited windspeed to calculate the storm index for the affected point.
- "I create an index to measure storm severity by incorporating two elements, windspeed and population density" (Pugatch 2019)

(Jaycox et al. 2010)

New Orleans schoolchildren participated in a trial and assessment of an intervention after Hurricane Katrina. Group intervention at school and individual intervention at a clinic were the two options. Both treatments led to a reduction in symptoms of PTSD, but there were still elevated levels of PTSD even post treatment.

Spatial Scale

- Three schools in New Orleans participating in Project Fleur-de-Lis.
- Point location used - the student's homes were identified.

Temporal Scale

- Interventions began 15 months after Hurricane Katrina.
- "Students were assessed at baseline (December 2006–January 2007), at 5 months (April–May 2007) and at 10 months (September–October 2007). The CBITS groups ran March to May 2007 and TF-CBT was implemented February to September, 2007. This study only reports on the 10-month follow-up assessment results." (Jaycox et al. 2010)
- For this, it sounds like a storm-wide assessment of intensity would be fine (wouldn't need finer time resolution)

Exposure

- Exposure measured via self report by students using the Disaster Experience Questionnaire.
- "For an overall exposure to hurricane experiences measure, we tallied experiences listed in the top panel of Table 2, for a total number of experiences per student." (Jaycox et al. 2010)
- PTSD symptoms assessed using the Child PTSD Symptom Scale (a score greater than 11 is considered elevated symptoms).

Results/Outcomes

- More girls than boys were at risk for PTSD symptoms (63% for girls, and 37% for boys).
- PTSD scores at 10 months were generally improved from scores at baseline assessment in students who participated in the intervention.
- "More than 60% of students screened positive for elevated PTSD symptoms and were included in the intervention field trial." (Jaycox et al. 2010)

(Bourque et al. 2006)

This paper is a review of all the mortalities and morbidities and psychological effects attributed to Hurricane Katrina and hurricanes prior to Katrina. Also looks at the information on evacuation plans and how effective they have been.

Spatial Scale

- Hurricanes as well as health impacts such as death, mental health outcomes, and morbidities were mainly only discussed on the state level, occasionally talking about particular Louisiana parishes when

discussing Hurricane Katrina.

Temporal Scale

- This paper was a review and mainly lists major hurricanes prior to Katrina by year, sometimes mentioning the month they happened in. They cover Hurricanes Elena and Gloria (September 1985), Hugo (1989), Andrew (1992), Marilyn and Opal (1995), Georges (1998), Floyd (1999), Isabel (2003), the entire 2004 hurricane season, and Hurricane Katrina (2005).

Exposure

- Mortality, morbidities, infectious disease, vibrio infections, and psychological problems were mainly assessed at state levels and reported in the immediate aftermath of the hurricane in question.

Results/Outcomes

- NOAA's Tropical Prediction Center estimates that between 1970 and 1999, 1% of deaths in hurricanes were caused by storm surges, 59% by freshwater (inland) flooding, and 12% by wind.

(Harville et al. 2010)

- Low birth rates and preterm births were studied in Louisiana at three spatial levels: Orleans Parish (New Orleans), Region 1 (this includes Orleans Parish, and several others), and Louisiana as a whole.
- Spatial scales are county, multi-county, and state.

Temporal Scale

- Data used in analysis came from Louisiana birth records 2003-2007, in Medicaid-linked data.
- Birth outcomes among state residents were examined for the 2 years before and after Hurricane Katrina.

Spatial Scale

- The Regional Level is the scale that was used to study birth outcomes, and Louisiana is divided into 9 health regions.
- The Region of mother's residence was used to study rather than the region that the mother gave birth in.
- Region 1 was the Louisiana region hit most strongly by Hurricane Katrina and consists of Orleans,Jefferson,Plaquemines,and St Bernard parishes. The study looked at Orleans parish (city of New Orleans), Region 1, and Louisiana all together.

Exposure

- Exposure defined as giving birth in the two years after Hurricane Katrina.
- "Frequency and rate (percentage) of birth outcomes and odds ratios (ORs) and 95% confidence intervals (CIs) were calculated comparing the year before and after and 2 years before and after Hurricane Katrina."(Harville et al. 2010)
- It looks as though the main exposure was giving birth after Hurricane Katrina. Four bins were created (13-24 months prior to Katrina, 12 months prior to Katrina, 12 months after Katrina, 13-24 months after Katrina). The birth outcomes of the latter two bins were compared to the birth outcomes of the first two bins.

- Births are pooled together.

- [Based on this, probably cumulative storm-wide measurements and/or week resolution would be helpful for the time resolution. If they're looking at storm-related exposures over a year after the storm, then maybe monthly exposure assessments would be helpful, too?]

Results/Outcome

- Outcomes of interest were Low Birth Weight, and Preterm Birth.
- In Louisiana as a whole, rates of LBW rose in the two years after Hurricane Katrina, but rates of Preterm births did not.
- Overall, Hurricane Katrina was not associated with an increase in the rates of LBW and preterm births, in some areas there was a reduction of these. This may be due to population changes though because after the hurricane the population giving birth was at lower risk.

???(Ferdinand 2005)???

- Hurricane Katrina led to a large number of people with uncontrolled hypertension and cardiovascular disease. Higher rates of high blood pressure are seen in African Americans than in whites, and the rates of controlled blood pressure in disadvantaged communities in Louisiana is very low.

Spatial Scale

- 680 adults staying in Hurricane Katrina shelters in Houston Texas were given a survey
- 98% of these survey subjects were from New Orleans.
- [So, city / county for spatial level?]
- Population in areas of flooding was 76% black, and 29% below the poverty line.
- [It sounds like they might also be interested in sub-county level for the amount of flooding. Here they asked with self-report, it looks like, but this could also be provided by other exposure assessment. Did they have the address of each survey respondent? If so, maybe the spatial resolution is "point location?"]

Temporal Scale

- Surveys were administered from September 10 - 12, 2005.
- [It sounds like they were trying to get an overall view of flooding throughout the storm, rather than how flooding evolved from day to day, right?]

Exposure

- Exposure to flooding leads to evacuation and unexpected displacement, which increases the odds of losing medical records and information that include hypertensive patient's medication regimen, including frequency, dosage, and indications.
- [It sounds like they considered storm-related flooding as their exposure of interest. How did they measure the extent of flooding for each study subject? Was it by self-report (through the survey), or did they use other measurements or modeling?]

Results/Outcome

- Outcomes of concern in this paper are hypertension and cardiovascular disease.
- "There is a 1.8x greater rate of fatal stroke, 1.5x greater rate of coronary heart disease and mortality, and a 4.2x greater rate of end-stage renal disease in this population." (Ferdinand 2005)
- [For the previous statement, what is the comparison group? Is this for those surveyed compared to the state or city on average? Or is it for people with flooding during the storm versus those without?]
- "Only 52% of evacuees had health insurance at the time of the hurricane, and chronic conditions such as heart disease, hypertension, diabetes, and asthma were reported by 41% of the adults surveyed.

Furthermore, 29% of evacuees reported having problems in obtaining their necessary prescription drugs." (Ferdinand 2005)

(Christopher 2017)

This study investigated the association between two disasters (Hurricane Katrina and a 2011 tornado outbreak in Alabama) and birth outcomes (birth weight, pre-term birth, infant mortality, mode of delivery).

Temporal Scale

- July 1, 2004 to August 31, 2006 for Hurricane Katrina.
- March 1, 2010 to April 31, 2012 for April 2011 Alabama tornado disaster.
- "The gestation period for mothers in the sample ranged from 18 to 47 weeks, with a mean gestation period of 37.97 weeks (SD = 2.84 weeks)"[christopher2017effects]
- [It sounds like weekly-resolved data would be sufficient to match with the outcome data they have?]

Spatial Scale

- "For Hurricane Katrina, the population was delimited to pregnant women residing in the counties of Hancock, Harrison, Jackson, and Jones, Mississippi, who experienced a live singleton birth which survived or was born and died between the periods of July 1, 2004 to August 31, 2006." (Christopher 2017)
- "For the April 2011 Alabama tornado disaster, the population was delimited to pregnant women residing in the counties of Calhoun, DeKalb, Franklin, Jefferson, Lawrence, Limestone, Madison, Marion, St. Clair, and Tuscaloosa, Alabama who were most likely affected by the April 2011 tornado disaster, and experienced a live singleton birth which survived or was born and died between the periods of March 1, 2010 to April 31, 2012." (Christopher 2017)
- [This definitely sounds like county-level exposure data would be sufficient, as it sounds like their health data is aggregated at the county level.]

Exposure

- Maternal prenatal exposure to Hurricane Katrina in Mississippi
- [How did they decide to include the counties they included in Mississippi for Katrina (Hancock, Harrison, Jackson, and Jones, Mississippi)? Were these counties selected because the central storm track passed through them, for example, or because they were given disaster declarations or something?]
- Maternal prenatal exposure to April 2011 Tornado disaster in Alabama.
- "The data consisted of customized delimited county-level linked birth and infant death data drawn from Alabama and Mississippi Linked Infant Births and Deaths Record Files for the period 1997-2013." (Christopher 2017)
- [Were controls (those unexposed to the storm in utero) just all the births in other years? (in other words, was the comparison made for other births in the county, but in other years)? Also, were all pregnant women in the selected counties considered "exposed" to the same degree (a binary classification of exposure, rather than a continuous measure)?]
- [For the figure you've included here, it looks like they might have picked the tornado counties based on the tornado tracks passing through them. Is the same true for Katrina? (exposure based on the central) track passing directly through the county?)]

Results/Outcome

- Response variables of interest included birth weight, preterm birth, infant mortality, and mode of delivery.
- Exposure to hurricanes increased odds of low birth weight and also increased risk for preterm birth, however it wasn't shown to have a significant association with increased infant mortality.

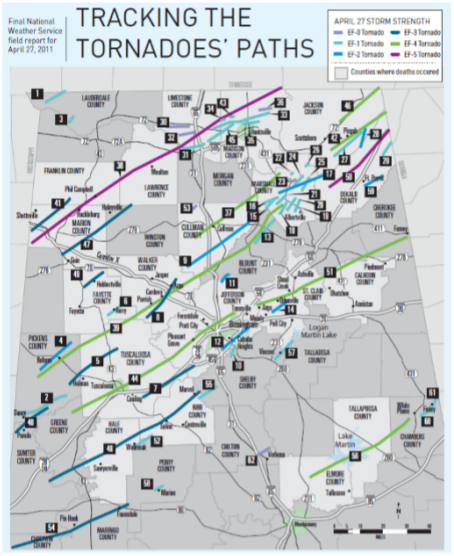


Figure 3. Illustration of the paths and types of tornadoes impacting Alabama on 27 April 2011. Adapted from "Cultivating a State of Readiness: Our Response to April 27, *2011*,"by Tornado Recovery Action Council of Alabama, 2012, p. 17. Retrieved from ema.alabama.gov/filelibrary/TRAC_Report.pdf

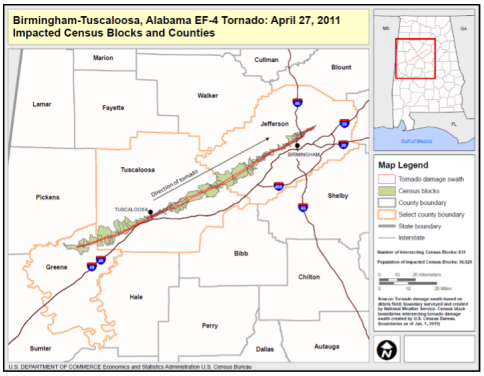


Figure 4. 2011 Alabama EF-4 Tornado track. From U.S. Department of Commerce, U.S. Census Bureau, Census Data & Emergency Preparedness, 2011 Tornadoes, Birmingham-Tuscaloosa Alabama EF-4 Tornado, 2014b. Retrieved from https://www.census.gov/newsroom/emergencies/2011_tornadoes.html

(Zahran et al. 2011)

This study investigated mental health outcomes following Hurricanes Katrina and Rita.

Temporal Scale

- "Mental health condition is measured as the reported count of poor mental health days experienced by a respondent in the previous 30 days. Data on mental health days are from the CDC's BRFSS, 2005–2006." (Zahran et al. 2011)
- [They focus only on Hurricanes Katrina and Rita, right?]
- [Do they have the exact date that the respondent took the survey? I'm guessing they just do these surveys once a year or something, in which case, they'd have a single outcome measurement for the year or the storm, and that wouldn't necessarily be close in time to the storm. Is that right? In that case, just a measure at the yearly scale, or a cumulative storm measurement, would probably be resolved enough temporally for the study.]

Spatial Scale

- Intensity of hurricane's path measured using data on property damage and crop loss from the Spatial Hazard Losses and Events Database.
- [As a note, I think maybe we mean "intensity of the hurricane along its path" rather than "intensity of hurricane's path"]
- [For the Spatial Hazard Losses and Events Database, could you add some details on that? Is that a database these authors created, or is it something publicly available? You could check the reference they use for this database.]
- [Based on a comment later, the spatial scale was at the county level. It looks like this is the finest resolution they have for each respondent, so you wouldn't need more resolved exposure measuments in this case.]
- [Did they use a continuous metric for exposure, or just separate into exposed / unexposed based on these damage / losses values in the database?]

Exposure

- "Individual exposure to Hurricane Katrina and/or Rita was determined by information on the temporal and spatial coordinates of each hurricane event, the date a respondent was interviewed by the CDC, and the respondent's place of county residence, as reported in the CDC's Behavioral Risk Factor Surveillance System (BRFSS) database" (Zahran et al. 2011)
- [Could you clarify for this exposure assessment? Based on one of the previous comments, they used damages data, but this is sounding like they used how close a county was to the track. Maybe they first used distance to the storm to determine exposed / unexposed and then used damages data to further distinguish how hard-hit each county was or something?]
- Number of poor mental healthd days expected to have spikes corresponding to hurricane events in affected but not unaffected areas with respect to hurricane exposure.
- [To clarify, did they use the same time period, but compare by location to compare exposed to unexposed? (so, in other words, instead of comparing one county over time they compared across counties?). If so, I think we definitely want to try to pull some more details on how they determined a county was exposed to the storm.]

Results/Outcomes

- Outcome of interest was mental health resilience of Hurricane Katrina and Rita survivors, stratified by vulnerability status. Number of poor mental health days used as metric for this.
- Vulnerability status measured by poor physical health, social support, education level, income, and being a single mother.
- Single mothers were identified as a particular vulnerability category of interest
- "Resistance refers to the capacity to limit displacement from equilibrium following a traumatic event. Resilience, by contrast, points to the ability to return to an equilibrium state—the more rapid the return to preevent functioning, the greater the resilience." (Zahran et al. 2011)
- Average number of poor mental health days in 30 was 3.37 for the population as a whole, and 5.95 for single mothers.
- Overall, hurricane exposed single mothers and exposed "others" all experienced an increased number of days of poor mental health.
- "We estimate that single mothers, as a group, suffered over $130 million in productivity loss from added postdisaster stress and disability." (Zahran et al. 2011)

(Zahran, Tavani, and Weiler 2013)

This study investigates ...

Temporal Scale

- [Are these recorded by date, or is there an event-wide estimate of total casualties that's used? Do they have a date for each disaster, or just the month or year?]

Spatial Scale

- Casualty counts are recorded at the county level in counties affected by either hurricanes or tornados.
- [So it sounds like this study has outcome data aggregated at the county level for the spatial level.]

Exposure

- "In the event of a natural disaster,people living in affected areas suffer both income and wealth losses. Wealth losses typically involve damage to residential or commercial property, whereas income losses involve lost wages, profits, dividends, and rents in consequence of the disaster." (Zahran, Tavani, and Weiler 2013)
- [It looks like they are looking at the level of county. How have they decided if a county is exposed to a hurricane? Are they using a disaster database that lists each disaster event for each county? Or did they pair up with hurricane tracks or something?]

Results/Outcomes

- Dependent variables analyzed are hurricane casualties and tornado casualties.
- [Are these only the casualties that were specifically linked to the disaster, or does it measure the total increase in excess deaths during the period of the disaster?]
- Predictor variables are disaster damage, recency bias, and day of the week.
- "Recency bias is a binary variable measuring whether or not a county was visited by a hazard event causing $1 billion of damage 12 months prior."(Zahran, Tavani, and Weiler 2013)
- [Where are they getting the disaster damage estimates?]

(Nordhaus 2010)

This study investigates patterns in exposure to and damages from tropical cyclones in the US [have I summarized this study correctly?].

Temporal Scale

- Annual number of tropical cyclones from 1970 to 2004 averaged at 85.
- Reliable data on the number of tropical cyclones has only been collected since 1960, so it is hard to accurately gage if the average number of tropical cyclones per year is increasing.
- "Using "best track'' or HURDAT data for North Atlantic storms, there has been a clear increase in the frequency of storms over the 1851–2005 period, particularly since 1980."
- [Are they just using total counts of storms per year? Or are they looking at specific storms? This would help us figure out the time resolution, and whether it would make sense as yearly or cumulative for the storm.]

Spatial Scale

- Study focues on tropical cyclones in the North Atlantic, focusing on the East Coast of the United States
- [Do they measure patterns by county or state? Or are they really pooling everything together to just have one measure across the whole east coast?]

Exposure

- Storm intensity is measured by something called "Hurricane Power" which is defined as a function of maximum wind speed squared or cubed [This is measured separately for each storm, right?]
- "NOAA has constructed a power index called the accumulated cyclone energy (ACE) index, which is a function of maximum wind speed squared." [nordhaus2010economics]
- This study analyzes economics impacts by looking at three primary factors: number of storms, maximum wind speed at landfall, and GDP.
- [Is this number of storms per year? How do they aggregate the maximum wind speeds across storms, if they're using both the number of storms and the maximum wind speed?]

Results/Outcomes

- Southern Atlantic coast is most vulnerable to hurricanes in the context of climate echange
- Damages appear to increase to the ninth degree of wind speed.
- [Where do they get their data on economic impacts / damages? Are they calculating this themselves or getting it from a database that's already been created? If they're calculating it themselves, what are the inputs?]
- It is estimated that climate change will increase the intensity of hurricanes and tropical cyclones, but it isn't clear if it will also increase the frequency.
- Based on 2005 incomes, it is estimated that average annual US hurricane damages will increase by $10 billion.

(Gaddis et al. 2007)

Temporal Scale

- Built capital recovery is typically measured in the short term because it is limited by available human labor and construction materials, whereas natural capital recovery may take much longer because it is often limited by natural processes.
- Standard discount rate may be appropriate for built capital stocks but it is inappropriate to apply it to social, human, and natural capital stocks.
- [For this study, do they have damages / economic data that they're using? If so, what is the time scale? For example, do they have one measurement per storm, or maybe are they using data that's collected every year?]

Spatial Scale

- Full cost accounting of damages after hurricanes must look at regional, national and international scales since communities and areas not affected by the direct results of the tropical cyclone or hurricane may still be impacted economically.
- It was noted that some regions benefit economically from storms, for example areas surrounding New Orleans saw their property values go up because of people trying to leave the New Orleans area.
- [If this is a quantitative scale (rather than a commentary or something), do they have data on damages that they're looking at? In that case, do they have those numbers by state or by county or by some other aggregation? This is what we'd want to list for the spatial scale here.]

Exposure

- Economic damage in the form of built capital, human capital, natural capital, and social capital. [How do they get these values? Do they have a database of damages specifically from tropical cyclones? Or are they pairing up economic data from some other source with tropical cyclone dates and places?]

Results/Outcomes

- Current policies that incentivize settling in vulnerable coastal areas should be replaced with policies that encourage populating the interior of the country which is experiencing negative population growth.
-

(Narita, Tol, and Anthoff 2009)

Temporal Scale

- Model runs from the years 1950 (1950 to 2000 used for model calibration) to 3000
- [For this study, I think we're also interested in figuring out what data they used to make the model that they ultimately use for future damages. To project out, they must have some estimate of the relationship between damage and tropical cyclones today, and then they're using that estimated relationship to project damages in the future. In that case, how did they build their model of the relationship between tropical cyclones and damages? Did they use observed data from previous years? If so, did they have damage estimates by storm, or by year, or at some other time scale? We'll want to know that to answer the "temporal" scale question for this paper (and similarly the spatial scale to answer the "spatial" question—in other words, if they had data from the past that they used to estimate this association, was it by country or by state or by county or at some other aggregation?]

Spatial Scale

- Globe divided into 16 regions to test scenarios.
- [Are these regions the level that the data was collected and used to build the present-day damages model, though?]

Exposure

- FUND version 3.4 used to analyze climate change impacts attributable to enhancement of tropical cyclone activity
- "Essentially, FUND is a model that calculates damage caused by climate change for 16 regions of the world listed in Table 1 by making use of exogenous scenarios of socioeconomic variables. The scenarios comprise projected temporal profiles of population growth, economic growth, autonomous energy efficiency improvements and carbon efficiency improvements (decarbonization), emissions of carbon dioxide from land use change, and emissions of methane and of nitrous oxide. Carbon dioxide emissions from fossil fuel combustion are computed endogenously on the basis of the Kaya identity. The calculated impacts of climate change perturb the default paths of population and economic outputs corresponding to the exogenous scenarios. The model runs from the years 1950 to 3000 in time steps of a year, though the outputs for the 1950 to 2000 period is only used for calibration, and the years beyond 2100 are used for approximating the social cost of carbon under low discount rates, a matter that does not concern us in this paper."(Narita, Tol, and Anthoff 2009)

Results/Outcomes

- Direct economic damages to the USA calculated to almost USD $19 billion annually.

(Pistrika and Jonkman 2010)

Temporal Scale

-

Spatial Scale

- Greater New Orleans metropolitan area was studied. The area was divided into three sections based on "bowls" aka polders.
- [Can we find out a little bit more about what these "bowls" are? I assume that they have some geographic definition? This is really interesting—it looks like we have a new spatial scale that's different from county or ZIP code and is based more on something that's meaningful for flooding.]
- [How do these bowls compare to neighborhoods? Would you have several neighborhoods in one, or are they smaller than a neighborhood?]

Exposure

- Hydrodynamic flood simulations used to analyze relationship between flood characteristics and damage to buildings.
- [In other words, it sounds like they had some model of flooding that they could use to simulate floods, and then did they compare those outputs to the actual data that was observed after a specific storm to buildings? Or is this study purely a simulation study? If it's only a simulation study, we probably won't include it, because our focus is more on helping to connect observations from a storm with human impacts studies, and if it was just a simulation study, it wouldn't need observations as inputs, I don't think.]
- Momentum = mass x velocity = density x volume x velocity => Momentum = density x flooded horizontal area x (depth x velocity)
- Characteristics of the flood (load/flood action) and building resistance and are used to predict the structural damage. This then is used to analyze and predict the economic damage by looking at the total replacement cost and the building's market cost prior to the disaster.

Results/Outcome

- Outcome of interest is direct damage to residential buildings in New Orleans caused by flooding after Hurricane Katrina [Hmmm. Again, it would be helpful to clarify here if they were using real data on the damage observed to buildings after that storm?]
- "The spatial level of detail of the analysis is a determining factor for the correlation between predictions and observations. The smaller the spatial unit of the analysis the poorer the relationship between flood characteristics and damage." (Pistrika and Jonkman 2010)
- "The highest damage percentages and structural damage mainly occurred in areas where higher flow velocities occurred, especially near the breaches in the Lower 9th Ward neighborhood. Due to the approach that was used for damage quantification, buildings that sustained structural damage, had damage levels higher than 50% of their market value." (Pistrika and Jonkman 2010)
- "An alternative approach has been proposed that could be used to distinguish three different damage zones based on the combination of water depth and flow velocity. There appeared to be clear differences between the average, observed damage values in the three zones. This approach could be useful to determine the extent of flood damage and distinguish the main damage zones for an area affected by flooding due to breaching of flood defenses." (Pistrika and Jonkman 2010)
- [Again, can you tell if they were using *observations* about the water depth and flow velocity during Hurricane Katrina for this analysis, or did they just simulate what they expected those to be, based on some flood simulation model, rather than use real observations? If they used real observations, then I think we need to find out a bit more about how they got those. Did they put out their own sensors to collect it? Or were they using data from the USGS, for example?]

(Xian, Lin, and Hatzikyriakou 2015)

FEMA's flood risk mapping techniques are tested against a survey quantitatively assessing the damage to 380 structures in Ortley Beach, New Jersey, after Hurricane Sandy in 2012.

Temporal Scale

- Damage was surveyed in the aftermath of Hurricane Sandy

Spatial Scale

- 380 structures in a heavily affected area of Ortley Beach

Exposure

- "we quantitatively measure the damage percentage for each of the significant building components (foundation, exterior walls, wall siding, windows, doors, roof, and roof cover). Moreover, we assess the damage percentage to each component at each story and each side of a structure. The survey indicates that different sides and stories of a structure suffered different levels of damage due to the different surge/wave effects." (Xian, Lin, and Hatzikyriakou 2015)
- Different factors were put in a database: Distance from the coast, ground elevation, elevation above ground, and year building was built.

Results/Outcome

- Overall, the side facing the ocean, and the first floor of a building were typically at a greater risk for damage than the other three sides and other floors.
- Buildings built after 1979 tended to withstand damage from the hurricanes greater than buildings built before this year.

(Willison et al. 2019)

Quantifying the US federal response and resulting inequality in Texas and Florida versus Puerto Rico. Hurricanes Irma, Harvey, and Maria are all analyzed.

Temporal Scale

- Analysis spans landfall to six months after each hurricane, in this case Harvey, Irma, and Maria.

Spatial Scale

- Florida, Texas, and Puerto Rico were all analyzed at the state/territory level.

Exposure

- "To examine differences in disaster responses across the three hurricanes, we focus on measures of federal spending, federal resources distributed and direct and indirect storm-mortality counts. Federal spending estimates come from congressional appropriations and FEMA records. Resource estimates come from FEMA documents and news releases. Mortality counts come from National Oceanographic and Atmospheric Administration (NOAA) reports, respective vital statistics offices and news reports. Damage estimates came from NOAA reports. In each case, we compare the responses and the severity at critical time points after the storm." (Willison et al. 2019)

Results/Outcome

- "Our results show that the federal response was faster and more generous across measures of money and staffing to Hurricanes Harvey and Irma in Texas and Florida, compared with Hurricane Maria in Puerto Rico. This result would be unsurprising if Hurricane Maria was less damaging than Irma and Harvey. However, Hurricanes Harvey and Irma made landfall as category four hurricanes,1 5 and Maria hit Puerto Rico as a 'high-end' category 4, or just below the threshold of a category 5 hurricane.6

Maria caused more damage in Puerto Rico than Irma in Florida or Harvey in Texas in terms of loss of electricity and housing destruction,1 5 6 with overall damage estimates comparable to Harvey, and greater than estimates for Irma.1 Assuming that infrastructure costs are higher in Texas and Florida, and therefore more expensive to repair, compared with Puerto Rico, the high damage estimates in Puerto Rico emphasise the severity of storm damage." (Willison et al. 2019)

(Xian et al. 2018)

Hydrodynamic storm surge and wave modeling was coupled with rapid damage surveying in the Florida Keys to assess physical damage.

Temporal Scale

- Field surveys were carried out September 21-24 soon after Hurricane Irma (September 10 is when it made landfall).
- Rapid survey method involved driving at a speed of 10 mph throughout affected areas and taking GPS informed pictures from the rear side windows.

Spatial Scale

- Big Pine Key and Marathon are the two survey locations in the Florida Keys, they were the two areas that were most affected by the hurricane.
- Over 1600 residential buildings were surveyed using the rapid survey method.

Exposure

- After conducting a damage and assessment survey after Hurricane Irma, a statistical regression approach is used to quantify the contribution of various hazard and vulnerability factors.
- "To understand the hazard and inform the field survey, we first use the coupled hydrodynamic and 41 wave model ADCIRC+SWAN (Dietrich et al. 2012, Marsooli and Lin 2017) to simulate the 42 storm tide (i.e., water level) and wave height for Hurricane Irma. To simulate Irma's storm tide 43 and wave (Figure 1), we apply the surface wind (at 10-m) and sea-level pressure fields from 44 National Center for Environmental Prediction Final (NCEP FNL) operational global analysis data (0.25o x 0.25o 45 x 6 hours)." (Xian et al. 2018)
- The collected photos and satellite images are used to categorize damage state for each residential building surveyed.
- FEMA's damage state criteria that were used in Hurricane Sandy are used to categorize and assess the damage in Big Pine Key and Marathon, and include the categories No/very limited damage; Minor damage; Minor damage; and Destroyed.

Results/Outcome

- Hydrodynamic forces induced by storm surges and waves were the primary cause of destroyed and heaviliy damaged buildings.
- Observed storm surge damage is consistent with the hydrodynamic models.
- Analysis on Big Pine Key revealed that distance from the coastline was the most significant predictor for damage state
- On Marathon, building type and size were the two main predictors.

(Shao et al. 2017)

This study focuses on the effects of external influences and perceptions of flood risk on individual's behavior relating to purchasing flooding insurance. Flood insurance ownership rates are relatively low and despite

the fact that home owners in Special Flood Hazard Areas are required to buy flood insurance if they are receiving a mortgage from a federally backed or regulated lender, the law is not heavily enforced.

Temporal Scale

- Individual levels variables constructed from data collected in 2012 Gulf Coast Climate Change Study
- Data collected by phone interviews from January 3rd through April 4, 2012.

Spatial Scale

- State level
- Stratified random sampling strategy drew independent samples in Texas, Louisiana, Mississippi, Alabama, and Florida.
- Contextual variables pertaining to flooding risk taken at the county level in these states.

Exposure

- 3856 respondants, response rate was 17.6%

Dependent Variables

- "The two dependent variables are based on responses to two survey questions. The two questions are 'do you haveflood insurance?' and 'do you have flood insurance to feel safer or because it is required?' " (Shao et al. 2017)

Independent Variables

- "The individual-level independent variables, including socio-demographic features, home ownership, distance from the coast(self-reported), trust in the local government and flood-related risk perceptions, are all constructed based on survey items." (Shao et al. 2017)
- "The contextual variables include spatial information about flood hazards estimated by FEMA, peak height of storm surge from the most recent hurricane landfall, and economic damages from the most recent and most impacted flooding events, respectively. They are all at county-level"

Results/Outcome

- People from racial minorities were more likely to buy flood insurance voluntarily than whites when controlling for other variables, perhaps reflecting that whites perceive less risk than minorities.
- People of higher socioeconomic status (both higher levels of education and income) were more likely to buy flood insurance.
- A perception that flooding and storm intensity is increasing also made coastal residents more likely to buy flood insurance.
- The other major factors in predicting whether or not a resident would buy flood insurance were self reported distance from the coast, and belief in local government's preparedness to address climate change.

(Xian, Lin, and Kunreuther 2017)

This paper is about creating an economically optimal elevation level (OEL), because it is more economical to use this rather than 1 foot above base flood elevation (BSE). "Under the regulations of both ASCE 242 and NFIP, FEMA requires coastal houses with repetitive losses and/or substantial damage from flood events to be elevated to at least 1 foot above the BFE and recommends all houses in SFHA to be elevated to this level (FEMA, 2011). However,this requirement/recommendation does not provide guidance for home owners about how many feet exactly their houses should be raised to."(Xian, Lin, and Kunreuther 2017)

Temporal Scale

- "The house information data used in this study, including location, ground elevation, house size, and house value, were collected by a team of students and faculty from University of Notre Dame and Princeton University in an onsite survey three weeks after Sandy." (Xian, Lin, and Kunreuther 2017)

Spatial Scale

- Three actual houses in Ortley Beach, New Jersey were used to test the OEL model.

Exposure

- "We propose that an economically optimal elevation level (OEL)for coastal houses can be estimated through a cost-benefit analysis(CBA). Specifically, the OEL can be calculated as the level that minimizes the sum of the upfront elevation cost and present value of cumulative annual expected losses over the lifespan of a house."(Xian, Lin, and Kunreuther 2017)

Results/Outcome

- About half of the houses at Ortley Beach would save 10,000 dollars per structure if elevated to OELs instead of 1-foot freeboard, and about 5% of the houses could save up to 100,000 dollars.

(Deryugina, Kawano, and Levitt 2018)

Temporal Scale

- Data taken from individual Federal tax returns and third party information returns filed between 1999 and 2013.

Spatial Scale

- City of New Orleans, Louisiana is the focus of the study and New Orleans residents were identified as those with a New Orleans zip code on their tax return or on their W2 form.
- Cities with similar characteristics to Louisiana are compared, with three pre-Katrina dimensions: median earnings, population growth rate, and percentage of the population that is black. These cities were Baltimore, MD, Birmingham, AL, Detroit, MI, Gary, IN, Jackson, MS, Memphis, TN, Newark, NJ, Portsmouth, VA, Richmond, VA, and St. Louis, MO.

Exposure

- "We explore five key dimensions across which one might expect the economic impact of the hurricane to be heterogeneous: whether a household's own home was severely affected by the storm, pre-Katrina income, age, homeownership, and whether the household left New Orleans." (Deryugina, Kawano, and Levitt 2018)

Results/Outcomes

- After a few years, the income of New Orleans residents affected by Hurricane Katrina actually recovered and surpassed that of controls in other cities.

(Shao et al. 2017)

This is a different article than the other one with the name shao2017understanding. This one is about perception of increasing hurricane strengths in the Gulf States.

Temporal Scale

- Individual levels variables constructed from data collected in 2012 Gulf Coast Climate Change Study
- Data collected by phone interviews from January 3rd through April 4, 2012.
- Previous hurricanes that made landfall were used from the past 20 year period of 1992 to 2011.

Spatial Scale

- State level
- Stratified random sampling strategy drew independent samples in Texas, Louisiana, Mississippi, Alabama, and Florida.
- Respondants had to have lived in coastal counties with at least one hurricane landfall between 1992 and 2011. (The reasoning is that hurricanes don't often occur at a single location, and human memory is short so anything past 20 years wouldn't be accurate).

Exposure

- Spatial pattern of perception of increasing hurricane strength is mapped and used as the dependent variable.
- Hurricane strength is measured by maximum windspeed at landfall, storm surge, and economic damage.

Results/Outcomes

- Outcome of interest is coastal residents' perceptions of increased hurricane strength. Intensity of past hurricanes, physical characteristics like wind speed, consequences such as economic damage, and people's opinions of climate change are the four factors that are framed as research questions to see how they affect this perception of increased hurricane strength.
- Perceptions of increasing hurricane strength are stronger in Louisiana and Mississippi, likely because of memory of Hurricane Katrina, and less strong moving away from this epicenter into the Gulf Coasts of Texas and Florida.

(Grech and Scherb 2015)

This study looked at whether or not Hurricane Katrina had an influence on the male/female ratio of births in the Gulf states.

Temporal Scale

- January 2003 to December 2012 was the time frame from which live birth data was collected and analyzed.
- Precipitation data was collected from the US National Weather Service and in this study a precipitation map is presented from August 29 to September 1, 2005.

Spatial Scale

- State level
- Data on monthly male and female live births were obtained from the CDC's website for the states of Alabama, Florida, Louisiana, and Mississippi.

Exposure

- In this study, precipitation mainly in the form of rainfall was the metric for assessing hurricane exposure.

Results/Outcomes

- A dose-response relationship was observed between rainfall and the male to female sex ratio of live births 8 to 10 months later.

- " 8–10 months (April to June 2006) after the hurricane, M/F jumped significantly from 1.052 to 1.071 with a SOR of 1.018 " (Grech and Scherb 2015)

(Yan et al. 2020)

Multi-year, multi-state study that estimated relative risks of storm exposures on community health outcomes like mortality and Medicare hospitalizations.

Temporal Scale

Medicare claims come from the county level.

Spatial Scale

Days. "For each combination of exposure metric and health outcome, we estimated storm-associated health risks for a window from two days before to seven days after the day of storm's closest approach." (**yan2019tropical?**)

Exposure

Exposure was defined with five metrics: distance to storm track, cumulative rainfall, maximun sustained wind speed, flooding, and tornadoes.

Outcome

The outcome of interest was hospitalizations for cardiovascular or respiratory health effects.

(Parks et al. 2021)

This study looked at tropical cyclone exposure and the association with hospitilizations rates in older adults.

Temporal Scale

Day. Association between tropical cyclone exposure up to 7 days after the day of exposure.

Spatial Scale

County level.

Exposure

Exposure assigned to a particular day if the peak sustained wind that day exceeded a gale force greater than or equal to 34 knots on the Beaufort scale when the cyclone was at the point of closest approach to the county.

Outcome

The highest increase in hospitalizations after exposure to the tropical cyclones was due to respiratory illnesses. This occured across all seven days after exposure (23%), but peaked after the first day. Injury hospitalizations also increased all seven days, peaking on the second day at 13.5%.

Implications

Exposure misclassification is likely a possibility, as patients were assigned exposure based on their county of residence even though this may not be the county they were in when the cyclone hit. This misclassification is expected to be non-differential bringing the association towards the null, as correlation with the outcome is unlikely.

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