Technical Note

Measuring the Storm: Methods of Quantifying Hurricane Exposure with Pregnancy Outcomes

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Abstract: Increasing coastal populations and storm intensity may lead to more adverse health effects from tropical storms and hurricanes. Exposure during pregnancy can influence birth outcomes through mechanisms related to healthcare, infrastructure disruption, stress, nutrition, and injury. However, accurate estimation of health effects may be limited by nonspecific exposure definitions that create potential misclassification. The two predominant hurricane exposure assignments are (1) the county of a FEMA presidential disaster declaration; and (2) the specified area within a storm track. The authors propose a third method: meteorological severity of wind speed. Based on the Saffir-Simpson categories, wind speed was examined through binary and quartile comparisons. All three methods of exposure classification were compared by examining the associations with county-level preterm birth and low-birth-weight rates among Florida women who were pregnant during the 2004 hurricane season. The county-level environmental quality index developed by the EPA was used to control for county-level environmental factors. Although the models yielded unexpected negative results and insignificant rate differences, a descriptive and mapping analysis of the exposure methods showed clear heterogeneity of county exposure. **DOI: 10.1061/(ASCE)NH.1527-6996.0000204.** © *2015 American Society of Civil Engineers.*

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Background

The effects of natural disasters and related losses have grown with increasing populations in vulnerable areas and with severity of large-scale disasters (Van Aalst 2006). Specifically, future vulnerability to hurricanes is influenced by coastal population growth, urbanization, and global climate change. The Atlantic and Gulf coasts of the United States, where hurricanes most often make landfall, are home to over 50% of the nation's population, and projected to exceed 55% by 2015 (Adamo and de Sherbinin 2011). This population vulnerability is likely to lead to an increase in the health effects resulting from tropical storms and hurricanes. Potential health effects include mortality, injury, economic distress, psychosocial stress, and disruption of healthcare (Shultz et al. 2005). Vulnerable populations, including pregnant women, may be disproportionately affected by hurricane-related health effects. Hormone fluctuation during pregnancy may influence stress reactions around hurricane occurrence, and potential lapses in access to healthcare could greatly affect reproductive outcomes (Mulder et al. 2002; Xiong et al. 2008; Zahran et al. 2010).

The exposure definitions used in hurricane-related health research vary greatly across published studies (Duff and Cooper 1994; Guill and Shandera 2001; Cohan and Cole 2002; Shultz et al. 2005; Xiong et al. 2008; Zandbergen 2009; Badakhsh et al. 2010; Zahran et al. 2010; Currie and Rossin-Slater 2013). The current disaster literature focuses primarily on two methods of assigning disaster exposure: (1) FEMA presidential disaster declarations (Zahran et al. 2010; McCarthy 2011; Doocy et al. 2013a, b, c); and (2) spatial data on the specific storm track trajectory (Currie and Rossin-Slater 2013). The authors demonstrate a novel method of using meteorological data to define exposure to hurricanes, to accurately understand the health effects of hurricanes.

Methods

Hurricane Exposure Measurement

Three different methods used to assess hurricane disaster exposure were considered: (1) FEMA presidential disaster declarations (McCarthy 2011); (2) exposure using spatial data on the specific storm trajectory (Powell et al. 1998); and (3) a novel meteorological measure based on the Saffir-Simpson hurricane intensity scale.

The data on declarations were extracted from FEMA presidentially declared disaster archives (McCarthy 2011). Exposure is defined by federal aid released in a county for a given disaster event. The spatial storm trajectory method uses the maps of inland storm tracks and applies a symmetrical buffer to identify the affected areas. Historical track data were derived from the National Oceanic and Atmospheric Association's (NOAA) Atlantic hurricane database in the form of geographic points and lines, which were imported into *ArcMap 10* geographic information system (GIS) software (Demuth et al. 2004, 2006). Current literature using spatial methods applies several buffer distances, ranging from 30 to 100 km, to categorize the potential exposure (Zahran et al. 2010;

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Currie and Rossin-Slater 2013). The eye of a major storm is typically 30 to 60 km wide and surrounded by the strongest winds (Weatherford and Gray 1988). Both disaster declarations and storm trajectory data may induce misclassification of exposure. Disaster declarations are not intended for research, but rather for the provision of disaster assistance; moreover, hurricane force and damage is generally not symmetrical around the storm track, with maximum weather effects of hurricanes generally in the right-front quadrant, often northeast of the hurricane.

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. Details of the data collection and the HRD real-time hurricane wind analysis system have been published elsewhere (Powell et al. 1998). The authors used wind-speed cutoffs as defined by the Saffir-Simpson hurricane scale to explore a quantitative and reproducible method of assigning hurricane exposure based on widely accepted thresholds of hurricane wind effects. The Saffir-Simpson hurricane wind scale categorizes hurricanes into five distinct categories of severity: Category 1 [119–153 km/h (74–95 mi/h)], 2 [154–177 km/h (96–110 mi/h)], 3 [178–208 km/h (111–129 mi/h)], 4 [209–251 km/h (130–156 mi/h)], and 5 [252 km/h and higher km/h (157 and higher mi/h)] (Simpson and Saffir 1974). Tropical storm wind speeds are classified as 63–118 km/h (39–73 mi/h).

2004 Hurricane Season Study Population

The three exposure methods were compared using reproductive health data from 2004, the most active hurricane season in Florida history (Smith and McCarty 2009). Fig. 1 displays the hurricane tracks of storms that made landfall in Florida during 2004.

Using the 2004 hurricane season allows the investigation of several different exposure methods across four hurricanes in a single year. In 2004, four hurricanes made landfall in Florida: Charley (August 13, strongest of the season), Frances (September 5), Ivan (September 21), and Jeanne (September 25).

Mapping and Analysis

To compare the three exposure methods, descriptive and mapping comparisons were made. The authors also assessed the three exposure methods in relation to several reproductive health outcomes using Florida birth certificate data. The authors compared eight exposure contrasts for each of the 2004 hurricanes: FEMA disaster declaration, three symmetrical spatial buffers (30, 60, and 100 km), and four meteorological maximum wind-speed methods {continuous, categorical (based on the Saffir-Simpson wind scale), and two binaries [>63 and 119 km/h (>39 and 74 mi/h)] of maximum wind speed} (Table 1). Each exposure method was first contrasted visually using *ArcMap 10* and then descriptively by comparing the number of exposed counties and calculating the percent differences.

To further contrast the exposure methods modeled, hurricane exposure was modeled with several reproductive health indicators, including county preterm-birth and low-birth-weight rates. The authors used county-level Vital Statistics data obtained from the Florida Department of Health to calculate county-specific rates of low 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.

The authors focused on reproductive health indicators, as previous studies have shown how pregnant women and fetuses may be disproportionality vulnerable to disruptions in healthcare, psychosocial stresses, and injury and mortality during hurricane exposure (Harville et al. 2010). Preterm-birth babies are live births born after 20 weeks completed gestation and before 37 weeks completed gestation. Low-birth-weight babies are live births born after 20 weeks completed gestation and weighing less than 2,500 g (5.5 lbs) (Abrams and Newman 1991; Engle 2006).

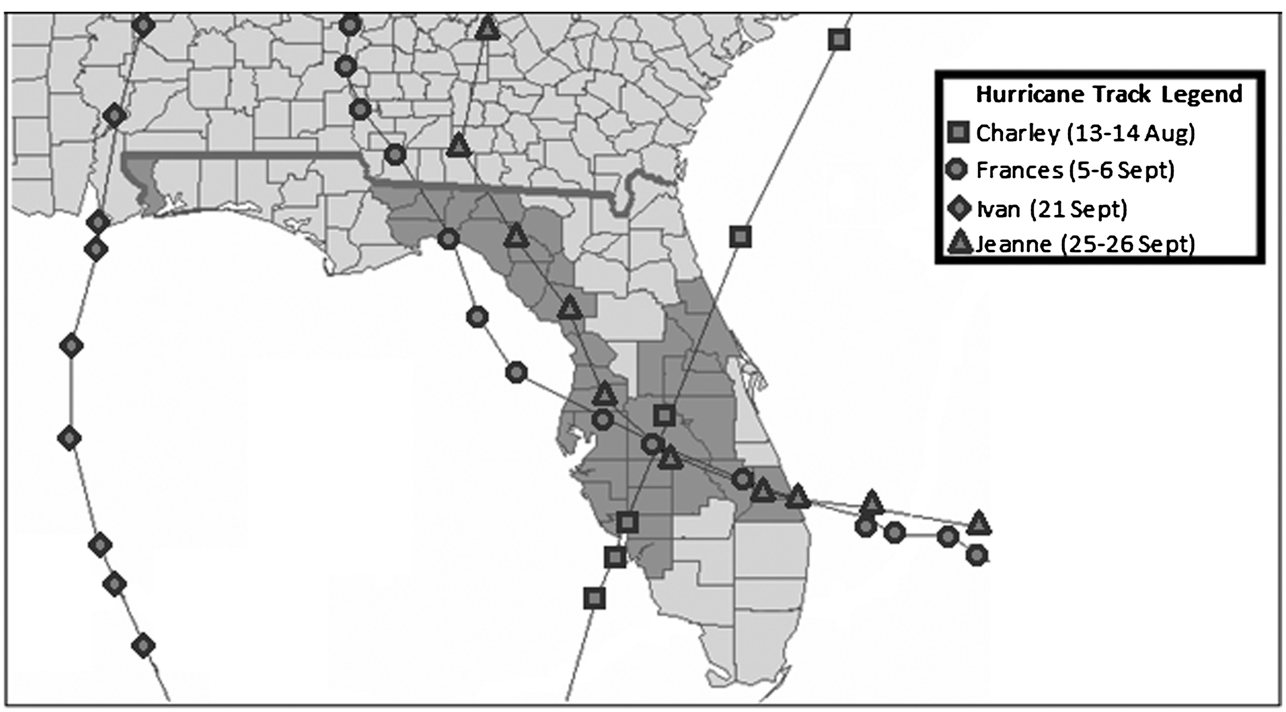


Fig. 1. 2004 Florida hurricane track county map (exposed areas highlighted)

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 Binary classification with exposed counties within 60 km of storm track Binary classification with exposed counties within 100 km of storm track	Classification determined when the county boundary touched within the symmetrical buffer distance; then a given county would be considered exposed
Maximum wind speed	
Continuous measure of maximum wind speed in kilometers per hour 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)	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)]

The authors modeled county-level hurricane exposure and county-level preterm-birth and low-birth-weight rates using linear models. Both preterm birth and low birth weight are indicators of poorer health; therefore, the authors hypothesized a positive association between increasing hurricane exposure and each reproductive health outcome. County-level rates were calculated using the mother's primary residence as indicated on the Vital Statistics records. Exclusions included all Florida births in which the mothers' primary residences were outside of Florida, in addition to births <20 weeks completed gestation, as these are not generally recorded in Vital Statistics records and are not properly captured in birth records. Preterm-birth rates were calculated as the number of county preterm births (births less than 37 weeks completed gestation) divided by the total number of county live births multiplied by 100. Similarly, low-birth-weight rates were calculated as the number of county low-birth-weight births [births less than 2,500 g (5.5 lbs)] divided by the total number of county live births multiplied by 100.

To adjust for county-level differences in both population and environmental characteristics, the authors applied the county-level environmental quality index (EQI) developed by the EPA (Messer et al. 2014). The EQI includes variables encompassing five environmental domains: air, water, land, sociodemographic, and built environment. Crude and adjusted estimates were compared to adjust for potential confounding by social and environmental factors. All analyses were conducted in *SAS Version 9.2*. This research was approved by the Florida Department of Health Institutional Review Board (IRB) (No. H13049) and the IRB of the University of North Carolina at Chapel Hill (No. 13-0784).

Results

Descriptive Results

Table 2 provides the number of Florida counties classified as exposed to hurricanes using each of the described methods. Each method yielded a different number of exposed counties. The disaster declaration method consistently assigned a higher number of counties exposed. For example for Hurricane Ivan, the disaster declaration method identified 44 exposed counties, whereas the other methods yielded 11 counties or fewer, a 120% difference in exposed counties.

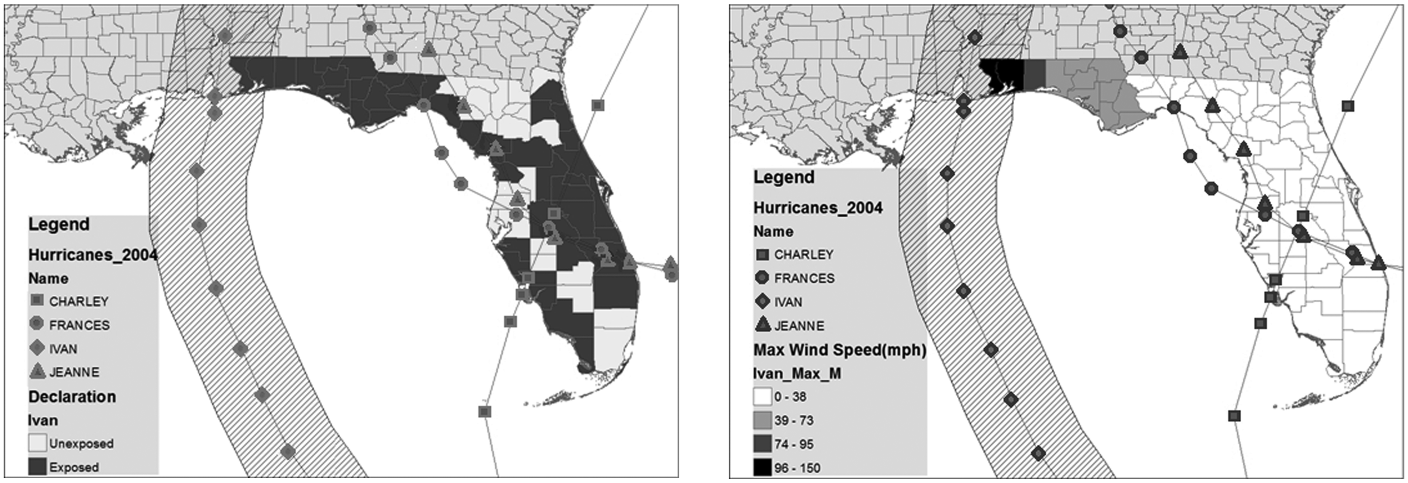
The geographic spatial buffer exposure method yielded different results than either the disaster declaration method or the binary maximum wind-speed-exposure classifications. For all hurricanes except Hurricane Ivan, the 60 and 100-km buffer identified a similar number of counties as the binary 63-km/h (39-mi/h) wind-speed 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.

Maps were generated to visually compare the number of counties designated as exposed using each exposure method. For example, Figs. 2(a and b) show comparisons of Hurricane Ivan based on the 100-km buffer around Ivan's storm track, which iden-

Table 2. Number of Counties Exposed by the Hurricane according to Exposure Method

Exposure method	Charley	Frances	Ivan	Jeanne	All 4 hurricanes
Disaster declaration	26	66	44	52	66
30-km buffer	16	19	1	27	38
60-km buffer	23	36	2	37	43
100-km buffer	32	47	2	47	47
Maximum wind speed$_{(\text{continuous})}$[a]	220 km/h (137 mi/h)	165 km/h (102 mi/h)	167 km/h (104 mi/h)	171 km/h (106 mi/h)	220 km/h (137 mi/h)
Saffir-Simpson$_{(\text{four categories})}$[b]	3	2	1	3	14
Wind speed ≥ 63 km/h$_{(\text{binary})}$ (39 mi/h$_{(\text{binary})}$)	26	54	11	35	63
Wind speed ≥ 119 km/h$_{(\text{binary})}$ (74 mi/h$_{(\text{binary})}$)	5	7	3	11	17

[a]For the maximum-wind-speed exposure method, the maximum wind speed over the 67 counties for each storm is displayed.
[b]For the Saffir-Simpson four-category method, the counties classified in the high category are displayed in the table.



(a) (b)

Fig. 2. Hurricane tracks for 2004 Hurricane Ivan (a) 100-km buffer and declaration exposure; (b) category 4 maximum wind-speed exposure

tifies two counties as exposed [Fig. 2(a)], and the four-category Saffir-Simpson categorization of exposure by maximum wind speed in the county [Fig. 2(b)]. Overall, the number of counties categorized as exposed using the 100-km buffer and maximum wind exposure methods were similar, whereas the disaster declaration method designated more counties as exposed, including many that were away from the storm track, and areas of highest maximum wind speed.

Statistical Results: Preterm Birth

Overall, the crude-point estimates between hurricane exposure and preterm births were negative, indicating a potential decrease in preterm birth rates with increasing hurricane exposure; however, most of these were not statistically significant. The results, including model estimates for exposure and corresponding p-values for significance ($p < 0.05$) for all analyses with exception to the 60-km spatial buffer (similar to the 100-km buffer), are given in Table 3.

The models were adjusted for county-level environmental and sociodemographic characteristics using the EQI. In 30 of 40 models, the addition of the EQI adjusted the model in the expected direction (more positive association), indicating that a portion of the unexpected directionality may be the result of county-level population differences. Overall, in adjusted models, the association between hurricane exposure and the county's preterm birth rate was found to be negative, with the exception of Hurricane Ivan.

Across the eight potential exposure methods, the relationship between exposure and preterm birth rates was unexpectedly negative for all hurricanes except Hurricane Ivan. Of all exposure methods, only the continuous measure of maximum hurricane wind speed of Hurricane Ivan was statistically significant and positively associated with preterm birth (0.03, $p = 0.04$). However, the continuous maximum wind speed exposure method yielded significant negative associations for the other three hurricanes. The association between the disaster declaration method of exposure classification and preterm birth was inconsistent and insignificant across all hurricanes. Overall, none of the exposure methods were consistently associated with preterm birth.

Statistical Results: Low Birth Weight

Similar to the analysis of preterm birth rates, the overall association between hurricane exposure and low birth weight was negative, indicating a decrease in low-birth-weight rates with increasing hurricane exposure. Most of these associations were not statistically significant. The model estimates for exposure and corresponding p-values for significance for all analyses (except the 60-km buffer) are provided in Table 4.

Table 3. Hurricane Exposure and Preterm Birth Rate Linear Models for All 67 Florida Counties

		Declaration		30 km		100 km		Maximum km/h		Saffir-Simpson		Binary > 79		Binary > 34	
Hurricane	Model	Estimate	p-value	Estimate	p-value	Estimate	p-value	Estimate	p-value	Estimate	p-value	Estimate	p-value	Estimate	p-value
Charley	Crude	−1.10	0.04	−1.32	0.03	−1.95	<0.001	−0.03	0.00	−0.76	0.03	−0.94	0.35	−1.4	0.007
	Adjusted	−0.88	0.09	−0.90	0.14	−1.67	0.002	−0.02	0.01	−0.64	0.05	−0.78	0.42	−1.15	0.03
Jeanne	Crude	−1.02	0.10	−0.40	0.45	−0.49	0.39	−0.03	<0.001	−1.08	<0.001	−1.75	0.01	−1.75	<0.001
	Adjusted	−0.85	0.16	−0.64	0.22	−0.48	0.38	−0.03	0.01	−0.91	0.003	−1.6	0.02	−1.42	<0.001
Ivan	Crude	−0.12	0.85	0.97	0.65	0.34	0.83	0.02	0.03	0.45	0.33	−0.54	0.67	1.12	0.11
	Adjusted	0.48	0.40	1.57	0.45	0.86	0.56	0.02	0.04	0.47	0.29	−0.06	0.96	0.96	0.16
Frances	Crude	−0.87	0.69	−0.85	0.14	−0.12	0.83	−0.05	0.00	−1.15	0.4	−1.48	0.08	−1.51	0.02
	Adjusted	−0.16	0.94	−0.7	0.21	−0.45	0.43	−0.04	0.01	−0.95	0.02	−0.98	0.25	−1.34	0.03
All hurricanes	Crude	−0.87	0.69	−0.48	0.08	−0.47	0.02	−0.02	<0.001	−0.58	<0.001	−1.62	0.006	−2.18	0.05
	Adjusted	−0.16	0.94	−0.48	0.06	−0.42	0.04	−0.02	0.005	−0.5	0.002	−1.42	0.01	−1.72	0.11

Note: All exposure methods are shown except the 60-km spatial buffer. Results were the similar to 100-km buffers. The adjusted models used the EQI to control for county-level environmental and sociodemographic characteristics.

Table 4. Hurricane Exposure and Low-Birth-Weight-Rate Linear Models for All 67 Florida Counties

Hurricane	Model	Declaration Estimate	Declaration p-value	30 km Estimate	30 km p-value	100 km Estimate	100 km p-value	Maximum km/h Estimate	Maximum km/h p-value	Saffir-Simpson Estimate	Saffir-Simpson p-value	Binary > 79 Estimate	Binary > 79 p-value	Binary > 34 Estimate	Binary > 34 p-value
Charley	Crude	−0.62	0.19	−0.31	0.57	−1.13	0.01	−0.02	0.05	−0.36	0.30	−0.08	0.93	−0.9	0.06
	Adjusted	−0.47	0.32	0.03	0.95	−0.9	0.06	−0.01	0.14	−0.27	0.37	0.03	0.97	−0.73	0.12
Jeanne	Crude	−0.33	0.56	−0.1	0.83	−0.1	0.84	−0.02	0.02	−0.69	0.01	−0.93	0.14	−1.16	0.01
	Adjusted	−0.21	0.7	−0.26	0.58	−0.09	0.86	−0.02	0.06	−0.56	0.05	−0.82	0.18	−0.94	0.06
Ivan	Crude	0.11	0.82	1.08	0.57	0.28	0.84	0.02	0.06	0.18	0.66	0.02	0.98	0.3	0.63
	Adjusted	0.53	0.29	1.48	0.43	0.64	0.63	0.02	0.09	0.19	0.63	0.35	0.75	0.19	0.76
Frances	Crude	0.12	0.95	−0.26	0.62	0.34	0.5	−0.03	0.03	−1.1	0.002	−1.1	0.14	−1.78	0.002
	Adjusted	0.61	0.75	−0.15	0.76	0.14	0.78	−0.02	0.11	−0.98	0.007	−0.77	0.31	−1.68	0.003
All	Crude	0.12	0.95	−0.1	0.67	−0.17	0.37	−0.01	0.03	−0.41	0.03	−0.6	0.26	−2.64	0.005
hurricanes	Adjusted	0.61	0.74	−0.08	0.75	−0.13	0.47	−0.007	0.12	−0.35	0.02	−0.46	0.38	−2.37	0.01

Note: All exposure methods are shown except the 60-km spatial buffer, which was removed for special allocation. Results were the similar to 100-km buffers. The adjusted models used the EQI to control for county-level environmental and sociodemographic characteristics.

After adjusting for environmental and sociodemographic characteristics using the EQI, the estimates of 32 out of 40 models adjusted in the expected direction (more positive association). This indicates that a portion of the unexpected directionality may be the result of county-level population differences. Overall, in most adjusted models the association between hurricane exposure and the county's low-birth-weight rate was found to be negative with exception to Hurricane Ivan.

Across the eight exposure methods, the associations with low-birth-weight rates were mostly negative. Hurricane Ivan was the exception, with positive associations with low birth weight across all eight exposure methods; however, none were statistically significant. Significant negative associations were found for Hurricane Frances when using both the four-category maximum wind-speed method and the binary >34 wind-speed method (-0.98, $p = 0.007$; and -1.68, $p = 0.003$, respectively).

Discussion

Descriptive analysis and mapping of three different exposure methods—FEMA disaster declaration, spatial data based on storm trajectory, and meteorological severity of wind speed—displayed clear heterogeneity of exposure assignment. The number of counties classified as exposed varied greatly among the methods, with the largest difference being Hurricane Ivan, which affected the far-western Florida panhandle. The disaster declaration method consistently assigned a higher number of counties as exposed to hurricanes, supporting the assertion that the use of this method, developed for providing federal assistance to affected jurisdiction, likely overassigns county-level hurricane exposure. The authors found no statistically significant associations between counties designated as exposed using the disaster declaration method and low-birth-weight infants and preterm-birth delivery. Although this could be the result of heterogeneity of exposure and limited statistical power, consistent null findings support the authors' hypothesis of exposure misclassification.

Using disaster declarations to classify exposure to disaster may overrepresent exposed areas, as declarations are not intended for research use, but rather for the provision of assistance. If the disaster declaration method misclassifies counties as exposed that do not have a high enough exposure to cause health effects, this would be considered exposure misclassification. Potential misclassification would likely mask the health effects of hurricane exposure by assigning some less-exposed populations as exposed, biasing the results toward the null. Given the descriptive and statistical findings, the authors believe that there is sufficient evidence that counties that are not as severely exposed are being assigned exposure, therefore yielding findings biased toward the null.

The spatial hurricane track with a symmetrical buffer-exposure method had more similar results to the novel maximum-wind-speed exposure method. Descriptively, maps of each storm showed that a similar number of counties were exposed. For example, exposure was similar for the 97-km/h (60-mi/h) buffer and the binary 63-km/h (39-mi/h) (tropical storm) wind speed. A major difference between the two methods was the exposure status of counties located in the upper-right side of each storm track, where the maximum-wind-speed method identified much higher exposure than to the left of the storm track. Symmetrical buffers cannot account for the rotation and pattern of hurricane winds. For example, in the birth-weight analysis, positive (insignificant) associations were found between the spatial analysis and Hurricanes Ivan and Frances, whose track went up Florida's west coast. For these two storms in particular, the spatial method may suggest an association with more statistical power.

Although one of the strengths of the spatial method is that it can take into account the areas potentially affected by more severe hurricane weather on one side of the track, another possibility is that this method may effectively be estimating the predicted effect or perceived stress. One would expect individuals along the storm track to have previous knowledge of the cone of the storm, as a result of improvements in meteorological modeling and forecasting. Several studies have shown that pregnant women with high (generally self-reported) stress and anxiety levels are at an increased risk for many poor pregnancy outcomes including spontaneous abortion, preterm labor, and low birth weight (Hobel et al. 1999; Mulder et al. 2002; Federenko and Wadhwa 2004). In studies that are specific to researching hurricane-related perceived stress and predicted knowledge of storm, the symmetrical spatial buffer may be adequately addressing this question.

Of the four categorizations of maximum wind speed, none appeared to perform better, and in most cases the direction of effect in modeling was unexpected. Statistical significance was most often achieved using a continuous measure of maximum wind exposure, but this is likely the result of higher statistical power. One limitation of the meteorological data is that wind speeds under 40 km/h (25 mi/h) were imputed as 0 km/h. This would imply that a categorical measure would likely be more accurate than the continuous measure. Results of the two binary-cut points for maximum wind speed appeared to be very storm dependent.

Environmental and sociodemographic county-level characteristics were adjusted for using EQI. Although both the crude and adjusted associations in most models were negative, the EQI-adjusted models shifted toward the expected positive direction. These adjustments may indicate that a portion (if not all) of the unexpected directionality may be the result of county-level population differences. The EQI may be ruling out some effects; however, many population characteristics and pregnancy characteristics were not controlled in these models.

The authors considered some additional meteorological models to define hurricane exposure (Kruk et al. 2010). However, in the analysis, county-level specificity was chosen to reduce potential misclassification of more finite geographic units and consistency with the currently described methods. One limitation of this geographic level is the range of Florida county sizes, which varies from 622 to 5,268 km^2 (240 to 2,034 mi^2) (Florida Department of State 2013), as it may be harder to obtain wind-speed meteorological data at these smaller geographies. Another alternative could be to apply both wind speed and precipitation or flooding to better understand the meteorological effects.

Conclusions

As populations continue moving toward coastal regions and storms intensify, the need to understand the effect that hurricane exposure may have on health is growing. Studies following major hurricanes in the United States, like Andrew, Katrina and Sandy, have demonstrated the potential lasting health effects on vulnerable populations such as women who were pregnant during the storm. Although hurricane exposure and reproductive health has been studied, the heterogeneity of exposure methods makes the comparability across geographic areas and individual storms difficult. The authors found no associations between hurricane exposure and low birth weight rate/preterm-birth delivery; however, for increased comparability, further exploration of this novel strategy should be explored with additional health outcomes. Meteorological wind-speed modeling provides a novel and reproducible approach to characterize hurricane exposure and its effect on the population's health.

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Disclaimer

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