Hurricane names: A bunch of hot air?

Gary Smith *

Department of Economics, Pomona College, United States

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ABSTRACT

It has been argued that female-named hurricanes are deadlier because people do not take them seriously. However, this conclusion is based on a questionable statistical analysis of a narrowly defined data set. The reported relationship is not robust in that it is not confirmed by a straightforward analysis of more inclusive data or different data.

Jung, Shavitt, Viswanathan, and Hilbe (2014) argue that people do not take hurricanes with female names seriously and are consequently underprepared and more likely to be killed. The authors report that this "hazardous form of implicit sexism" is supported by their analysis of 92 hurricanes that hit the United States between 1950 and 2012.

Maley (2014) notes that average number of deaths were higher for male-named storms (14.5 versus 12.7) when there were fewer than 100 deaths, and that all of the reported deadliness of female-named storms comes from four storms with death tolls above 100, three of which occurred during years when all hurricanes had female names. Malter (2014) and Christensen and Christensen (2014) criticize the selective choice of explanatory variables and the fragility of the results.

A straightforward examination of the data suggests several additional reasons for skepticism. When it appears that a study's conclusions may be sensitive to the study's assumptions, there are two kinds of checks. One is to see if the conclusions are sensitive to other plausible assumptions. The second is to analyze a completely different set of data. The current paper reports that both ways of attempting to replicate the original results find that the conclusions are not robust.

1. Data

The National Hurricane Center (2015) classifies tropical cyclones based on the maximum sustained wind speed: tropical depression (less than 39 mph), tropical storm (39–73 mph), hurricane (more than 73 mph), and major hurricane (more than 110 mph). Tropical storms and hurricanes are generally given names like Hurricane Sandy, but tropical depressions are not.

Jung et al. (2014) examine a narrowly defined dataset: U.S. fatalities from Atlantic hurricanes that made landfall in the United States. When a strong, surprising conclusion is drawn from restricted data, it can be instructive to see whether the conclusion is robust with respect to the myriad decisions used to restrict the data. Here, there are several issues:

(1) Why exclude tropical storms? In 1994 Tropical Storm Alberto made landfall near Destin, Florida, with maximum sustained winds of 65 mph and caused historic flooding in Alabama and Georgia that resulted in at least 30 deaths and caused $1 billion in damages (in 1994 dollars). Alberto was classified as a tropical storm, rather than a hurricane, because its winds peaked at 65 mph, below the 73 mph threshold for hurricanes. During the years 2010–2014, eighteen Atlantic tropical storms caused a total of 235 deaths while twenty-two Atlantic hurricanes caused 614 deaths, nearly half of which were due to Hurricane Sandy (286 deaths). If there is implicit sexism in reaction to hurricane names, there should also be implicit sexism in response to tropical-storm names.

(2) Why exclude storms that do not make landfall? In 1991 Hurricane Bill moved along the East Coast of the United States producing heavy rainfall, large waves, and dangerous rip currents. Two people were killed, one in Florida and the other in Maine. Berg and Avila (2011) wrote that,

Large swells, high surf, and rip currents generated by Bill caused two deaths in the United States. Although warnings about the dangerous waves had been posted along the coast, over 10 000 people gathered along the shore in Acadia National Park, Maine,

* Correspondence to: Fletcher Jones Professor Pomona College, 425 N. College Way, Claremont, CA 91711, United States.
E-mail address: gsmith@pomona.edu

on 24 August to witness the event. One wave swept more than 20 people into the ocean; 11 people were sent to the hospital, and a 7-yr-old girl died. Elsewhere, a 54-yr-old swimmer died after he was washed ashore by large waves and found unconscious in New Smyrna Beach, Florida.

Some people did not take this hurricane seriously. Jung et al. (2014) note that hurricane fatalities may involve fishing boats, surfers, swimmers, and people washed into the sea by waves, and write that

hurricanes sometimes move in and out of contact with land and also cause fatalities before making landfall (e.g., oil rig workers, boaters). Such deaths are appropriately part of the dataset as they reflect the preparedness issues being examined.

However, Jung et al. (2014) only count offshore fatalities if the storm makes landfall. If there is implicit sexism in reaction to storms that make landfall, there should also be implicit sexism in response to storms that do not make landfall.

(3) Why exclude fatalities outside the United States? In 1980 Hurricane Allen had a sustained windspeed of 190 mph, the highest ever recorded for an Atlantic hurricane. It made landfall near Brownsville, Texas, on the U.S.-Mexico border. There were at least 269 deaths and close to $1 billion in damages (1980 dollars); however, Jung et al. (2014) only counted two deaths from Hurricane Allen—two people who drowned in the Corpus Christi area. Jung et al. (2014) say that they counted both direct and indirect deaths but, in addition to the two Corpus Christi drownings, there were three fisherman who drowned after being swept off Galveston jetties, two Texas heart attack victims, thirteen deaths during an attempted helicopter evacuation of Louisiana offshore oil rigs, four drownings when a Louisiana offshore oil rig collapsed, and "several deaths in automobile accidents during the period of evacuation" (National Hurricane Center 1980). Thus Wikipedia (Hurricane Allen, 2015) counts "seven deaths in Texas and 17 in Louisiana (most resulting from the crash of a helicopter evacuating workers from an offshore platform)."

Even more serious is the omission of 245 fatalities in other countries. Many storm fatalities are in Mexico, the Caribbean, and Central America. The World Economic Forum's *Global Gender Gap Report* (2014), ranked 142 countries from first to worst based on economic, political, and social gender-based disparities. The U.S was ranked 20 and Mexico was ranked 80. All Caribbean and Central American countries, except Nicaragua, were ranked lower than the United States. If this "hazardous form of implicit sexism" is true and these countries are generally more sexist than the United States, the disparity between fatalities for female-named and male-named storms should be even larger than in the United States.

Overall, if the implicit-sexism theory is true of U.S. fatalities from hurricanes that make landfall in the United States, it should also be true of fatalities from tropical storms, from storms that do not make landfall or make landfall in other countries, and of non-U.S. fatalities. I investigate whether this is so.

Another way to test the robustness of provocative results is to analyze fresh data. Jung et al. (2014) only consider Atlantic storms. I also analyze Pacific storms. For example, in 1983 Hurricane Tico made landfall in Mexico, where 135 people were killed (including 7 fishermen whose boats sank) and then moved north into the United States, killing a total of 7 people in Texas, Oklahoma, and Kansas. If there is sexism in responses to storms attacking North and Central America from the east, there should be similar sexism in storms attacking from the west.

2. Randomization

In 1950, 1951, and 1952, hurricanes and tropical storms were named using the military phonetic alphabet (Able, Baker, Charlie, …). A switch was made to all female names in 1953. Many feminists decried this sexism, with Roxcy Bolton noting that, "Women are not disasters, destroying life and communities and leaving a lasting and devastating effect." The switch to the current system of alternating male and female names was made in 1979 and the current system provides an implicit randomization in that the choice of a male or female name is made before anything is known about the specific storm being named.

The pre-1979, all-female data used by Jung et al. (2014) are problematic because the average number of deaths per hurricane was 29.1 during the all-female era and 16.2 afterward. Perhaps there were more fatalities in earlier years because hurricanes tended to be stronger (the average hurricane category was 2.26 during the all-female era and 1.96 afterward), the infrastructure was weaker, or there was less advance warning.

There is no concrete way to compare storm warnings before and after 1979, but there is anecdotal evidence of improvement. On September 20, 1938, the *Springfield Union* newspaper in Springfield, Massachusetts, printed this weather forecast for western Massachusetts: "Rain today and possibly tomorrow." (Johnson, 2013). The Great Hurricane of 1938 hit the next day, killing 99 people in Massachusetts. In Springfield, the Connecticut River rose six-to-ten feet above flood level. Overall, nearly 700 people were killed and property damage was estimated at nearly $5 billion in 2015 dollars (1938 New England hurricane, 2015). Seventy-five years later, the chief National Weather Service Meteorologist in Taunton, Massachusetts, observed that, "It is inconceivable for a hurricane to arrive unannounced like it did in 1938." (Johnson, 2013)

The National Oceanic and Atmospheric Administration (2012) boasted that,

NOAA's investment in ocean and atmospheric research, coupled with technological advancements, has led to a remarkable transformation in hurricane monitoring and forecasting. Emerging from these combined factors has come intricate computer modeling, a vast network of ground- and ocean-based sensors, satellites, and Hurricane Hunter aircraft…. Advances of the last half-century have brought tremendous improvements in hurricane forecasting and, despite a growing coastal population, have yielded a dramatic decline in hurricane-related fatalities.

Even allowing for some self-promotion by the NOAA, it is clearly potentially misleading to treat the storm danger from 1950 through 1978 the same as in more recent years. It is more scientifically valid to analyze storms during the post-1978 period when male and female names were assigned randomly.

3. Methods

Tropical-cyclone fatality data are ill-suited for regression or correlation analysis because they consist of a large number of storms with very few fatalities and a small number of storms with a very large number of fatalities. Indeed, Jung et al. (2014) discarded the two most catastrophic hurricanes—Katrina (1833 deaths) and Audrey (416 deaths)—because, "Retaining the outliers leads to a poor model fit due to over-dispersion."

In addition to discarding two outliers, Jung et al. (2014) tried to make the data more suitable for regression analysis by constructing a masculinity-femininity index (MFI) based on the responses of nine people who were asked to gauge the masculinity

or femininity of hurricane names on a scale of 1 to 11.

An MFI based on the opinions of nine raters (who may not have been randomly selected) is not necessarily reliable. For example, Hurricane Sandy which had, by far, the largest death toll in their post-1978 dataset is generally considered a unisex name, yet Jung et al. (2014) reported that Sandy got an average score of 9.0 (strongly feminine). Is Sandy really more feminine than Edith (8.5), Carol (8.1), and Beulah (7.3)? I surveyed 44 people and got an average score for Sandy of 7.25. The fragility of the MFI suggests it might be better to do a more straightforward and robust statistical analysis.

Using their MFI, Jung et al. (2014) estimated at least a dozen models. They report that "a series of negative binomial regression analyses" were performed using several combinations of standardized and unstandardized variables. They "also modeled the data using different count models, including a generalized Poisson, Poisson inverse Gaussian, and the three-parameter models: NB-P, Famoye generalized negative binomial, and generalized Waring NB regression." In addition to the MFI, the authors experimented with using the hurricane name as a binary variable (0 for a male name, 1 for a female name) and also tried, as an explanatory variable, "years elapsed since the occurrence of hurricanes… However, this variable was dropped for the main analysis as its effect was non-significant in all models."

It is well known (Smith, 2014) that it is misleading for researchers to estimate several models and report the results they like best. As Nobel Laureate Ronald Coase (1988) succinctly put it, "If you torture the data long enough, it will confess."

In addition to this data dredging, a fundamental problem with their statistical analysis is that they used estimates of the monetary damages from each storm as an explanatory variable. Monetary damage is not an exogenous determinant of fatalities. Damage is an endogenous variable and its use as an explanatory variable can bias the estimated coefficients in regression models.

Most truly exogenous potential explanatory variables for storm fatalities are noisy, unreliable predictors of fatalities. For example, maximum wind speed is appealing and Jung et al. (2014) report that they would have used it if pre-1979 data had been available. However, in 2005 Hurricane Wilma, one of the most severe Atlantic tropical cyclone ever recorded, reached a wind speed of 185 mph and made landfall in the United States with a windspeed of 120 mph, yet there were only 5 U.S. fatalities. Fatalities depend on many things that are exceedingly difficult to measure and include in a regression model, such as the specific path of the storm.

To the extent that the regression models estimated by Jung et al. (2014) have significant explanatory power, it is due to the inappropriate inclusion of monetary damages as an explanatory variable. Jung et al. (2014) report that, "Total deaths had the strongest association with normalized damage. Perhaps this is because it reflects other unobserved factors potentially responsible for hurricane fatalities, such as population density, route, and duration of hurricane, indicating that costlier hurricanes are much deadlier." True enough, but the inclusion of damages as an explanatory variable means that the coefficient estimates are biased in unknown ways.

Instead, I will make a direct comparison of the frequency and number of fatalities from female-named and male-named storms.

4. Analysis

Jung et al. (2014) conclude that female names "cause" more deaths during major storms but there is "no effect of masculinity-femininity of name for less severe storms." However, if people react differently to female-named storms, this bias should be *weaker* for major storms. Consider Hurricane Sandy, the deadliest

post-1978 hurricane in their data set.

Hurricane Sandy made landfall in Jamaica on October 24, 2012, killing 2 people and knocking out 70 percent of the island's power, and made landfall in Cuba on October 26, with winds of 155 miles per hour, killing 11 people and destroying more than 15,000 homes. An additional two people were killed in the Dominican Republic, fifty-four in Haiti, and one in Puerto Rico. Nine U. S. governors declared a state of emergency before Sandy made landfall in New Jersey on October 29. New York City's Mayor Michael Bloomberg suspended all city mass transit services, including busses, subways, and trains; closed public schools; and ordered mandatory evacuations of many parts of the city (Effects of Hurricane Sandy in New York, 2015). Nonetheless, there were 48 New York City fatalities and another 109 fatalities in other parts of the United States. Is it really credible that, despite the dozens of people killed before Sandy hit the United States and the extraordinary actions taken by elected officials in the United States, people did not take Hurricane Sandy seriously because they thought Sandy was a female name?

If the implicit-sexism theory is true, it ought to be most apparent for storms of questionable danger. It is implausible that the response to a potential storm of the century—with the catastrophic warnings broadcast by news media that feed on sensationalized reporting—depends on whether the name is perceived to be a feminine or masculine. It is more plausible that relatively minor storms (like Hurricane Bill mentioned earlier) might be dismissed as more nuisance than danger.

Either way, data should not be omitted just because they show little or no effects. The catastrophic decision to launch the space shuttle Challenger in below-freezing weather was based in part on a flawed statistical analysis that excluded seventeen flights where there had been no O-ring failures (Dalal, Fowlkes, and Hoadley, 1989). It is generally better to include all the data.

I analyzed all storms (hurricanes and tropical storms), all storms with fatalities, all storms with 1–99 fatalities, and all storms with more than one hundred fatalities. In addition to Atlantic storms, I looked at Pacific storms, in each case for those years in which male and female names were determined randomly. All statistical analyses are reported.

5. Results

I follow Jung et al. (2014) in reporting total direct and indirect deaths, which is reasonable given the uncertain distinction between the two. If a range is given for the number of fatalities, I used the midpoint. For example, Hurricane Pauline was estimated to have between 230 and 400 fatalities, I used the midpoint 315.

6. Atlantic storms

During the years 1979 through 2014, there were 229 Atlantic hurricanes (138 with fatalities) and 191 Tropical Storms (76 with fatalities). Of the 420 storms in total, 210 had male names and 210 had female names.

Table 1 compares the frequency of female-named and male-named storms among storms that had fatalities, 1–99 fatalities, and more than 99 fatalities. The exact non-parametric *P*-values were calculated from the hypergeometric distribution. Female-named storms were slightly more likely to have fatalities (52.86% versus 49.05%) and more likely to have 1–99 fatalities (49.05% versus 41.90%), while male-named storms were much more likely to have more than 99 fatalities (7.14% versus 3.81%), but none of these differences are statistically significant at the 5% level.

Table 2 compares the average number of fatalities for female-

Table 1

Number of Female-Named and Male-Named Atlantic Hurricanes and Tropical Storms.

Storms	Female Names	Male Names	P-Value
All	210	210	
With Fatalities	111	103	0.252
1 to 99 fatalities	103	88	0.085
More than 99 fatalities	8	15	0.099

Table 2

Average Fatalities From Atlantic Hurricanes and Tropical Storms.

Storms	Female Names		Male Names		P-value
	Number	Mean	Number	Mean	
All	210	35.98	210	131.01	0.307
With Fatalities	111	68.07	103	267.12	0.293
1 to 99 fatalities	103	11.83	88	14.01	0.411
More than 99 fatalities	8	792.25	15	1,752.00	0.470

Table 3

Number of Female-Named and Male-Named Pacific Hurricanes and Tropical Storms.

Storms	Female Names	Male Names	P-Value
All	293	286	
With Fatalities	42	46	0.319
1 to 99 fatalities	39	42	0.361
More than 99 fatalities	3	4	0.487

Table 4

Average Fatalities From Pacific Hurricanes and Tropical Storms.

Storms	Female Names		Male Names		P-value
	Number	Mean	Number	Mean	
All	293	4.03	286	8.21	0.501
With Fatalities	42	28.14	46	51.07	0.553
1 to 99 fatalities	39	9.46	42	6.50	0.196
More than 99 fatalities	3	271.00	4	519.00	0.573

named and male-named storms. The *P*-values are for a standard difference-in-means *t* test with possibly unequal standard deviations. Storms with more than 99 fatalities tended to be male-named, including the deadliest storm, Hurricane Mitch in 1998 with 18,974 fatalities—far ahead of Hurricane Jeanne in 2004, which was the second deadliest with 3,042 fatalities. The Hurricane-Mitch outlier makes the average number of fatalities much higher for male-named storms, whether looking at all storms, all storms with fatalities, or storms with more than 99 fatalities. Even for storms with 1–99 fatalities, male-named storms were, on average, deadlier than female-named storms. As with the frequency of fatal storms, none of the observed differences in average fatalities are statistically significant at the 5% level.

7. Pacific storms

Male names were introduced for Pacific storms beginning with the 1978 season; however, there are no fatality data for 1978 or 1979. I analyzed data for 1980 through 2014, during which there were 319 hurricanes (61 with fatalities) and 262 tropical storms (27 with fatalities).

Table 3 shows that male-named storms were more likely to have fatalities (16.08% versus 14.33%), 1 to 99 fatalities (14.69% versus 13.31%), and more than 99 fatalities (1.40% versus 1.02%), but none of the differences are close to being statistically significant at the 5% level Table 4.

The deadliest Pacific Storm was Hurricane Paul with 1696 deaths in 1982; the second deadliest was Hurricane Pauline with 315 deaths in 1997. As with Atlantic storms, male-named storms had a higher average number of fatalities for all storms, for storms with fatalities, and for storms with more than 99 fatalities. Unlike Atlantic storms, the average number of fatalities was higher for female-named storms with 1 to 99 fatalities though, once again, none of the observed differences are statistically significant at the 5% level.

8. Conclusion

It has been reported that female-named hurricanes are deadlier than male-named hurricanes, which is interpreted as evidence of a sexist tendency to not take female-named hurricanes as seriously as male-named hurricanes and, consequently, to not take the same precautions. This evidence was reported to be the strongest for major hurricanes and nonexistent for lesser hurricanes, even though it seems implausible that people threatened by well-publicized major hurricanes would not take them seriously. If there are different responses to female-named and male-named hurricanes, it should be more evident when the consequences are smaller.

The reported conclusion is based an analysis of U.S. fatalities from Atlantic hurricanes that made landfall in the United States. The analysis itself can be questioned for using an index of the femininity of hurricane names, the estimation of a large number of models with various combinations of variables and functional forms, and the use of endogenous monetary damages as an exogenous explanatory variable.

The robustness of the reportedly deadlier nature of female-named hurricanes was tested using a more inclusive set of data (tropical storms as well as hurricanes, storms that do not make landfall or make landfall in other countries, and non-U.S. fatalities) and also a fresh set of data (Pacific storms). A direct comparison of the frequency with which male-named and female-named storms cause fatalities, cause 1–99 fatalities, or cause more than 99 fatalities does not show a consistent pattern, let alone statistically significant differences. A comparison of the average number of fatalities from male-named and female-named storms for all storms, storms with fatalities, storms with 1–99 fatalities, and storms with more than 99 fatalities found that male-named storms generally have a higher average number of fatalities, though again none of the differences are statistically significant at the 5% level.

The assertion that female-named storms are deadlier than male-named storms is not robust, evidently because it relied on the questionable statistical analysis of a narrowly defined set of data.

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