

Are Female Hurricanes Deadlier than Male Hurricanes?



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Overview of Lesson

This lesson is based upon a data set partially discussed in the article *Female Hurricanes are Deadlier than Male Hurricanes* written by Kiju Junga, Sharon Shavitta, Madhu Viswanathana, and Joseph M. Hilbed. The data set contains archival data on actual fatalities caused by hurricanes in the United States between 1950 and 2012. Students analyze and explore this hurricane data in order to determine if the data supports the claim that Female named hurricanes are more deadly than Male named hurricanes.

GAISE Components

This investigation follows the four components of statistical problem solving put forth in the *Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report*. The four components are: formulate a question, design and implement a plan to collect data, analyze the data by measures and graphs, and interpret the results in the context of the original question. This is a GAISE Level B activity.

Common Core State Standards for Mathematical Practice

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
5. Use appropriate tools strategically.
8. Look for and express regularity in repeated reasoning.

Common Core State Standards Grade Level Content (High School)

- S-ID. 1. Represent data with plots on the real number line (dot plots, histograms, and box plots).
- S-ID. 2. Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.
- S-ID. 3. Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).

NCTM Principles and Standards for School Mathematics

Data Analysis and Probability Standards for Grades 9-12

Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them:

- understand the meaning of measurement data and categorical data, of univariate and bivariate data, and of the term variable;
- understand histograms and parallel box plots and use them to display data.

Select and use appropriate statistical methods to analyze data:

- for univariate measurement data, be able to display the distribution, describe its shape, and select and calculate summary statistics.

Prerequisites

Students will have knowledge of calculating numerical summaries for one variable (mean, median, five-number summary, checking for outliers). Students will have knowledge of how to construct boxplots.

Learning Targets

Students will be able to calculate numerical summaries and use them to compare and contrast two data sets. Students will be able to use comparative boxplots to compare two data sets. Students will be able to check for outliers in data distributions.

Time Required

1 class period (to complete the lesson)

Materials Required

Pencil and paper; graphing calculator or statistical software package (optional, but would be very beneficial to use), and a copy of the Activity Sheet (at the end of the lesson).

Instructional Lesson Plan

The GAISE Statistical Problem-Solving Procedure

I. Formulate Question(s)

The teacher can begin the lesson by discussing some background information on hurricanes. According to <http://www.ready.gov/hurricanes> a hurricane is a type of tropical cyclone or severe tropical storm that forms in the southern Atlantic Ocean, Caribbean Sea, Gulf of Mexico, and in the eastern Pacific Ocean.

All Atlantic and Gulf of Mexico coastal areas are subject to hurricanes. Parts of the Southwest United States and the Pacific Coast also experience heavy rains and floods each year from hurricanes spawned off Mexico. The Atlantic hurricane season lasts from June to November, with the peak season from mid-August to late October. The Eastern Pacific hurricane season begins May 15 and ends November 30.

Hurricanes can cause catastrophic damage to coastlines and several hundred miles inland. Hurricanes can produce winds exceeding 155 miles per hour as well as tornadoes and microbursts. Additionally, hurricanes can create storm surges along the coast and cause extensive damage from heavy rainfall. Floods and flying debris from the excessive winds are often the deadly and destructive results of these weather events.

Junga et al analyzed archival data on actual fatalities caused by hurricanes in the United States between 1950 and 2012 and concluded that severe hurricanes with feminine names were associated with significantly higher death rates than hurricanes with masculine names.

The authors performed laboratory experiments to determine whether hurricane names lead to gender-based expectations about severity and this, in turn, guides respondents' preparedness to take protective action. They hypothesized that gender-congruent perceptions of intensity and strength are responsible for Male named hurricanes being perceived as riskier and more intense than Female named hurricanes.

U.S. hurricanes used to be given only female names, a practice that meteorologists of a different era considered appropriate due to such characteristics of hurricanes as unpredictability. This practice came to an end in the late 1970s with increasing societal awareness of sexism, and an alternating male-female naming system was adopted.

Even though the gender of hurricanes is now preassigned and arbitrary, the question remains: do people judge hurricane risks in the context of gender-based expectations?

II. Design and Implement a Plan to Collect the Data

Since this lesson does not involve direct data collection the teacher should provide students with the hurricane data set that appears in Table 1 (and on the Activity Sheet). An Excel version of the data set is included along with this lesson.

Table 1. Hurricane names and death totals for the years 1950 to 2012.

Hurricane	Year	Gender of Name	Number of Deaths	Hurricane	Year	Gender of Name	Number of Deaths
Easy	1950	Female	2	Elena	1985	Female	4
King	1950	Male	4	Gloria	1985	Female	8
Able	1952	Male	3	Juan	1985	Male	12
Barbara	1953	Female	1	Kate	1985	Female	5
Florence	1953	Female	0	Bonnie	1986	Female	3
Carol	1954	Female	60	Charley	1986	Male	5
Edna	1954	Female	20	Floyd	1987	Male	0
Hazel	1954	Female	20	Florence	1988	Female	1
Connie	1955	Female	0	Chantal	1989	Female	13
Diane	1955	Female	200	Hugo	1989	Male	21
Ione	1955	Male	7	Jerry	1989	Male	3
Flossy	1956	Female	15	Bob	1991	Male	15
Helene	1958	Female	1	Andrew	1992	Male	62
Debra	1959	Female	0	Emily	1993	Female	3
Gracie	1959	Female	22	Erin	1995	Female	6
Donna	1960	Female	50	Opal	1995	Female	9
Ethel	1960	Female	0	Bertha	1996	Female	8
Carla	1961	Female	46	Fran	1996	Female	26
Cindy	1963	Female	3	Danny	1997	Male	10
Cleo	1964	Female	3	Bonnie	1998	Female	3
Dora	1964	Female	5	Earl	1998	Male	3
Hilda	1964	Female	37	Georges	1998	Male	1
Isbell	1964	Female	3	Bret	1999	Male	0
Betsy	1965	Female	75	Floyd	1999	Male	56
Alma	1966	Female	6	Irene	1999	Female	8
Inez	1966	Female	3	Lili	2002	Female	2
Beulah	1967	Female	15	Claudette	2003	Female	3
Gladys	1968	Female	3	Isabel	2003	Female	51
Camille	1969	Female	256	Alex	2004	Male	1
Celia	1970	Female	22	Charley	2004	Male	10
Edith	1971	Female	0	Frances	2004	Female	7
Fern	1971	Female	2	Gaston	2004	Male	8
Ginger	1971	Female	0	Ivan	2004	Male	25
Agnes	1972	Female	117	Jeanne	2004	Female	5
Carmen	1974	Female	1	Cindy	2005	Female	1
Eloise	1975	Female	21	Dennis	2005	Male	15
Belle	1976	Female	5	Ophelia	2005	Female	1
Babe	1977	Female	0	Rita	2005	Female	62
Bob	1979	Male	1	Wilma	2005	Female	5
David	1979	Male	15	Humberto	2007	Male	1
Frederic	1979	Male	5	Dolly	2008	Female	1
Allen	1980	Male	2	Gustav	2008	Male	52
Alicia	1983	Female	21	Ike	2008	Male	84
Diana	1984	Female	3	Irene	2011	Female	41
Bob	1985	Male	0	Isaac	2012	Male	5
Danny	1985	Male	1	Sandy	2012	Female	159

*Note: hurricanes Katrina in 2005 (1833 deaths) and Audrey in 1957 (416 deaths) were removed from the data set.

Present the data to students and have them input the relevant values into a computer spreadsheet or their calculator. Once the data is ready for analysis, students will proceed through the questions on the activity worksheet.

III. Analyze the Data

The data analysis begins with students suggesting a graph that might be used to use to compare the death totals for Female and Male named hurricanes. Comparative graphs such as boxplots would be the most appropriate graphs for displaying these distributions.

Students then calculate the mean, standard deviation, and five-number summary of the death totals for Female and Male named hurricanes. The corresponding calculations are provided in Table 2.

Table 2. Numerical summaries of the hurricane death totals.

Gender	Mean	S.D.	Min	Q1	Median	Q3	Max
Female	23.76	47.47	0	2	5	21	256
Male	14.23	21.16	0	1	5	15	84

Once the values have been calculated, ask students which measure, the mean or the median, better represents a typical number of deaths from a hurricane and why? If, for example, we consider the Female named hurricanes, the mean would suggest that in a typical hurricane, there are about 24 deaths. However, by examining the data set, 49 of the 62, or 79% of the Female named death totals are less than or equal to 24 deaths. On the other hand, the median would suggest that in a typical hurricane there are 5 deaths. And, by definition, 50% of the Female named death totals are less than or equal to 5 deaths. Answers to this question may vary, but it seems that 5 deaths may be a more typical representation than would 24 deaths.

For each of the Female and Male named hurricanes, students determine whether there are any outliers. For the Female named hurricanes, the $IQR = 21 - 2 = 19$ and $1.5 \times IQR = 1.5 \times 19 = 28.5$ so the lower fence = $2 - 28.5 = -26.5$ and the upper fence = $21 + 28.5 = 49.5$. Thus, any death totals above 49.5 are considered outliers. For the Females, we see that there are 9 outliers in death totals. For the Male named hurricanes, the $IQR = 15 - 1 = 14$ and $1.5 \times IQR = 1.5 \times 14 = 21$ so the lower fence = $1 - 21 = -20$ and the upper fence = $15 + 21 = 36$. Thus, any death totals above 36 are considered outliers. For the Males, we see that there are 4 outliers.

Next, students construct comparative boxplots to display the distributions of the number of deaths for Female and Male named hurricanes. Once the boxplots have been constructed, discuss with students how to interpret them. Students should understand that there are about the same number of deaths between the minimum and Q1, Q1 to Q2 (median), Q2 to Q3, and Q3 to the maximum, or approximately 25% of the data will lie in each of these four intervals. The boxplots are displayed in Figure 1.

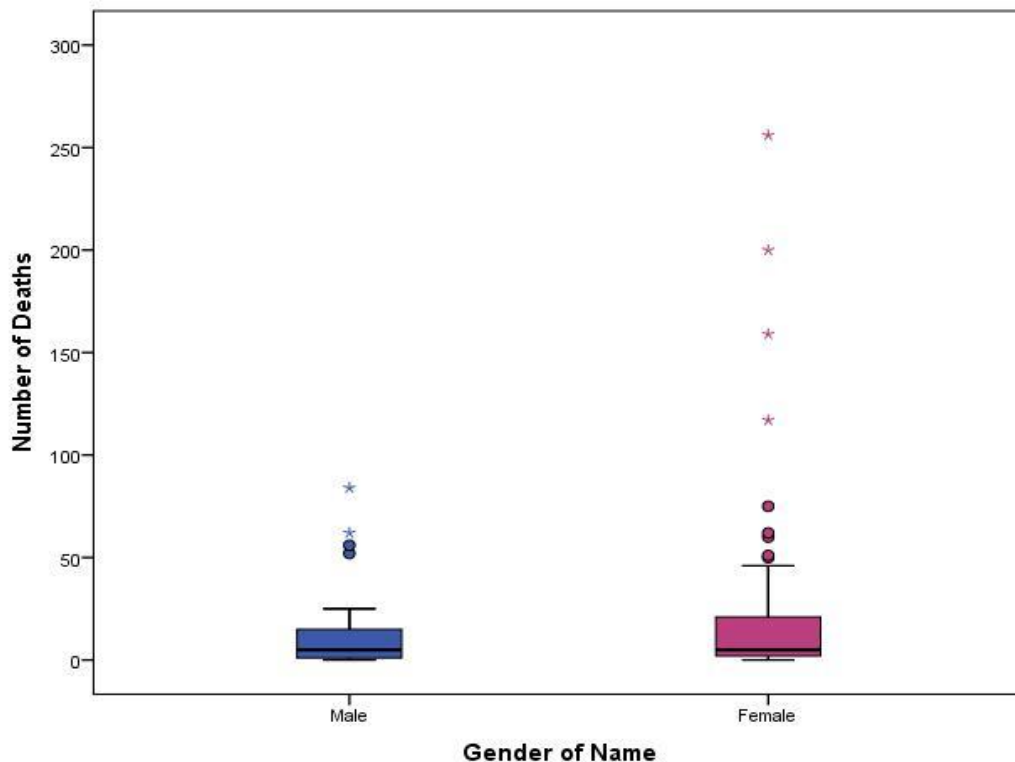


Figure 1. Comparative boxplots of number of deaths for Male vs Female hurricanes.

In order to examine the effect of an outlier or outliers on numerical calculations, ask students to consider only the Female named hurricanes. Earlier, it was noted that hurricanes Audrey (416 deaths) and Katrina (1833 deaths) were omitted from the analysis. Ask students to add the death totals from these two hurricanes to the dataset and redo the summary calculations. Then ask them to again explain which measure, the mean or the median, better represents a typical number of deaths from a hurricane and why? The revised calculations for the Female named hurricanes are shown in Table 3.

Table 3. Numerical summaries of Female named hurricane death totals, including hurricanes Audrey and Katrina.

Katrina/Audrey Included	Mean	S.D.	Min	Q1	Median	Q3	Max
No	23.76	47.47	0	2	5	21	256
Yes	58.16	235.33	0	2	5	22	1833

When the death totals for Audrey and Katrina are added to the data set, we see that the mean increases from about 24 to about 58. Additionally, the standard deviation experiences a vast increase from about 48 to about 235. With the two hurricanes excluded, we would claim that in a typical hurricane, there are about 24 deaths, give or take about 47 deaths. With the two hurricanes included, we would claim that in a typical hurricane, there are about 58 deaths, give or take about 235 deaths. Students can begin to see that when extreme outliers are part of a data set, the mean and standard deviation values could be strongly affected. The median number of deaths, on the other hand, remains unchanged at 5 deaths. Also note that the value of the

Interquartile Range (IQR) changes by only 1 death. Students can see that the quartiles are not affected by extreme data values and are therefore resistant (robust) measures of center and spread. The mean and standard deviation are not resistant.

IV. Interpret the Results

Based upon their numerical calculations, students are asked to state if they think that the Female named hurricanes are more deadly? If the focus is on the mean, then there may be an argument for Female named hurricanes being more deadly. The average number of deaths for Female hurricanes is 24 and for Male hurricanes, the average is 14. However, if the focus is on the median and the corresponding quartiles, the argument is not as strong for the Female hurricanes being more deadly. Both Female and Male hurricanes' median number of deaths is 5. The Female third quartile, 21, is 6 deaths more than the Male third quartile. Although this is a higher value, it may not be high enough to justify claiming that the Female hurricanes are more deadly.

Students are asked to thoroughly interpret the boxplots. They should compare and contrast center and spread for the two distributions. Then, they should state their opinion on whether or not it seems that the Female named hurricanes are more severe. When examining the comparative boxplots, students should describe similarities and differences in the distributions of the number of deaths for Female and Male named hurricanes. In a typical hurricane, it appears that the Female and Male death total is the same, 5 deaths. However, the range of the middle 50% of the death totals is higher for the Female named hurricanes: 2 to 21 deaths, than the Male named hurricanes: 1 to 15 deaths. The Male named hurricanes have less variation in the typical values than do the Female named hurricanes. As was noted earlier, the Female distribution contains 9 outliers (with four being considered extreme, as denoted by the asterisk on the boxplot) and the Male distribution contains 4 outliers (two of them extreme). With these things in mind, a clear-cut claim of the Female named hurricanes being more deadly is not the obvious conclusion.

Another thing to have students think about is the answer to this question: "How could the fact that all hurricanes had Female names until 1979 bias the results?" It could be that the data might indicate that more people die in Female-named hurricanes simply because more people died in hurricanes on average before they started getting male names (for many reasons – one being a better ability to prepare for disasters in later years versus earlier years – through media outlets, etc.).

Assessment

1. A football team (Team A) won four of eleven games that it played during a season. Point differences between teams in the eleven games were: +38, -14, +24, -13, -9, -7, -2, -11, -7, +4, +24. A positive difference indicates that Team A won the game, and a negative difference indicates that Team A lost.

(a) Find the value of the mean point difference and the value of the median point difference for the eleven games.

(b) Explain which of the two summary values found in part (a) is a better summary of the team's season.

2. For each of the following datasets, explain whether you would expect the mean or the median of the observations to be higher.

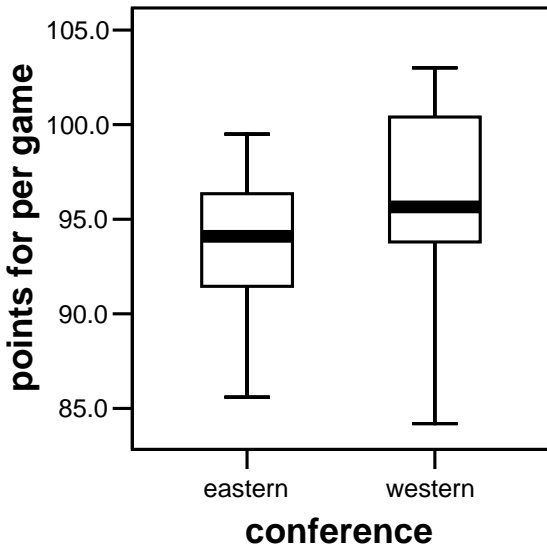
(a) In a rural farming community, for each household the number of children is measured.

(b) For all households in a large city, yearly household income is measured.

(c) For all students in a high school (not just those who were employed), income earned in a job outside the home in the past month is measured.

(d) For the coins in someone's pocket that has $\frac{1}{3}$ pennies, $\frac{1}{3}$ nickels, and $\frac{1}{3}$ quarters, the monetary value of each coin is recorded.

3. The comparative boxplot below shows the points scored per game for National Basketball Association (NBA) teams during the 2002-03 regular season. The data are broken down into Eastern and Western conference teams.



Find approximate values for the five-number summary for each conference. Compare the scoring in the two conferences.

Answer:

1. (a) Mean = +2.455; Median = -7. To find the median, first order the values, and then determine the middle value. The ordered data are: -14 -13 -11 -9 -7 -7 -2 4 24 24 38

(b) The median point difference is a better summary of the team's season. They lost seven games and only won four, so a negative difference was the more typical experience.

2. (a) The mean will be larger than the median. While most households may have between 0 and 4 or so children, there will be some households with large numbers of children, so the distribution will be skewed to the right.

(b) The mean will be larger than the median. People like Bill Gates will create large outliers. And, generally income data tends to be skewed to the right because high incomes can become quite high but incomes can't be any lower than 0.

(c) If all of the high school students are included, the mean will be higher than the median. This is because many high school students are too young to work or do not want to work, resulting in many students with \$0 income earned in a job outside the home. There is even a chance the median could be 0!

(d) The mean is 10.33 cents. Calculate this assuming there is one of each type of coin. The calculation is $(1+5+25)/3 = 31/3 = 10.33$. The exact number of each type of coin doesn't matter. As long as there are equal numbers of each type, the mean will be 10.33 cents. The median is the middle amount so it will be 5 cents. The mean is higher than the median because the monetary amounts are skewed to the right.

3. (a) East: min = 86, Q1 = 91, median = 94, Q3 = 96, max = 100;

West: min = 84, Q1 = 94, median = 96, Q3 = 100, max = 103

(b) In general, scoring is higher in the Western conference. The median of 96 points in the Western conference is higher than the median of 94 points in the Eastern conference. The third quartile of 100 in the Western conference is 4 points higher than the third quartile of 96 in the Eastern conference. In the Western conference 75% of the games had 94 or more points versus only 50% of the games having 94 or more points in the Eastern conference.

Possible Extension

In the article *Female Hurricanes are Deadlier than Male Hurricanes* written by Kiju Junga, Sharon Shavitta, Madhu Viswanathana, and Joseph M. Hilbed, the researchers said they didn't just analyze death tolls from actual hurricanes, they also conducted a series of experiments to test their hypothesis. In one experiment, the researchers tested whether participants would be more likely to evacuate due to a "Hurricane Christopher" vs. a "Hurricane Christina." As expected, it was found that more people would flee their homes if Hurricane Christopher came barreling toward them compared to an impending Hurricane Christina.

The name 'Extension' here is a bit misleading. If the teacher is interested in expanding upon the descriptive statistics topics covered in the main activity, she might wish to collect some data from her students prior to discussing the main activity.

The next two pages contain two data collection sheets. The scenario on the two sheets is the same except for Sheet A uses a masculine hurricane name (Victor) and Sheet B uses a feminine hurricane name (Victoria).

Determine some way to 'randomly' distribute Sheet A to half of the students and Sheet B to the other half. Have the students provide their likeliness of evacuation and collect the data sheets. Then, explain to students that half of them read a scenario about hurricane Victor while the other half read a scenario about hurricane Victoria.

Once the data is collected, the students can be involved in a brainstorming session about how to use the data to determine if hurricane Victor seemed more threatening than hurricane Victoria and then possibly generalize their results (which would allow for a discussion about whether or not a sample is representative of a population).

Here is one possibility for comparing fear of hurricane Victor to fear of hurricane Victoria: Depending upon class size and with the waiving of a couple of assumptions (and perhaps a discussion of why the assumptions may not be met), the mean likeliness to evacuate rating could be compared for Victor and Victoria. The means could be compared using the two-sample t test.

Data Collection Sheet A for Activity Extension (Victor)

Suppose that you live in a small county in the East Coast of the United States, a highly recreational and esthetic place, but also very vulnerable to storm or hurricane damage. One day, national and regional weather forecasts have reported that Hurricane Victor is approaching and he will directly hit your county within 24-hours. Your local officials just issued a voluntary evacuation order for protection from Hurricane Victor asking you to evacuate immediately.

Please indicate how likely you think you would be to evacuate. Circle a number.

Note: 1 = definitely will evacuate immediately and 7 = definitely will stay at home.

1 2 3 4 5 6 7



Data Collection Sheet B for Activity Extension (Victoria)

Suppose that you live in a small county in the East Coast of the United States, a highly recreational and esthetic place, but also very vulnerable to storm or hurricane damage. One day, national and regional weather forecasts have reported that Hurricane Victoria is approaching and she will directly hit your county within 24-hours. Your local officials just issued a voluntary evacuation order for protection from Hurricane Victoria asking you to evacuate immediately.

Please indicate how likely you think you would be to evacuate. Circle a number.

Note: 1 = definitely will evacuate immediately and 7 = definitely will stay at home.

1 2 3 4 5 6 7



References

1. *Guidelines for Assessment and Instruction in Statistics Education* (GAISE) Report, ASA, Franklin et al., ASA, 2007 <http://www.amstat.org/education/gaise/>
2. First two assessment questions extracted from: *Mind on Statistics*. Third Edition by Utts/Heckard, 2006. Cengage Learning.
3. *Female Hurricanes are Deadlier than Male Hurricanes* by Kiju Junga, Sharon Shavitta, Madhu Viswanathana, and Joseph M. Hil. In *Proceedings of the National Academy of Sciences of the United States of America*: 10.1073/pnas.1402786111 May 14, 2014

The complete data set used in this article can be downloaded at:

<http://www.pnas.org/content/suppl/2014/05/30/1402786111.DCSupplemental>

4. Assessment question 3, taken from: *The Educated Sports Fan: Using Statistics to Analyze Sports* by John Gabrosek, Grand Valley State University.

Are Female Hurricanes Deadlier than Male Hurricanes? Activity Sheet

Background (Adapted from: "Female Hurricanes are Deadlier than Male Hurricanes, Study Says." by Holly Yan, CNN. June 3, 2014: <http://www.cnn.com/2014/06/03/us/female-hurricanes-deadlier/>)

Apparently sexism isn't just a social problem -- if you're in the path of a hurricane, gender bias might actually kill you. A study suggests people prepare differently for hurricanes depending on whether the storm has a male or female name. "Feminine-named hurricanes (vs. masculine-named hurricanes) cause significantly more deaths, apparently because they lead to a lower perceived risk and consequently less preparedness," a team of researchers wrote in the Proceedings of the National Academy of Sciences. In other words, a hurricane named "Priscilla" might not make people flee like a hurricane named "Bruno" would.

The study analyzed death rates from U.S. hurricanes from 1950 to 2012. "For severe storms, where taking protective action would have the greatest potential to save lives, the masculinity-femininity of a hurricane's name predicted its death toll," the study said. Hurricane Katrina in 2005, which left more than 1,800 people dead, was not included in the study because it was considered a statistical outlier. Neither was Hurricane Audrey in 1957, which killed 416 people. The study does note that both of those very deadly hurricanes had female names.

Why name hurricanes anyway? Giving hurricanes short, easy-to-remember names helps reduce confusion when two or more tropical storms are brewing at the same time, the National Hurricane Center said. For decades, all hurricanes were given female names in part because hurricanes were unpredictable, the study said, citing the "Encyclopedia of Hurricanes, Typhoons and Cyclones." "This practice came to an end in 1979 with increasing societal awareness of sexism, and an alternating male-female naming system was adopted," the report said.

Each year's list of hurricane names is alphabetical, alternating between male and female monikers. A U.N. World Meteorological Organization committee has already set up six years' worth of names. The lists repeat after each six-year cycle. "The only time that there is a change is if a storm is so deadly or costly that the future use of its name on a different storm would be inappropriate for obvious reasons of sensitivity," the National Hurricane Center said.

The table on the following page contains the hurricane data that was used in the article *Female Hurricanes are Deadlier than Male Hurricanes* by Kiju Junga, Sharon Shavitta, Madhu Viswanathana, and Joseph M. Hil. In *Proceedings of the National Academy of Sciences of the United States of America*, May 2014.

Hurricane	Year	Gender of Name	Number of Deaths	Hurricane	Year	Gender of Name	Number of Deaths
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Danny	1985	Male	1	Sandy	2012	Female	159

*Note: hurricanes Katrina in 2005 (1833 deaths) and Audrey in 1957 (416 deaths) were removed from the data set.

1. Suggest a graph that might be used to compare the death totals for Female and Male named hurricanes. Explain why you chose the graph that you did.

2. Calculate the mean, standard deviation, and five-number summary of the death totals for Female and Male named hurricanes.

Gender	Mean	S.D.	Min	Q1	Median	Q3	Max
Female							
Male							

(a) Which measure, the mean or the median, do you think better represents a typical number of deaths from a hurricane? Why?

(b) Based upon the numerical calculations, do you think that the Female named hurricanes are more deadly? Why? Or why not?

3. For each of Female and Male named hurricanes, determine whether there are any outliers.

4. Construct comparative boxplots that display the distributions of the number of deaths for Female and Male named hurricanes.

5. Thoroughly interpret the boxplots. Compare and contrast center and spread for the two distributions. Then, state your opinion on whether or not it seems that the Female named hurricanes are more severe.

6. How could the fact that all hurricanes had female names until 1979 bias the results from Question 5?

7. Now, consider only the *Female* named hurricanes. Earlier, it was noted that hurricanes Audrey and Katrina were omitted from the analysis. Add the death totals from these two hurricanes to your dataset and redo the summary calculations:

Katrina/Audrey Included	Mean	S.D.	Min	Q1	Median	Q3	Max
No							
Yes							

Which measure, the mean or the median, do you think better represents a typical number of deaths from a hurricane? Why?