This class is being conducted over Zoom. As the instructor, I will be recording this session. I have disabled the recording feature for others so that no one else will be able to record this session. I will be posting this session to the course's website.

If you have privacy concerns and do not wish to appear in the recording, you may turn video off (click "stop video") so that Zoom does not record you.

The chat box is always open for discussion and questions to the entire class. You may also send messages privately to the instructor or the TAs. Please note that Zoom saves all chat transcripts.

Introduction to Statistics

Stats 7

Mary Ryan

Aug. 4, 2020

https://canvas.eee.uci.edu/courses/28451

About the Teaching Team

- Instructor: Mary Ryan
  - 5th year Statistics PhD student
  - 📧: marymr@uci.edu
  - OH:

- TA: Kyle Conniff
  - 5th year Statistics PhD student
  - 📧: krconnif@uci.edu
  - OH:

- TA: Jenifer Rim
  - 4th year Statistics PhD student
  - 📧: jsrim@uci.edu
  - OH:

Tentative Schedule

Week 1

- Descriptive statistics & data visualization
- Data sampling & bias

Week 2

- Regression
- Basic probability

Week 3

- Midterm
- Discrete probability distributions

Week 4

- Continuous probability distributions & sampling distributions
- One-sample inference

Week 5

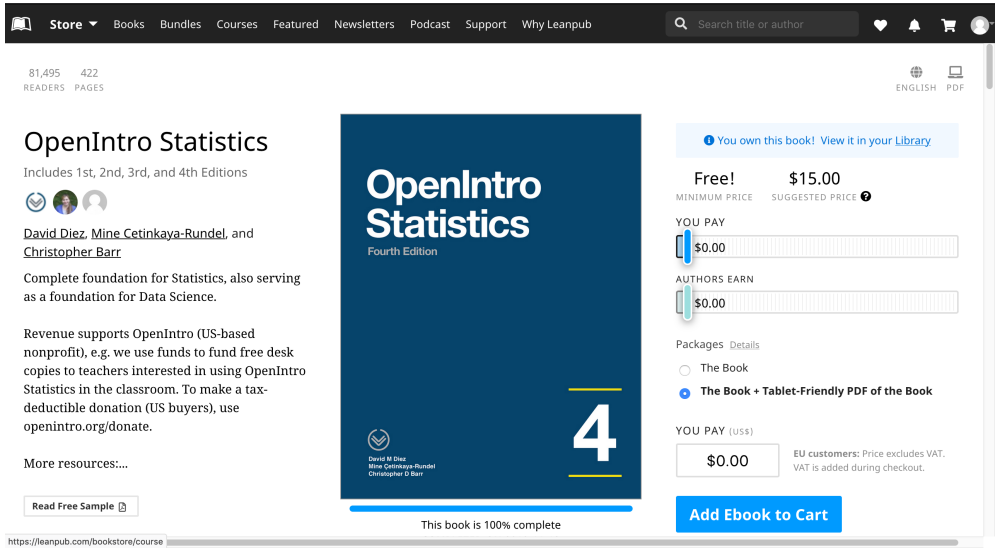
- Two-sample inference
- Inference for categorical data

Final Exam

Textbook

Recommended text: OpenIntro Statistics, 4th Edition

- PDF free to download



- Paperback copy $20 from Amazon

Assignments

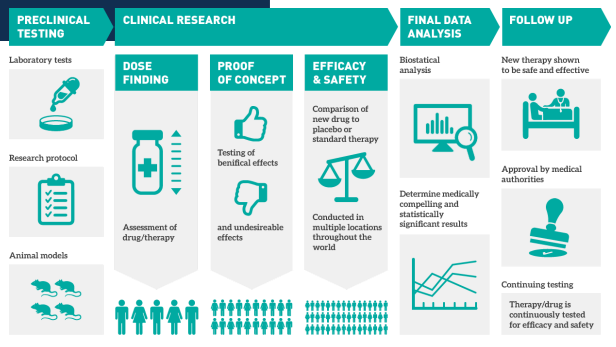
- Video Quizzes & Surveys: 15%
    - Short topic videos with embedded quiz questions to be completed before appropriate lecture, found on course website
- Homework: 25%
    - Weekly assignments, found on the course website
    - Open Tuesdays @ 1p
    - Due following Tuesday @ 12.59p (before lecture) via Canvas
    - For every day late, homework grade will suffer a 20% penalty
- Labs: 15%
    - Open Thursdays @ 4p, found on the course website
    - Due following Tuesday @ 12.59p (before lecture) via Canvas
- Midterm Exam: 25%
    - Date: Tuesday, Aug. 18 @ 1p
- Final Exam: 30%
    - Date: Tuesday, Sept. 8 @ 1p
    - Cumulative

If you have issues with either of the exam dates, let me know as soon as possible

What is Statistics?

What is Statistics?

United States® Census Bureau



BLS
BUREAU OF LABOR STATISTICS
U.S. DEPARTMENT OF LABOR

FiveThirtyEight

The Grammar of Science

Grammar takes a pile of words,

and helps turn it into a sentence that makes sense

In this class, we are going to learn about data, statistics,and how they impact our lives.

The Grammar of Science

Grammar takes a pile of words,

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In this class, we are going to learn about data, statistics,and how they impact our lives.

Statistics takes a pile of data,

and helps turn it into scientific conclusions that we can **interpret**

What Statistics Isn't

Just like all sentences that are grammatically correct aren't necessarily good at communicating their meaning...

Buffalo buffalo Buffalo buffalo

buffalo buffalo Buffalo buffalo

Statistics is not simply a machine where data goes in and truth pops out the other side

We need to use Statistics **conciously** and understand its **limitations**

Types of Data

- A variable is a measured characteristic of your data
    - A dataset is often made up of many different variables, of many different types

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- Categorical (qualitative) variables
  - Ordinal variable: categorical variable whose categories have a specific ordering
  - Nominal variable: categorical variable without any ordering
  - Binary variable: categorical variable with only 2 categories

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  - Nominal variable: categorical variable without any ordering
  - Binary variable: categorical variable with only 2 categories
- Quantitative variables
  - Discrete variable: takes on numerical values in jumps
  - Continuous variable: takes on numerical values that can go out to infinite decimal points

Types of Data

1) Number of cats at the animal shelter

2) Species of pet

3) Weight

4) Mood

5) Diagnosis

6) Population of Orange County

7) Airplane ticket class

Types of Data

1) Number of cats at the animal shelter — Discrete

2) Species of pet

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Types of Data

1) Number of cats at the animal shelter	Discrete
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Types of Data

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Types of Data

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8) Money you spend to wash 1 load of laundry

Types of Data

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3) Weight	Continuous
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5) Diagnosis	Nominal
6) Population of Orange County	Discrete
7) Airplane ticket class	Ordinal
8) Money you spend to wash 1 load of laundry	Continuous

Types of Data

8) Money you spend to wash 1 load of laundry

- I spend $1.75 per wash cycle

Types of Data

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    - Looks discrete, right?

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  - **Converted to Iraqi Dinar: 2080.75 ع.د**
  - **Converted to Euro: € 1.5596**

Types of Data

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Types of Data

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- I spend $1.75 per wash cycle
  - Looks discrete, right?
  - Converted to Iraqi Dinar: 2080.75 ع.د
  - Converted to Euro: € 1.5596
  - Converted to Mexican Peso: $ 40.285735
- While we might think of currency in "discrete" US Dollar (or Dinar, or Euro, or Peso) units, any amount of money can be converted from one currency to another
  - Currency conversion doesn't respect the fact that you don't carry around $1/12^{th}$ cents
  - So we generally think of currency as a continuous variable

How Do We Describe Our Data?

For categorical data, we might want to:

- Know how many observations are in each caetgory
  - Counts
- Know how large a category is compared to all observations
  - Percentages
  - $\frac{\#\text{ observations in a category}}{\text{Total observations}} \times 100$

How Do We Describe Our Data?

For quantitative data, we might want to:

- Know what the smallest value of a variable is
  - **Minimum**
- Know what the largest value of a variable is
  - **Maximum**
- Know the distance between the maximum and the minimum
  - **Range**
- Know what the center of our data is...

Journey to the Center of the Data

- Mean
  - The "typical value" of the data
  - $\bar{x} = \frac{\text{sum of data points}}{\text{number of data points}} = \frac{\sum_{i=1}^{n} X_i}{n}$
- Median
  - The "exact middle" of the data
  - 50% of data points are below the median, 50% of data points are above the median
- Mode
  - The most common value in the data

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Median

2, 5, 6, 8, 8, 8, 10, 13, 14, 16, 16, 19, 20, 21, 25

Median

2, 5, 6, 8, 8, 8, 10, 13, 14, 16, 16, 19, 20, 21, 25

Median

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Median

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2, 5, 6, 8, 8, 8, 10, 10, 13, 14, 16, 16, 19, 20, 21, 25

Median

2, 5, 6, 8, 8, 8, 10, 13, 14, 16, 16, 19, 20, 21, 25

2, 5, 6, 8, 8, 8, 10, 10, 13, 14, 16, 16, 19, 20, 21, 25

Median

2, 5, 6, 8, 8, 8, 10, 13, 14, 16, 16, 19, 20, 21, 25

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Median

2, 5, 6, 8, 8, 8, 10, **13,** 14, 16, 16, 19, 20, 21, 25

2, 5, 6, 8, 8, 8, 10, **10, 13,** 14, 16, 16, 19, 20, 21, 25

(10+13)/2 = 11.5

How Do We Describe Our Data?

- We might also want to know how much our observations vary
- Nice to compare how far away observations are from the center of the data (deviation)

$$x_i - \bar{x}$$

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  - If we just add the deviations up some of them might cancel out
  - Square the deviations to remove the sign:

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$$(x_i - \bar{x})^2$$

- But every observation has a different squared deviance. How do we get one metric?
  - Take an average!
  - Variance (s^2) $= \frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n-1}$
  - Standard deviation (s) $= \sqrt{s^2} = \sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n-1}}$

Variance & Standard Deviation

Variance (s^2) $= \frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n-1}$

Standard deviation (s) $= \sqrt{s^2} = \sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n-1}}$

- When variance/standard deviation is **large**, the observations vary from the mean a lot
- When variance/standard deviation is **small**, the observations generally stay close to the mean

Data Visualization

- Summarizing data with metrics are nice, but people are much better at identifying differences/patterns graphically

Data Visualization

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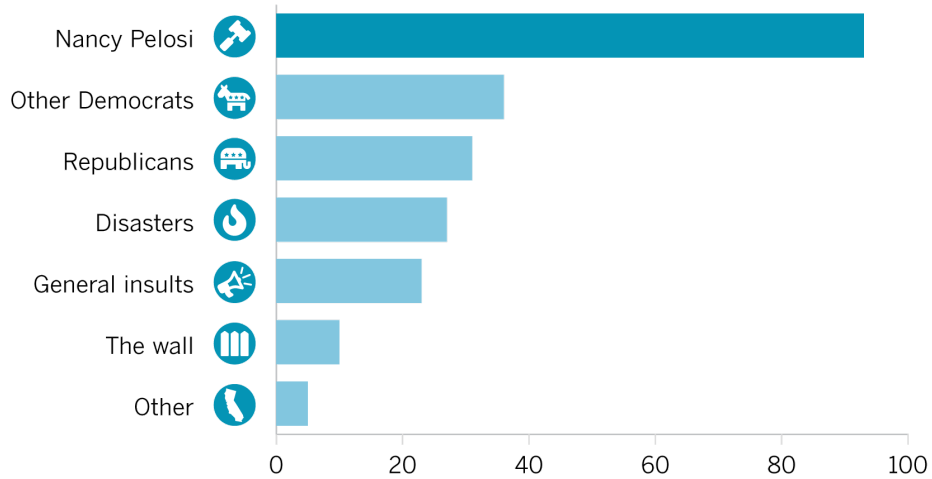
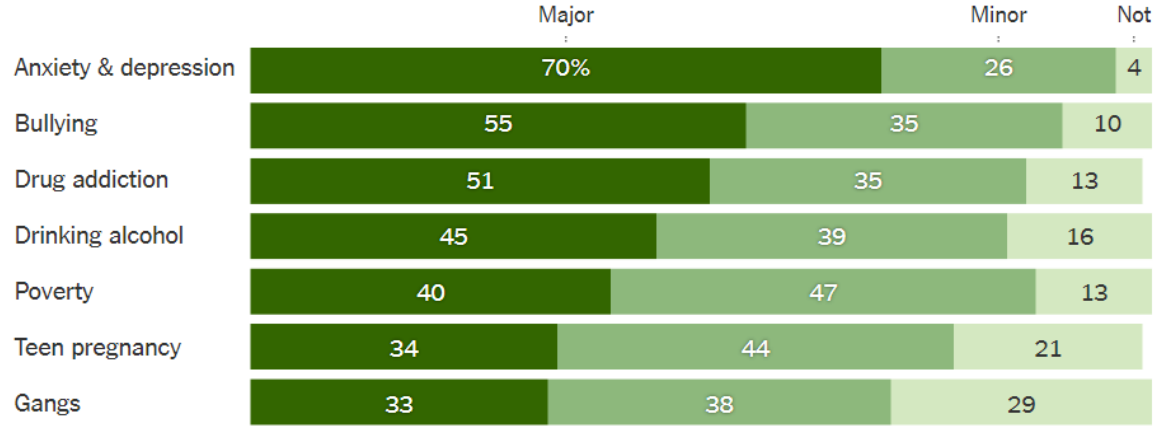
- Bar plot
  - Categories on one axis
  - Counts/percentages on the other axis
  - AKA: bar graph, bar chart, barplot



The California-related topics the president tweets most frequently about (Sept. 17, 2019), via Priya Krishnakumar at The LA Times

Data Visualization

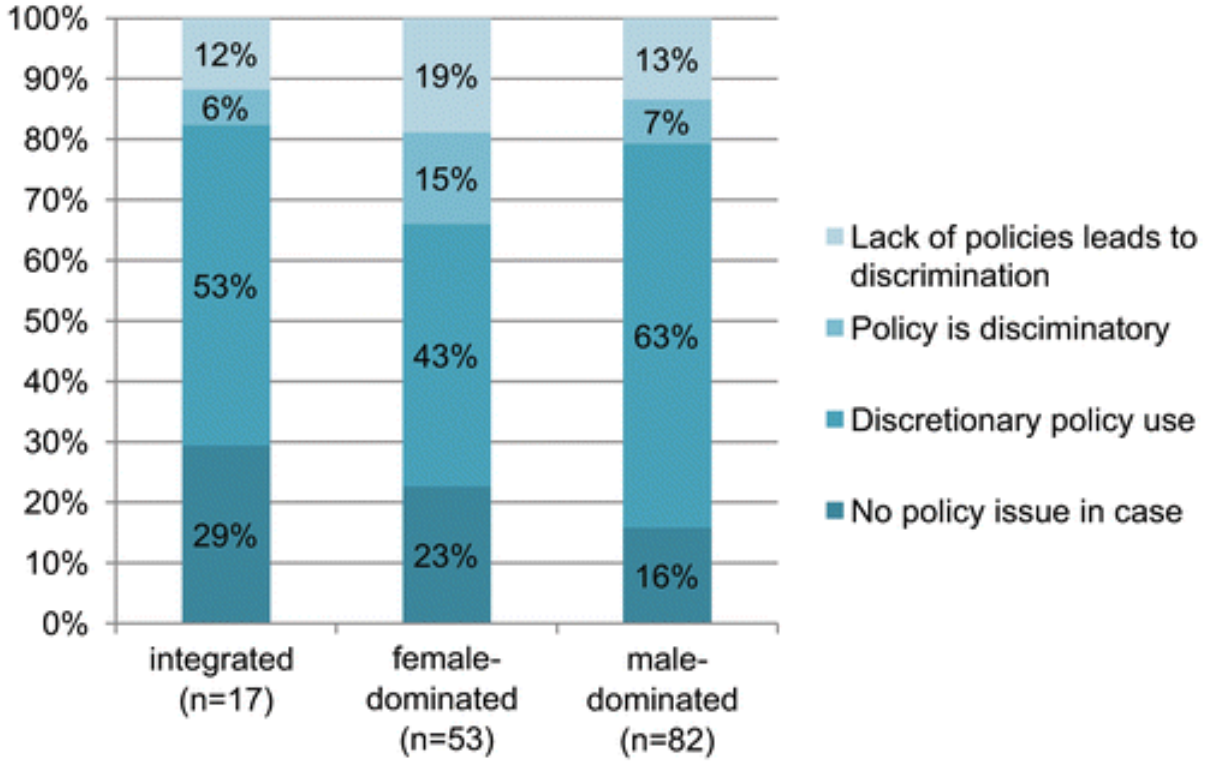
- Stacked bar plot
  - Categories on one axis
  - Percentage on other axis
  - Bar divided into percentages of how common 2nd categorical variable is within your axis category
  - Full bar should add up to 100%



Teenagers Say Depression and Anxiety Are Major Issues Among Their Peers (Feb. 29, 2019), via Karen Zraick at The New York Times

Data Visualization

- Stacked bar chart
  - What's going on here?



Gender Discrimination at Work: Connecting Gender Stereotypes, Institutional Policies, and Gender Composition of Workplace (Dec. 5, 2011), via Donna Bobbitt-Zeher at Gender & Society

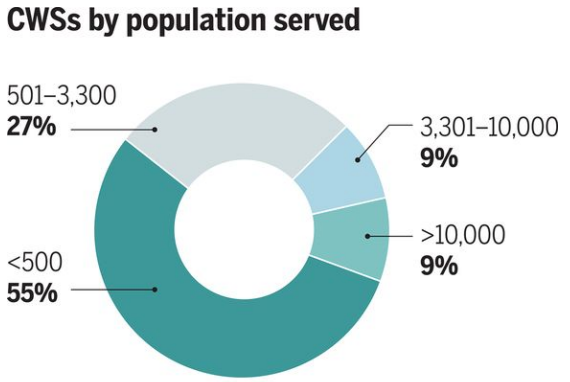
Data Visualization

- Pie chart
  - Can also visualize percentages
  - No real axes
  - Total circle = 100%
  - Each wedge corresponds to percentage of total observations correspond to one category
  - People are much worse at judging volume by circle wedge than volume by box, though

Salvaging the Pie (Sept. 26, 2014), via Joey Cherdarchuk at Darkhorse Analytics

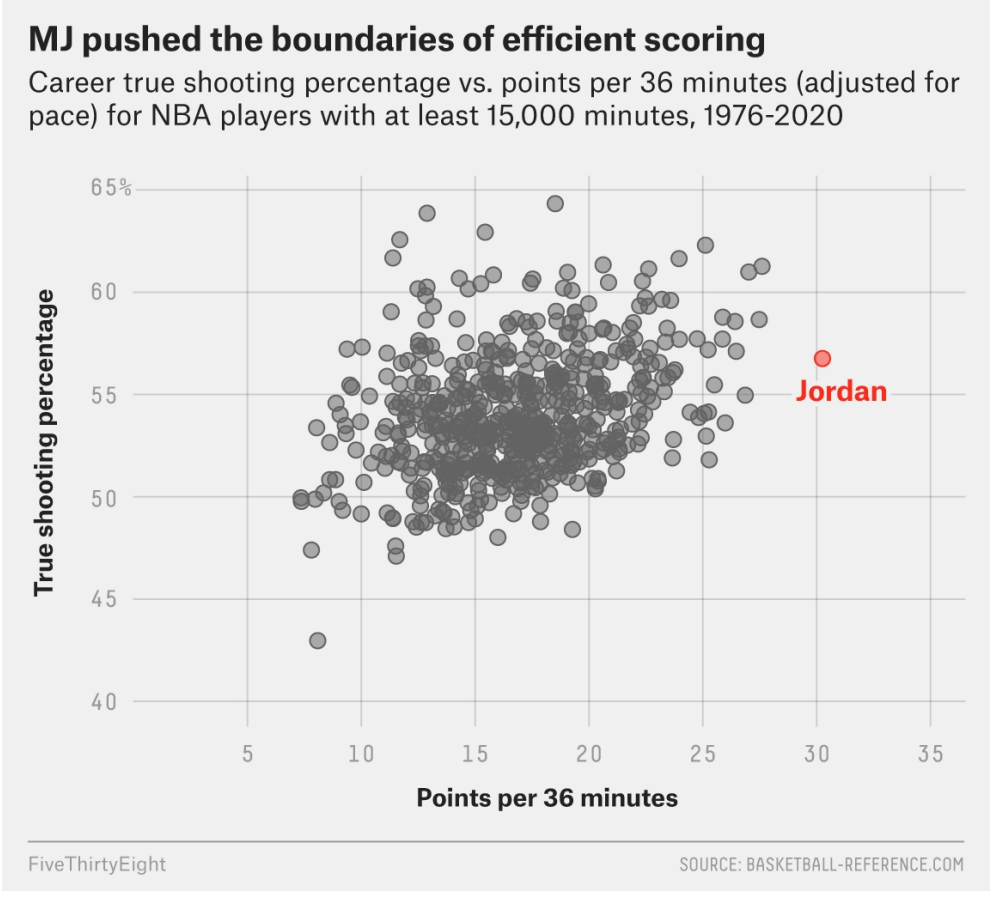
Data Visualization

- Pie chart & stacked bar plot
  - What's going on here?
  - CWS = community water system



Data Visualization

- Scatter plot
  - Quantitative variable on one axis
  - Another quantitative variable on other axis
  - Observations shown as points



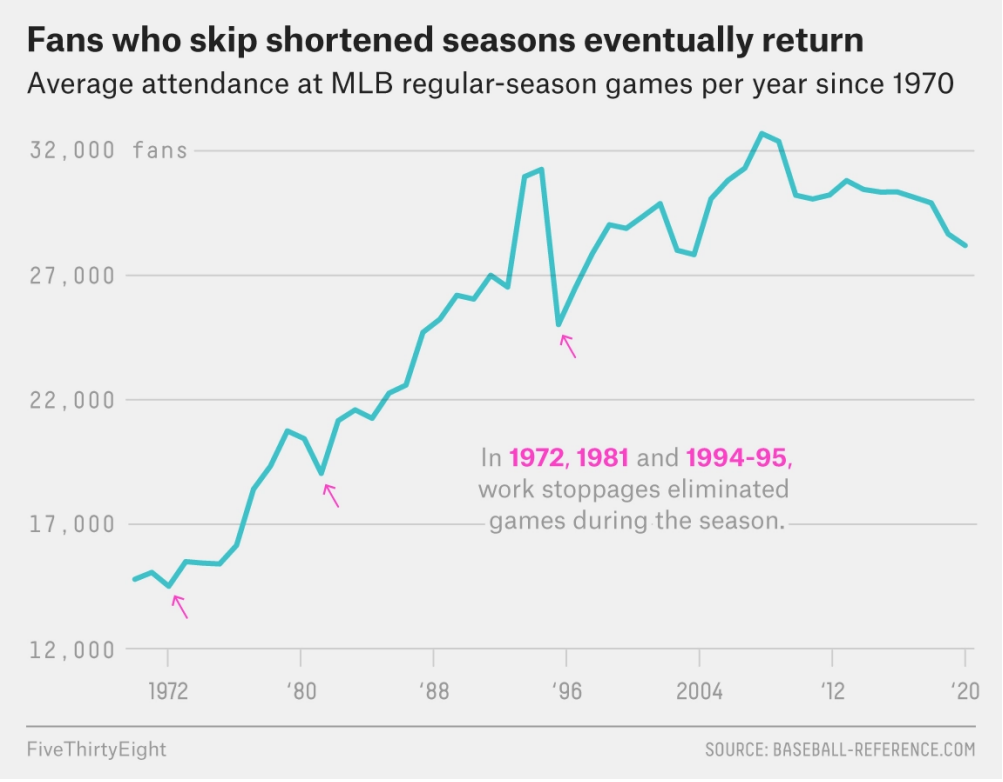
Why Michael Jordan Was The Best (April 17, 2020), via Neil Paine at FiveThirtyEight

Data Visualization

- Scatter plot
    - What's going on here?

Data Visualization

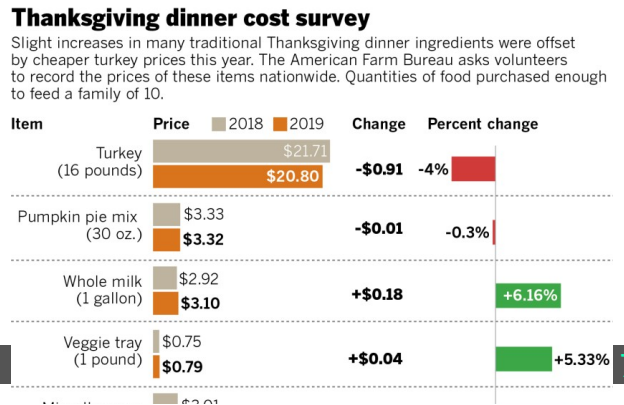
- Line plot
  - Time on one axis (usually x-axis)
  - Quantitative variable on other axis
  - Line connecting each observation (usually the peaks in the line)
  - Good for observing trends over time



Do Baseball's Labor Fights Drive Fans Away? (June 12, 2020), via Travis Sawchik at FiveThirtyEight

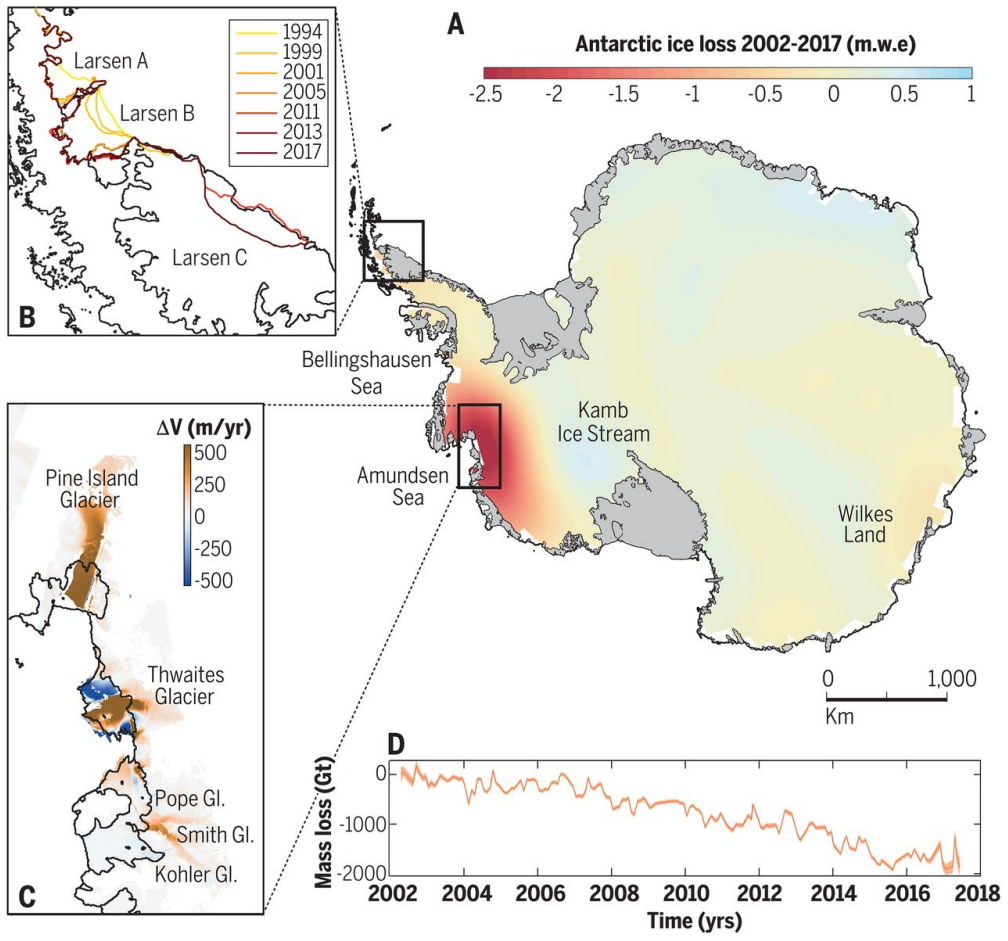
Data Visualization

- Line plots
  - What's going on here?



Data Visualization

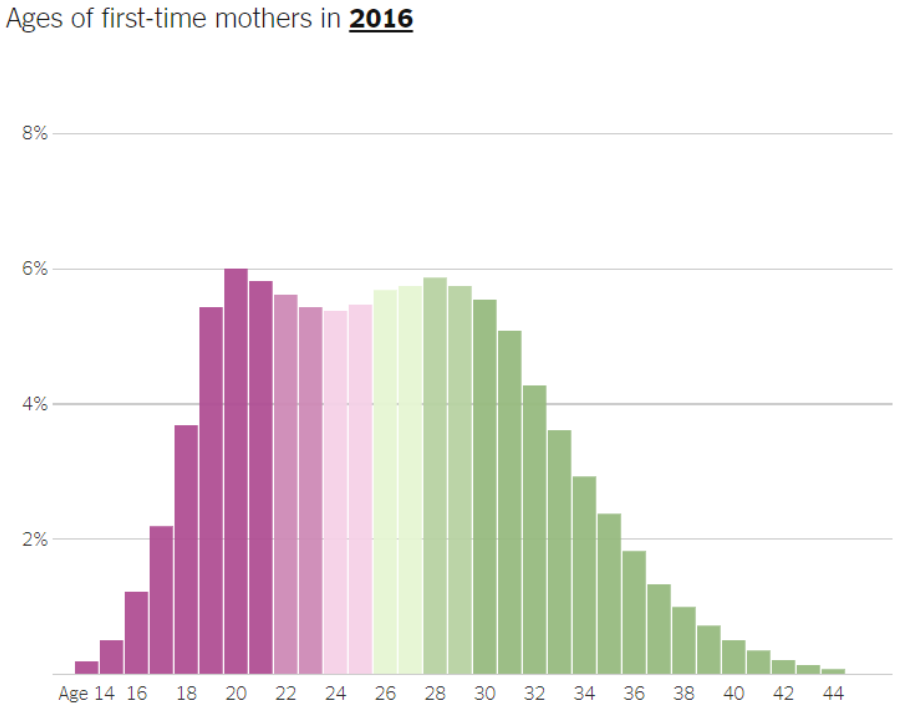
- Line plots
  - What's going on here (part D)?



History, mass loss, structure, and dynamic behavior of the Antarctic Ice Sheet (March 20, 2020), via Robin E. Bell & Helene Seroussi at Science

Data Visualization

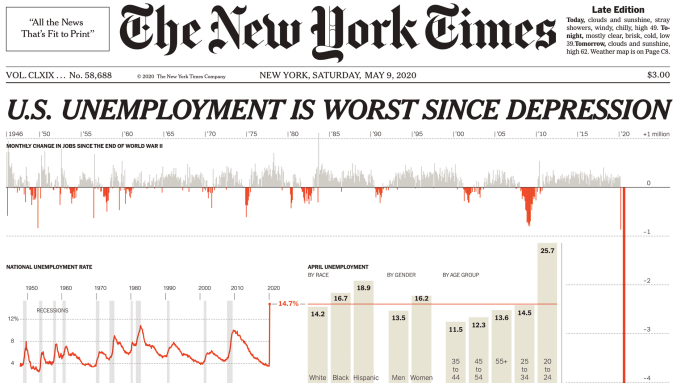
- Histogram
  - Like a bar plot, but instead of counts of observations in categories we have counts of observations in intervals (bins) of a quantitative variable
  - You can change the interval width (and the # of bars) for histograms; you can't combine or divide categories for bar plots
  - Good for figuring out the data's shape



The age of first-time mothers in 2016 (Aug. 4, 2018), via Quoctrung Bui at The New York Times

Data Visualization

- Histogram
  - What's going on here?


"All the News That's Fit to Print"

The New York Times

Late Edition

Today, clouds and sunshine, stray showers, windy, chilly, high 49. Tonight, mostly clear, brisk, cold, low 33.Tomorrow, clouds and sunshine, high 62. Weather map is on Page C8.

VOL. CLXIX . . . No. 58,688 © 2020 The New York Times Company NEW YORK, SATURDAY, MAY 9, 2020 $3.00

U.S. UNEMPLOYMENT IS WORST SINCE DEPRESSION

MONTHLY CHANGE IN JOBS SINCE THE END OF WORLD WAR II

NATIONAL UNEMPLOYMENT RATE

RECESSIONS

14.7%

APRIL UNEMPLOYMENT

BY RACE

14.2 White, 16.7 Black, 18.9 Hispanic

BY GENDER

13.5 Men, 16.2 Women

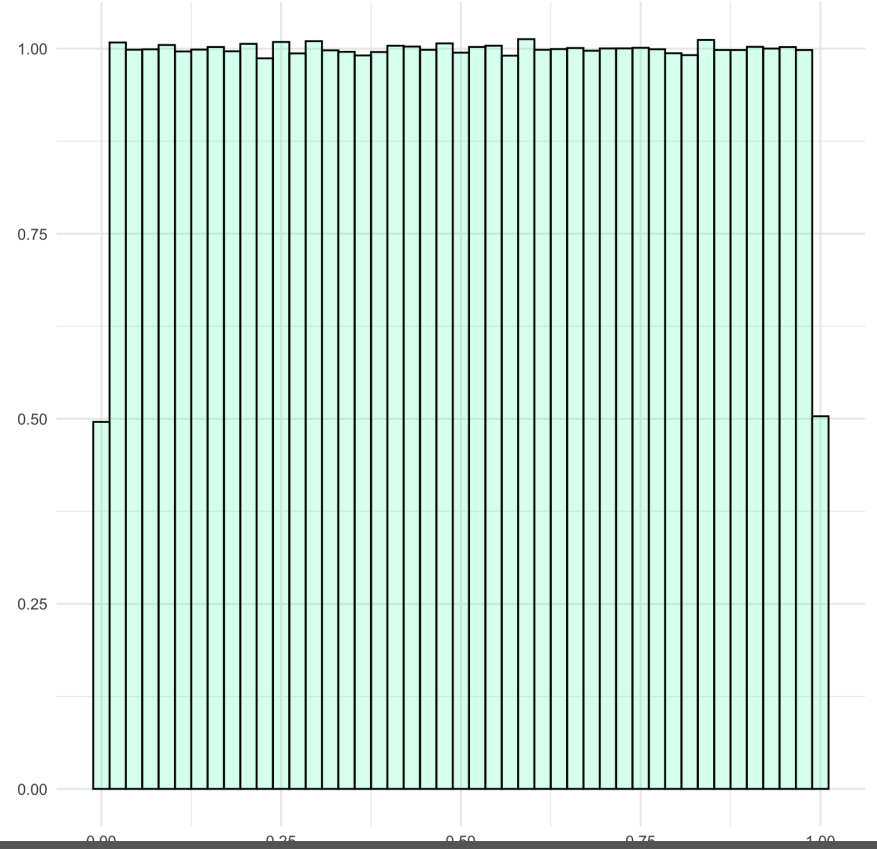
BY AGE GROUP

11.5 (35 to 44), 12.3 (45 to 54), 13.6 (55+), 14.5 (25 to 34), 25.7 (20 to 24)

Data Shapes

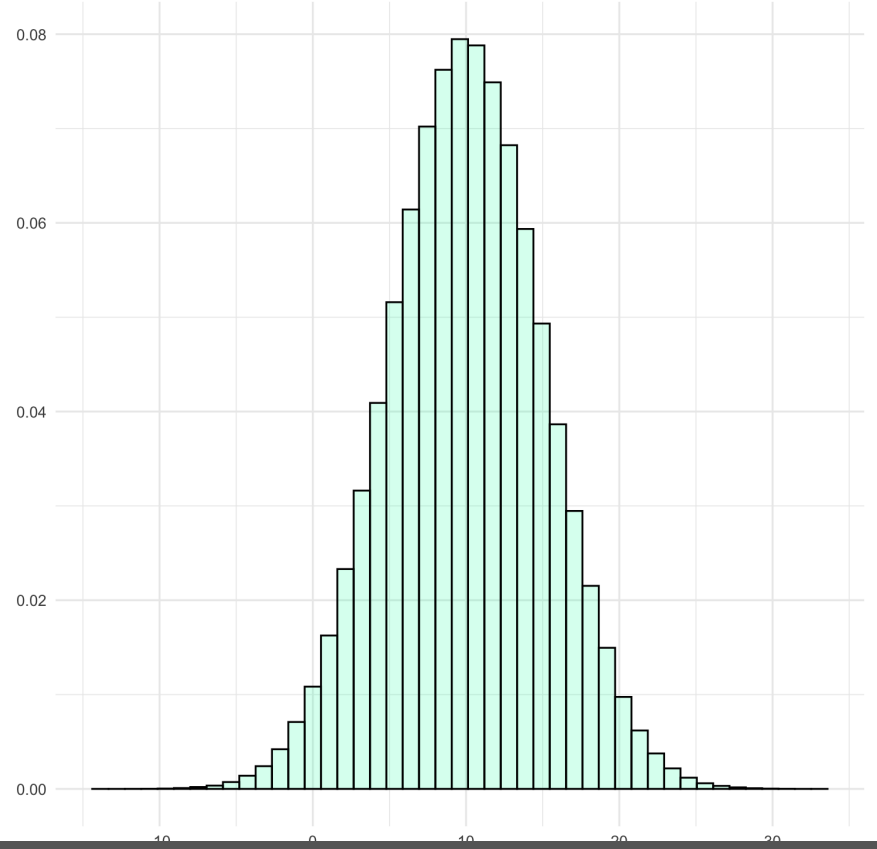
Uniform

- No defined peaks



Unimodal

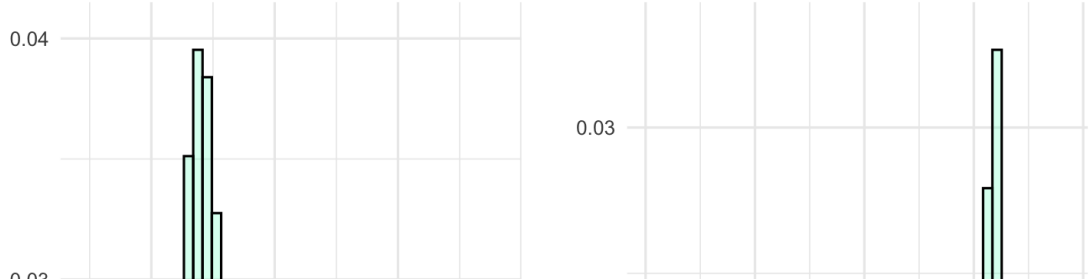
- One defined peak



Data Shapes

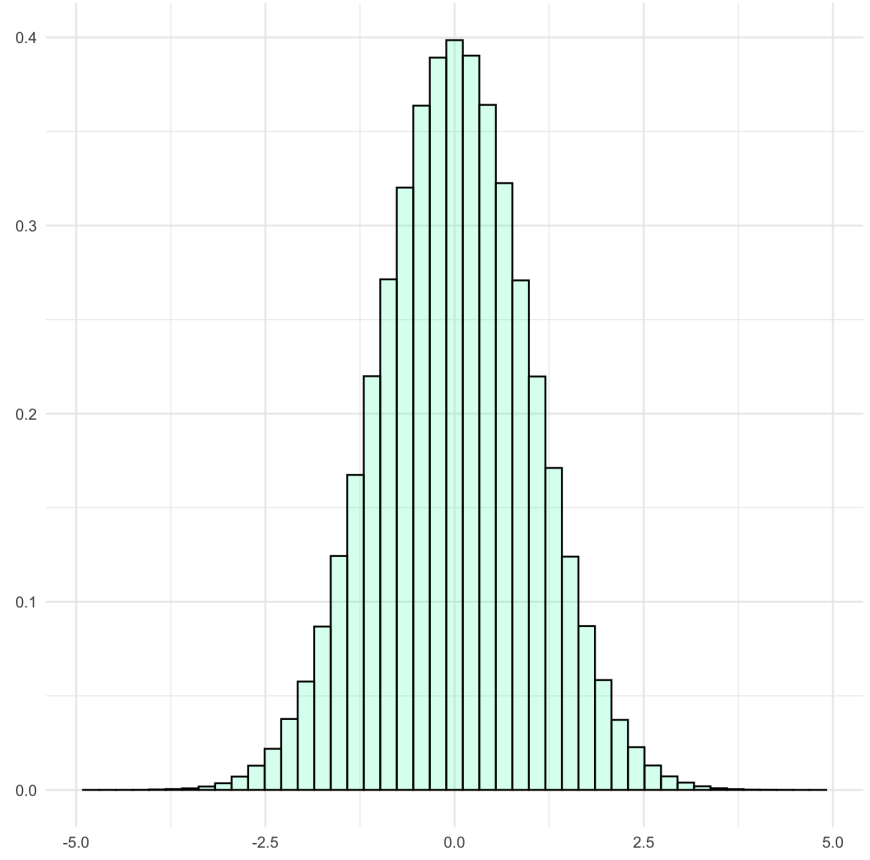
Multimodal

- Multiple defined peaks

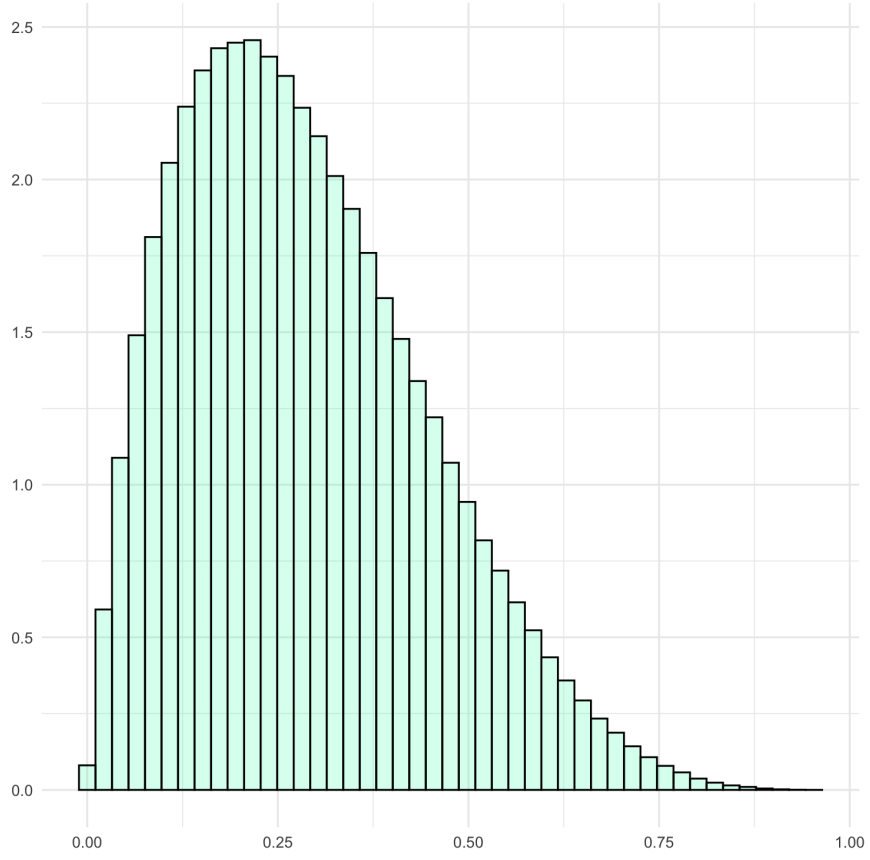


Data Shapes

Symmetrical

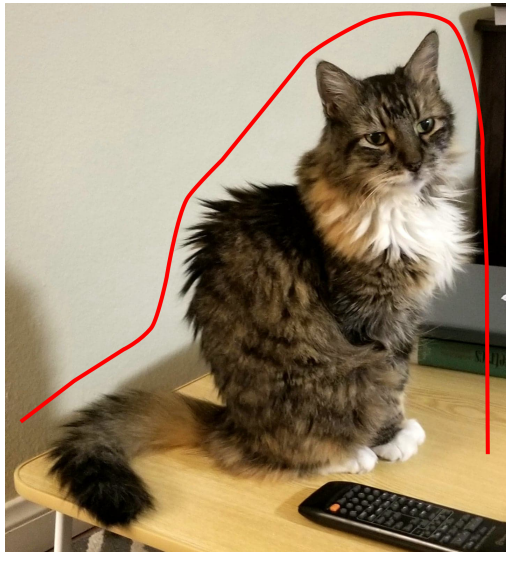


Skewed



Skew

- Skew is what happens when the mean and median aren't exactly the same
- Right (positive) skew
  - Mean to the right **(greater than)** median
- Left (negative) skew
  - Mean to the left **(less than)** median
- When in doubt, look for the "tail"



Left skew (and good bean)

Five Number Summary

- Getting a 10,000-foot view of the data's shape
- The five number summary contains:
  - Minimum
  - 1st quartile (25^{th} percentile)
    - 25% of data are below the 1st quartile
  - Median (50^{th} percentile)
  - 3rd quartile (75^{th} percentile)
    - 75% of data are below the 3rd quartile
  - Maximum

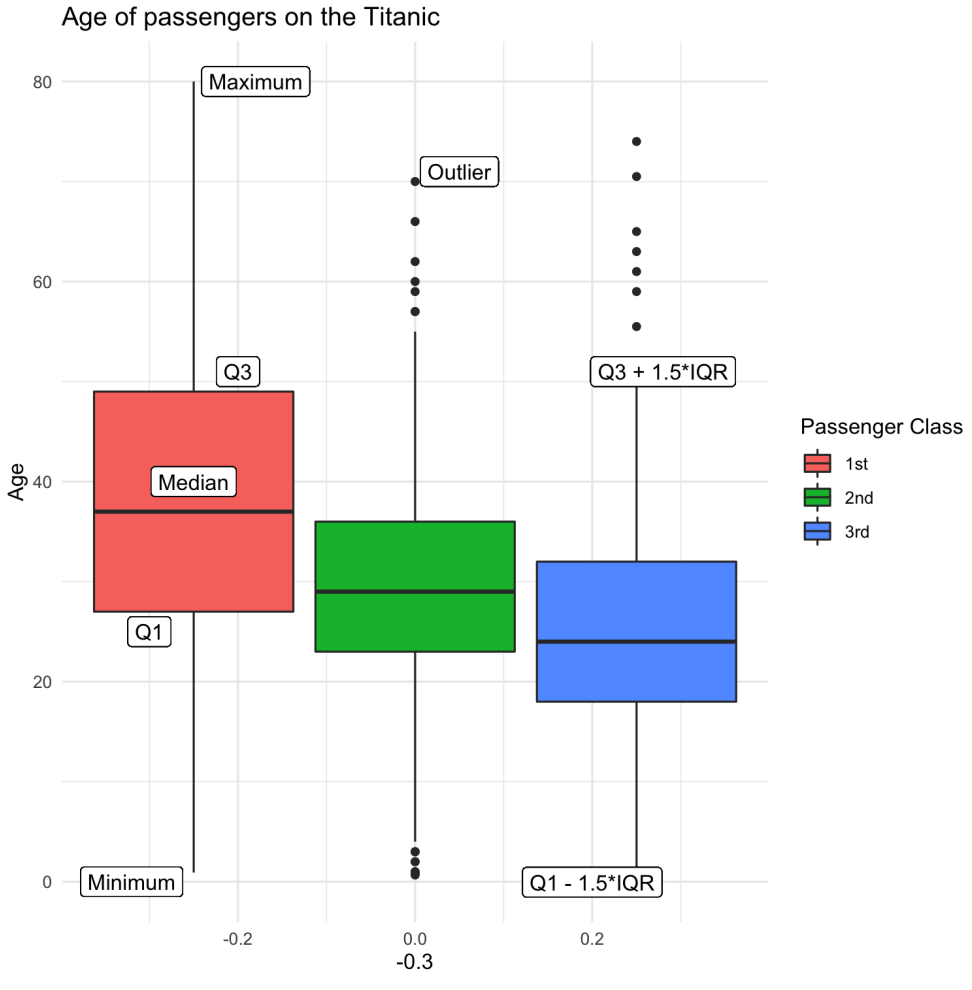
Data Visualization

- **Boxplot**
  - Bottom line of box at 1st quartile
  - Top line of box at 3rd quartile
  - Line in middle of box at median
  - Box "whiskers" extend from minimum to maximum, or to "outlier fences"

$$\text{Upper fence:} Q3 + 1.5 \times (Q3 - Q1)$$

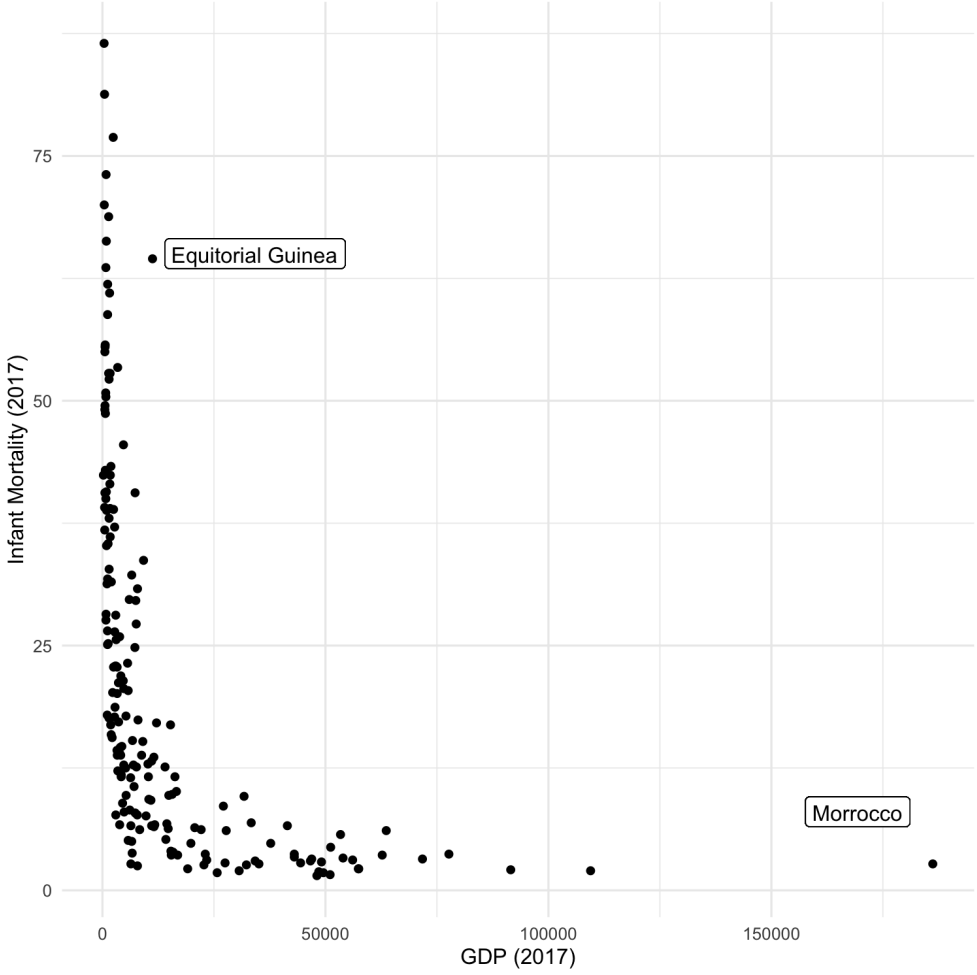
$$\text{Lower fence:} Q1 - 1.5 \times (Q3 - Q1)$$

  - Dots are outliers
    - Observations above $Q3 + 1.5 \times IQR$ or below $Q1 - 1.5 \times IQR$



Outliers

- Outliers are data points that are strangely far away from the rest of the data
- Could signal that the values of those observations are wrong
    - Data entry error, recorded in inches instead of centimeters, etc.
- Could just be strange observations
- Outliers will create skew, pull your mean away from the median



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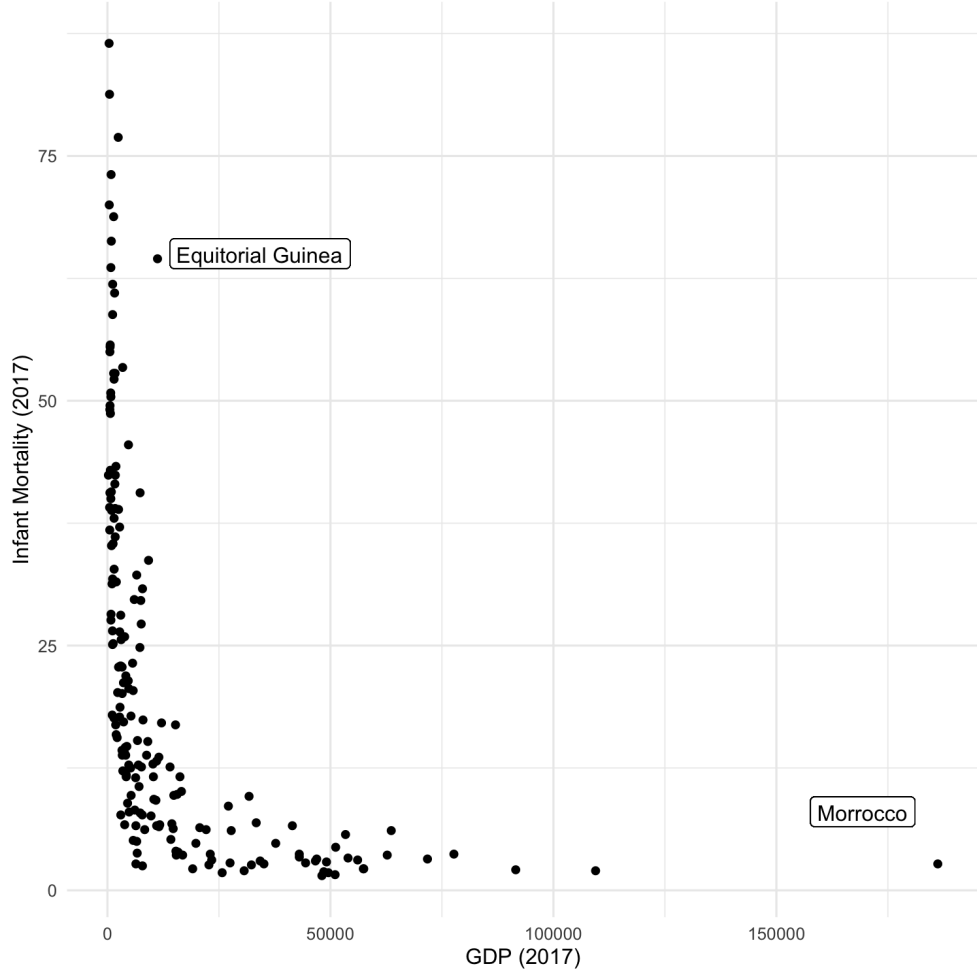
- What do we do with them?



Data Visualization

- Histogram vs. boxplot
  - Histograms give a more detailed view of data shape than boxplots
  - Because its less detailed, boxplots can be better for comparing the data shapes of multiple groups