ECON 3818

Chapter 2

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21 July 2021

Chapter 2: Describing Distribution with Numbers

Chapter Overview

- Population vs. Sample
- Measures of Central Tendency
- Mean

- Median

- Measures of Variability

- Quartiles
- Variance \& Standard Deviation

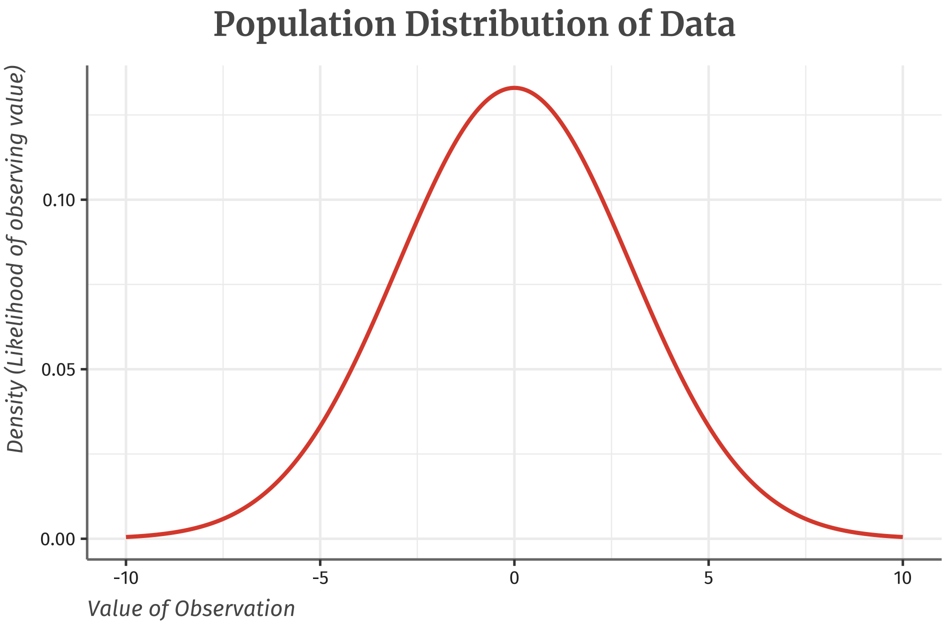
Population vs Sample

- **Population**: the entire entities under the study
- Examples: all men, all NBA players, all children under 5
- **Sample**: subset of the population
- Can be used to draw inferences about the population
- Examples: our class, Denver Nuggets players, daycares in Colorado
- Interested in parameters of the **population** distribution, we can estimate these parameters using data from **samples** since finding population parameters is infeasible

Population Distribution

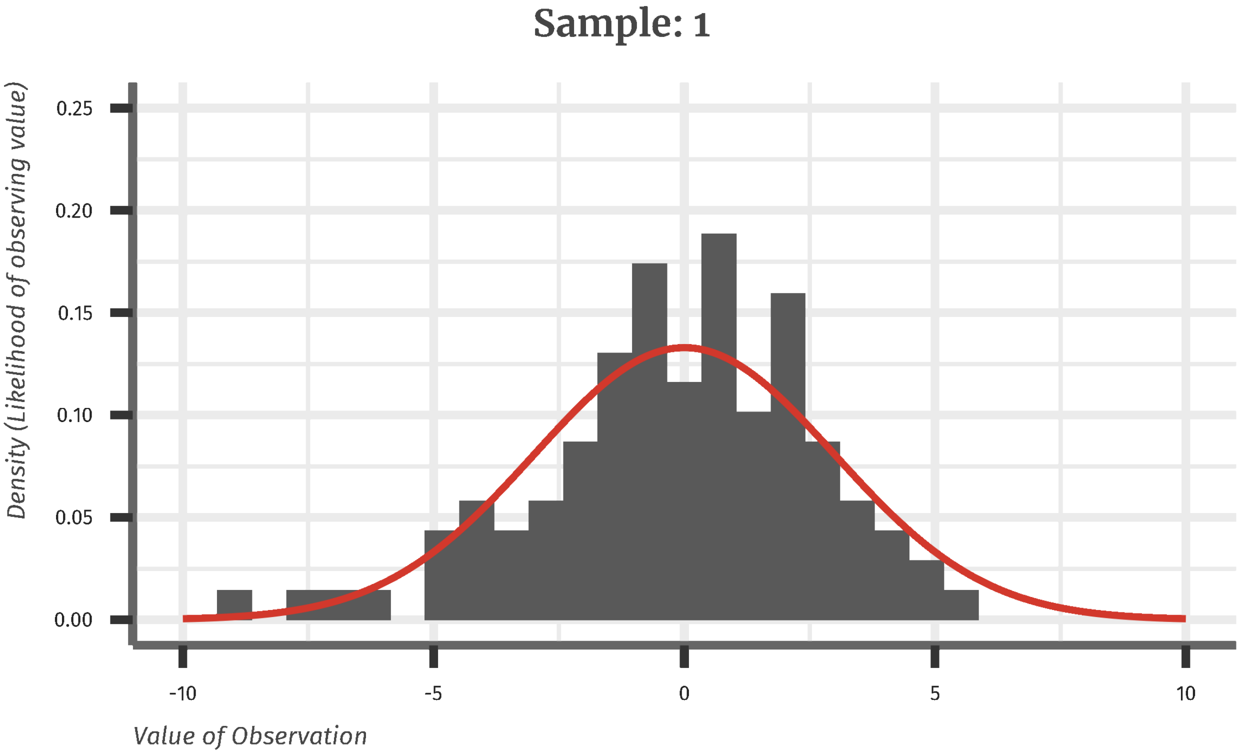
The following graph depicts the underlying population distribution

- We are interested in its parameters, but are unable collect data on every single observation



Population Inference

What we do instead is use a sample of the population and use that sample distribution to determine parameters of interest



Parameters of Interest

Two primary **population** parameters of interest:

- Measures of central tendency:
  - Population mean, μ
  - Population median
- Measures of variability:
  - Population variance, σ^2

We will *estimate* these using the **sample** distribution

Measuring Center: the Mean

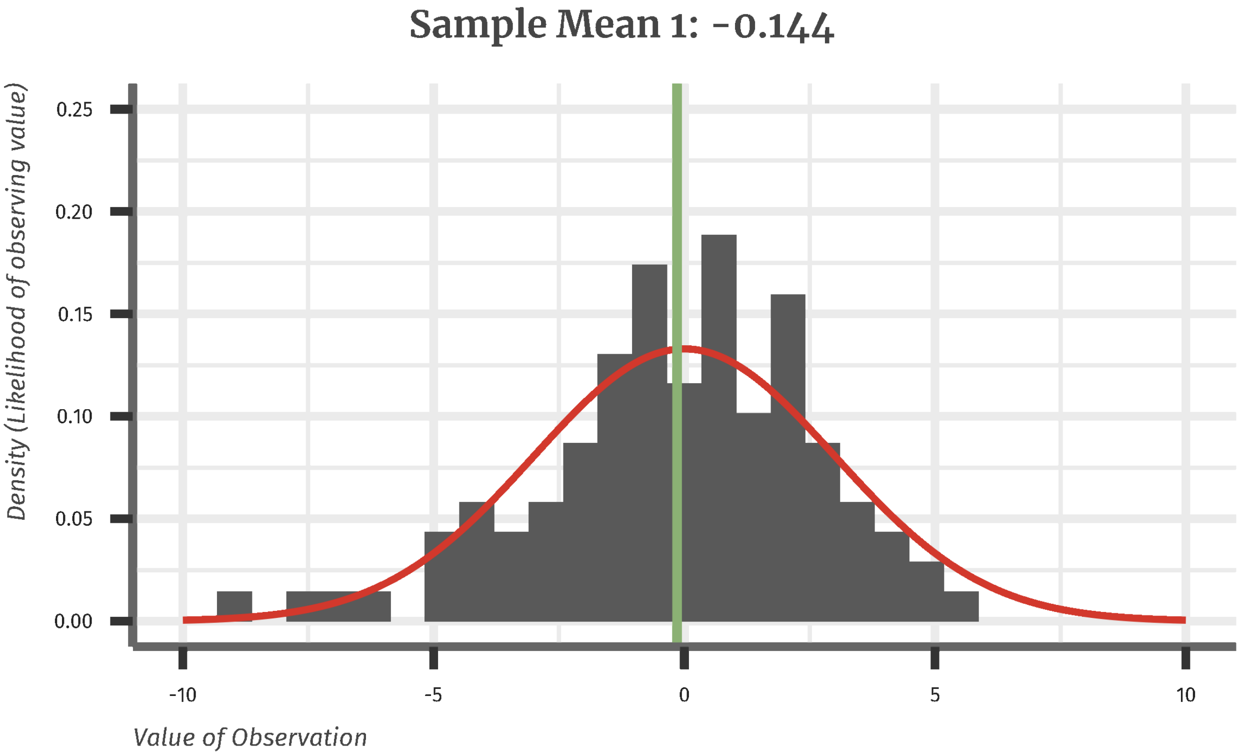
The most common measure of center is the arithmetic average, or **mean**

$$\bar{x} = \frac{x_1 + x_2 + \ldots + x_n}{n}$$

or more compactly:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Population Inference: Mean



Measuring Center: the Median

The **median** is the midpoint of a distribution

- Is more resistant to the influence of **extreme observations**

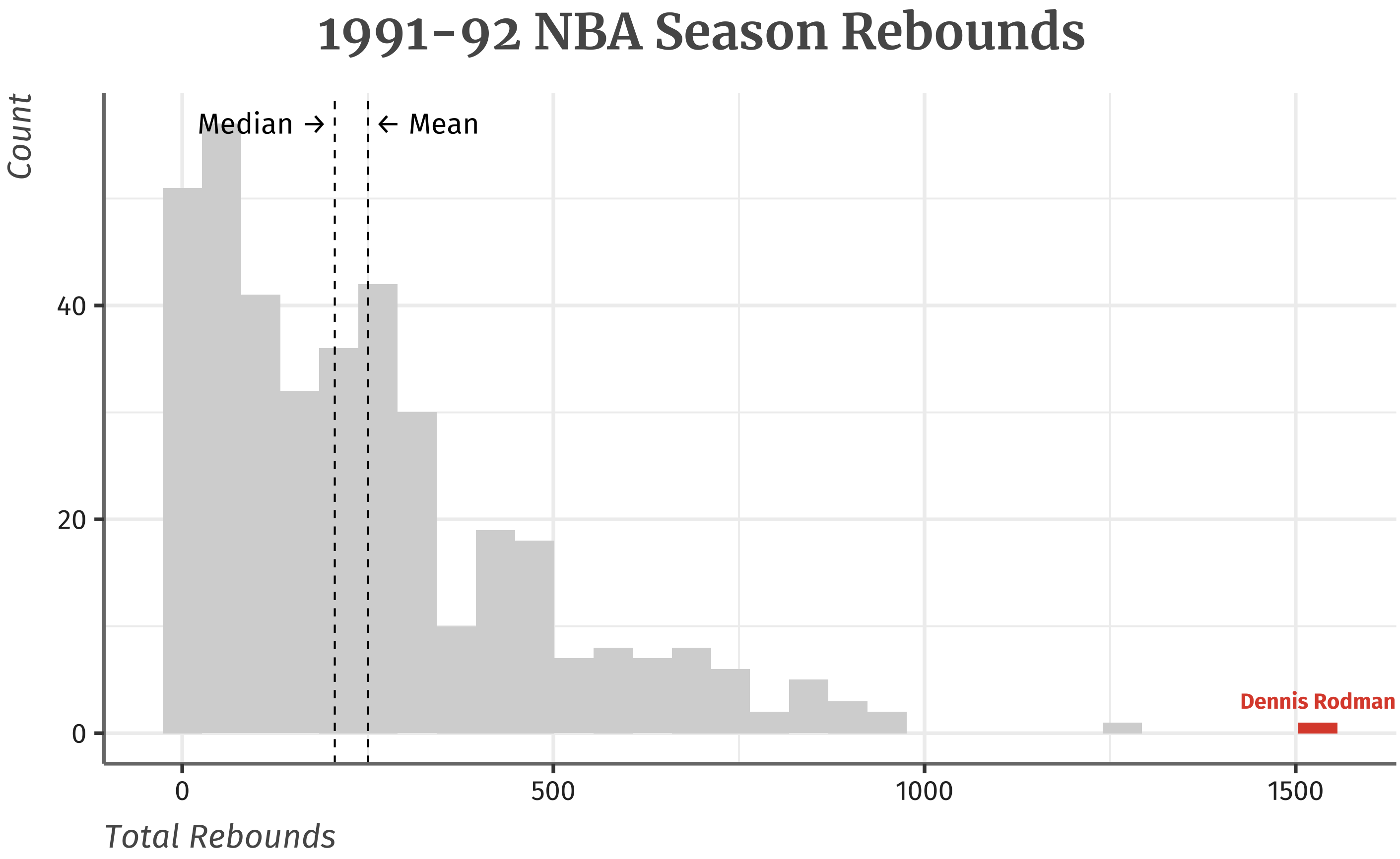
How to calculate median:

- Arrange observations from smallest to largest
- If there is odd number of observations, the median is the center observation. If there are even number of observations, the median is the average of two center observations

Mean vs. Median

- Although we will primarily be using the mean throughout the semester, the biggest drawback of the mean is that it is not resistant to **outliers**
- The median, however, is resistant to **outliers** so it can be important to calculate for smaller samples

Mean vs. Median Example

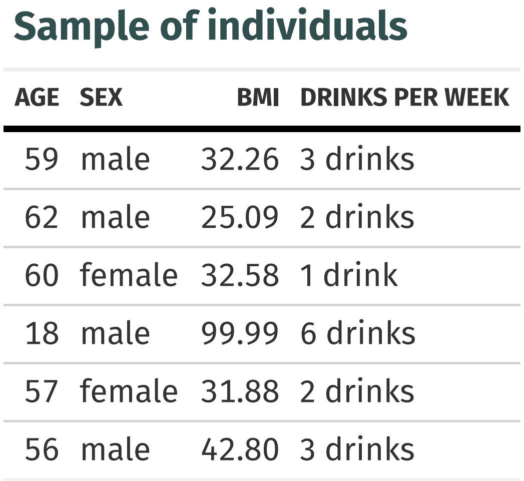


Data from Basketball Reference.

Median: 205.5 rebounds and **Mean**: 250.5 rebounds

Clicker Question

What is the sample average of the participants?



Sample of individuals

AGE	SEX	BMI	DRINKS PER WEEK
59	male	32.26	3 drinks
62	male	25.09	2 drinks
60	female	32.58	1 drink
18	male	99.99	6 drinks
57	female	31.88	2 drinks
56	male	42.80	3 drinks

a. 58

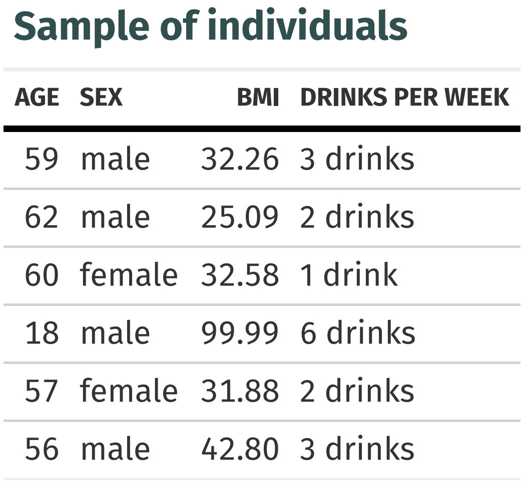
b. 51.2

c. 52

d. 49.7

Clicker Question

Which measure of central tendency best describes the age of participants?



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a. Median

b. Mean

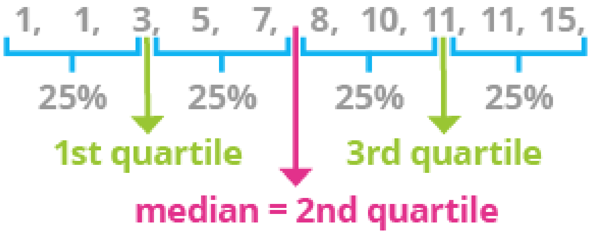
Measuring Variability

Measures of central tendency do not tell the whole story. To further characterize the distribution, we need to know how the data is spread out

- Quartiles
- Variance

Variability: Quartiles

- Measure of center alone can be misleading
- How to calculate quartiles:
- Arrange observations in increasing order and locate **median**
- The **first quartile** is the median of the observations located to the left of the median
- The **third quartile** is the median of observations located to the right of the median



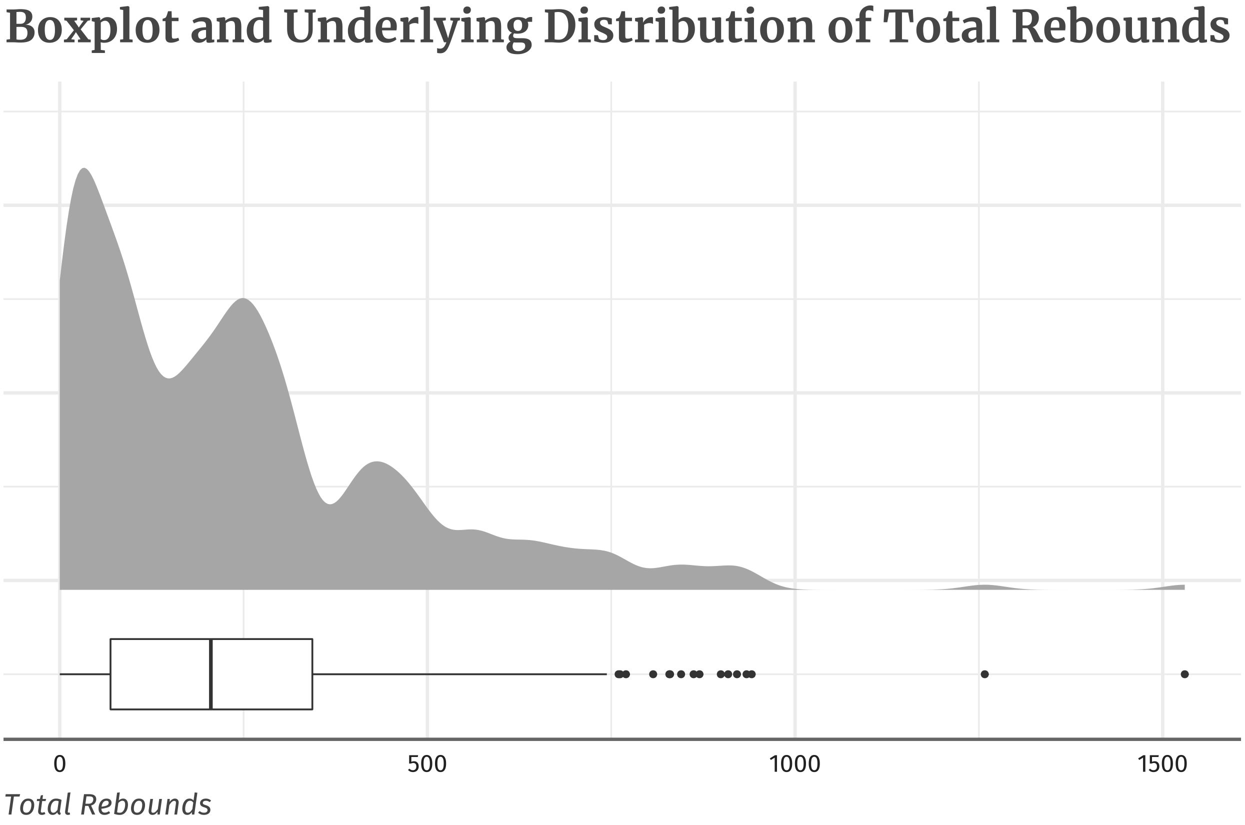
Boxplots

five-number summary: smallest observation (minimum), the first quartile, the median, the third quartile, and the largest observation (maximum)

We can use the **boxplot** using this five number summary to display quantitative data

- How to make a boxplot:
- A central box spans the first and third quartiles
- A line in the box marks the median
- Line extends from the box out to the smallest and largest observations

Boxplots


Boxplot and Underlying Distribution of Total Rebounds
0
500
1000
1500
Total Rebounds

Interquartile Range

The **interquartile range**, IQR, is the distance between the first and third quartiles

- IQR = $Q_3 - Q_1$
- The IQR measures the spread of the data and it also helps to identify outliers

Rule for outliers:

- An observation is an outlier if it falls more than $1.5 \times IQR$ above the third quartile or below the first

Variability: Variance

Variance: denoted, s^2, measures how "spread out" the data are on average

$$s^2 = \frac{(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + \ldots + (x_n - \bar{x})^2}{n-1},$$

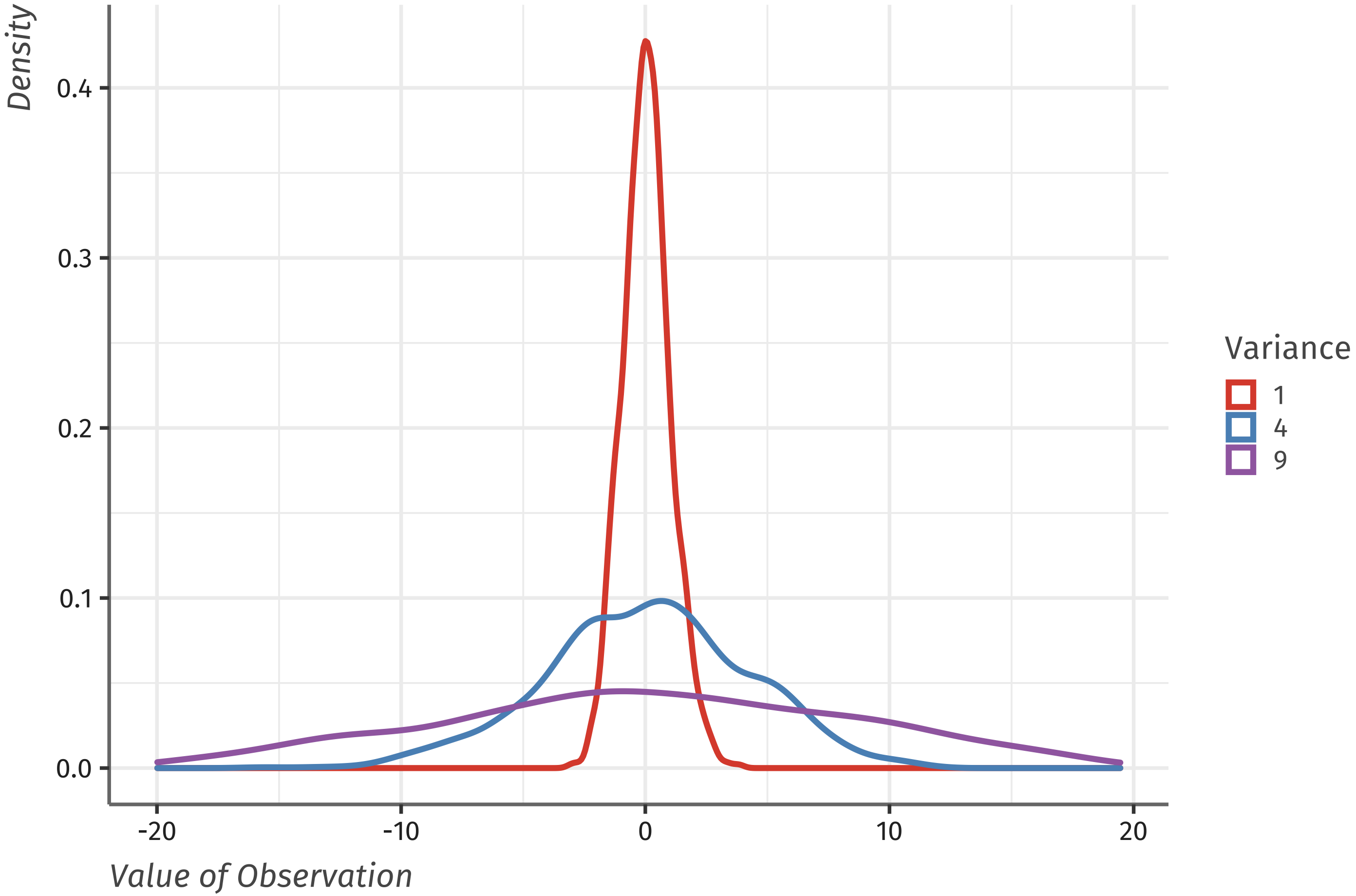
or more compactly

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

Standard deviation: looks at how far each observation is from the mean; square root of the variance

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

Visualizing Standard Deviation



Practice Question

Calculate the standard deviation of age?

Sample of individuals

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Properties of Standard Deviation, s

- $n-1$ is referred to as the degrees of freedom
- s measures variability about the mean
- s is always greater than or equal to zero, but usually > 0
  - When would it be $= 0$?
- As observations become more variable, s gets larger
- s is not resistant in the same way the sample mean is not resistant; a few outliers can change it a lot.

Summary of Summary Statistics

Two basic ways to summarize the center and spread of a distribution

- Mean and standard deviation (or variance)
- The five-number summary

When to Use Which

Use $\bar{x}$ and s when the distribution is reasonably symmetric and free of outliers

Use five-number summary if distribution is skewed, or has outliers

Greek Letters and Statistics

Greek Letters

- Greek letters like $\boldsymbol{\mu}$ and $\boldsymbol{\sigma}^2$ represent the truth about the population.

Latin Letters

- Latin lettes like $\bar{\boldsymbol{x}}$ and $\boldsymbol{s}^2$ are calculations that represent guesses (estimates) at the population values.

The goal for the class is for the latin letters to be good guesses for the greek letters:

$$\text{Data} \longrightarrow \text{Calculation} \longrightarrow \text{Estimates} \longrightarrow^{hopefully!} \text{Truth}$$

For example,

$$X \longrightarrow \frac{1}{n}\sum_{i=1}^{n} X_i \longrightarrow \bar{x} \longrightarrow^{hopefullly!} \mu$$

Install R and R Studio

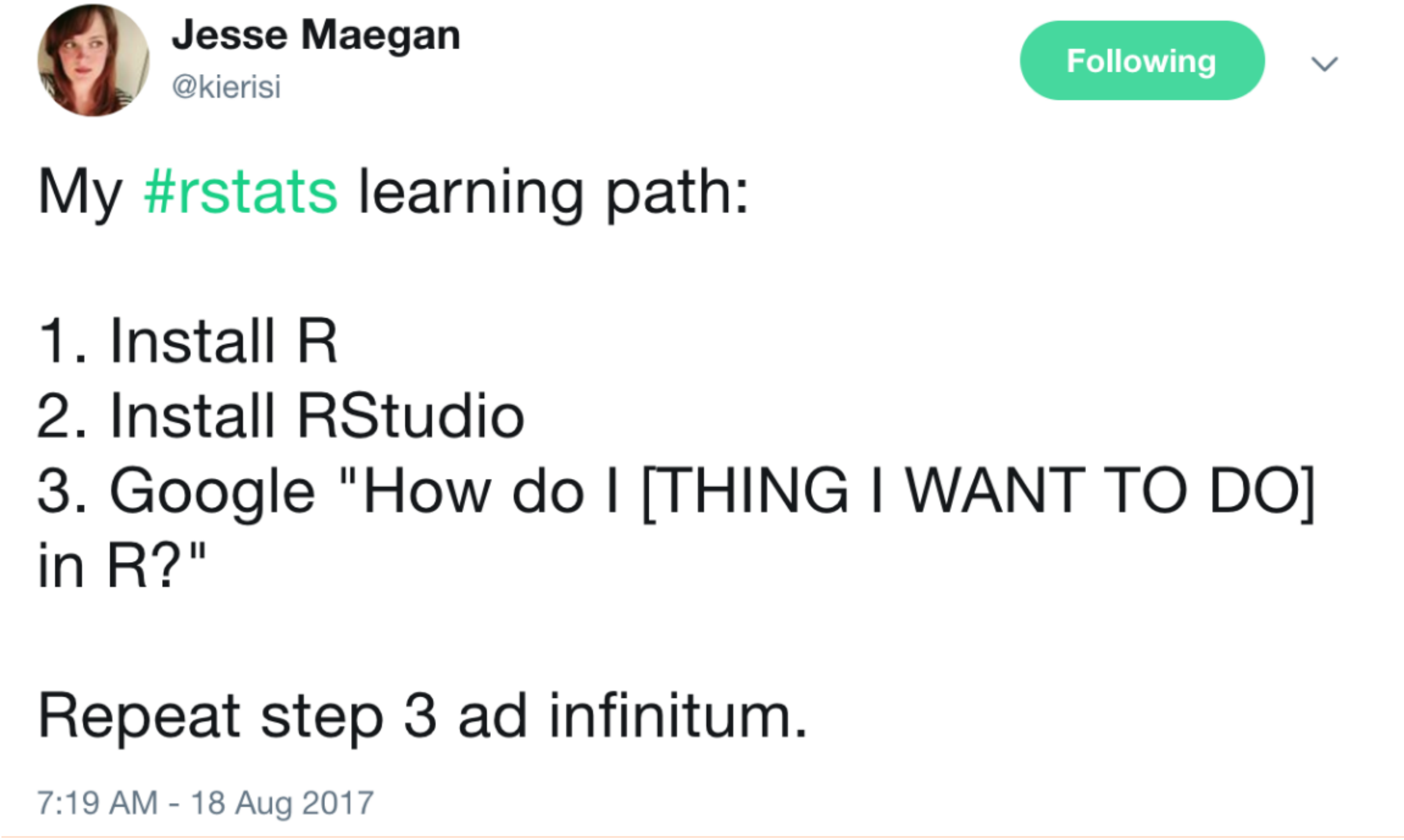
Download R: https://www.r-project.org/

- Click "download R" link under "Getting Started"
- Select a CRAN location (mirror site) and click link
- I selected the UC Berkeley one, pick one in USA
- Click on "Download R for Mac/Windows/etc" link at top of page
- Click on package to download, under "Latest Release"
- Save the .pkg file, double click open, and follow instructions

Download RStudio: https://www.rstudio.com/

- \url{www.rstudio.com} and click "Download RStudio"
- Click on "download RStudio Desktop"

How to use R



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My #rstats learning path:

1. Install R
2. Install RStudio
3. Google "How do I [THING I WANT TO DO] in R?"

Repeat step 3 ad infinitum.

7:19 AM - 18 Aug 2017