Numerical data

Visualization and summary statistics (part 1)

9/16/24

Variables types

- Variables can be broadly broken into two categories: numerical (quantitative) or categorical (qualitative)
- **Numerical** variables take a wide range of numerical values, and it is sensible to add/subtract/do mathematical operations with those values. Two types:
    1. **Discrete** if it can only take on finitely many numerical values within a given interval
    2. **Continuous** if it can take on any infinitely many values within a given interval
- **Categorical** variables are essentially everything else (more on this next week!)
- Examples and non-examples?

Example

We will be looking at some medical insurance data throughout these slides.

Which of the following variables are numerical? Which are discrete vs. continuous?

Show 5 entries Search:

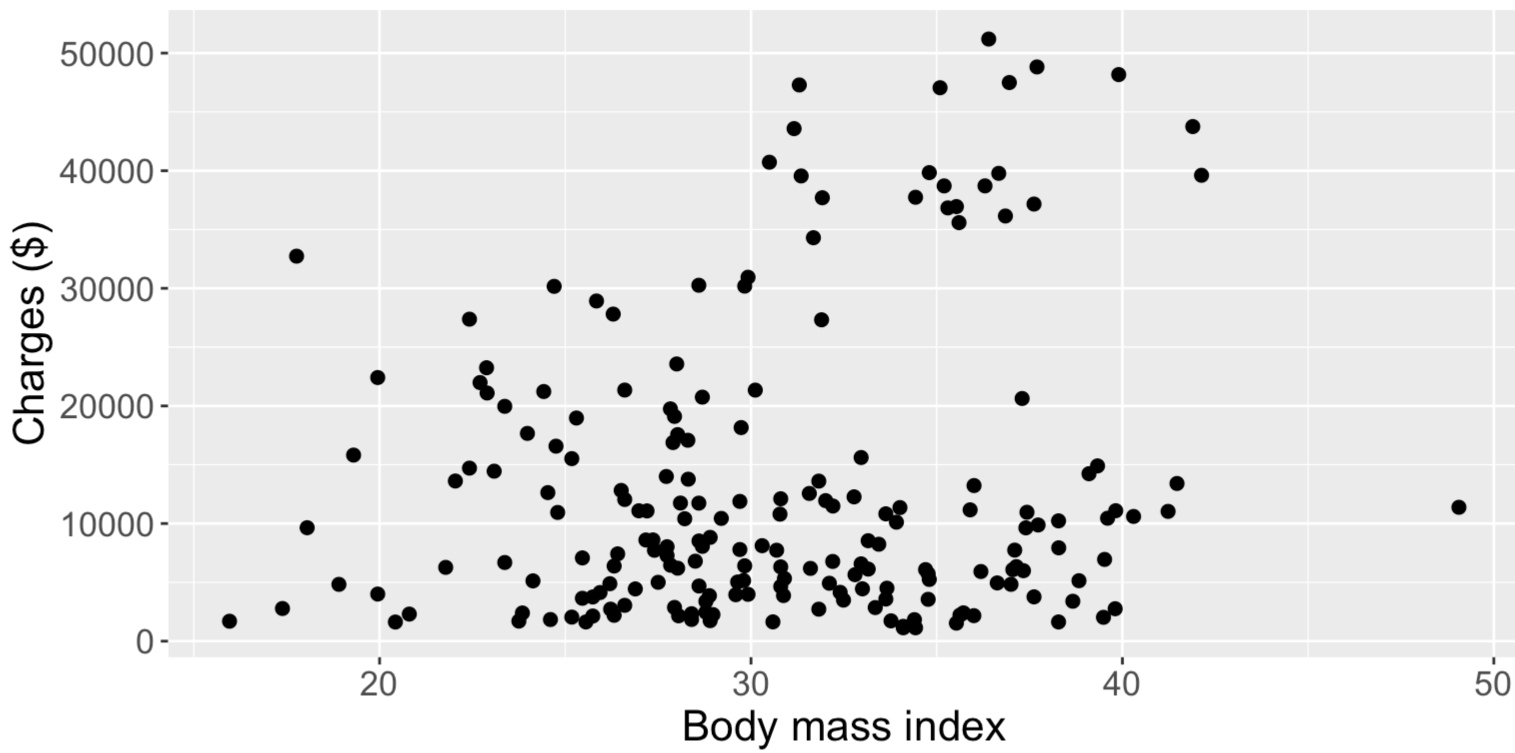
	age	sex	bmi	children	smoker	region	charges
1	19	female	27.9	0	yes	southwest	16884.924
2	18	male	33.77	1	no	southeast	1725.5523
3	28	male	33	3	no	southeast	4449.462
4	33	male	22.705	0	no	northwest	21984.47061
5	32	male	28.88	0	no	northwest	3866.8552

Showing 1 to 5 of 200 entries

Scatterplots

Scatterplots are *bivariate* (two-variable) visualizations that provide a case-by-case view of the data for two numerical variables

- Each point represents the observed pair of values of variables 1 and 2 for a case in the dataset

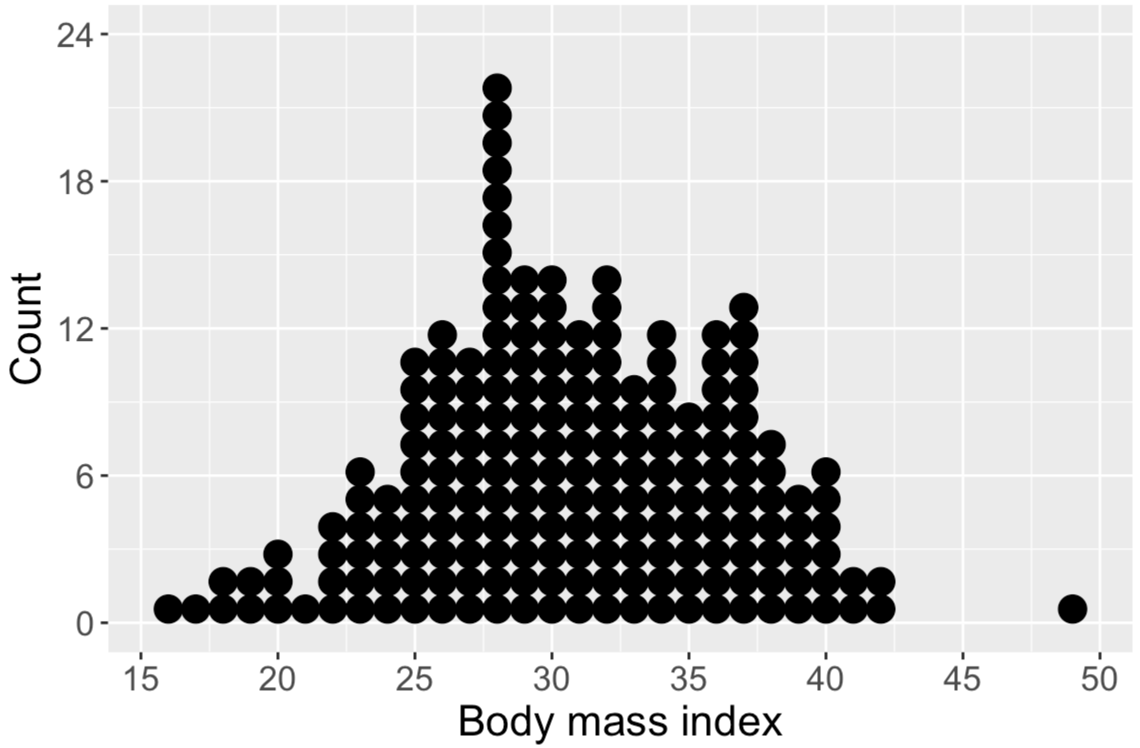


Scatterplots (cont.)

- How do we determine which variable to put on each axis?
- What do scatterplots reveal about the data, and how are they useful?

Dot plots

- Dot plots are a basic visualization that show the *distribution* of a single variable (univariate)
- In the following, we have a dot plot of `BMI` rounded to the nearest integer.



Binning

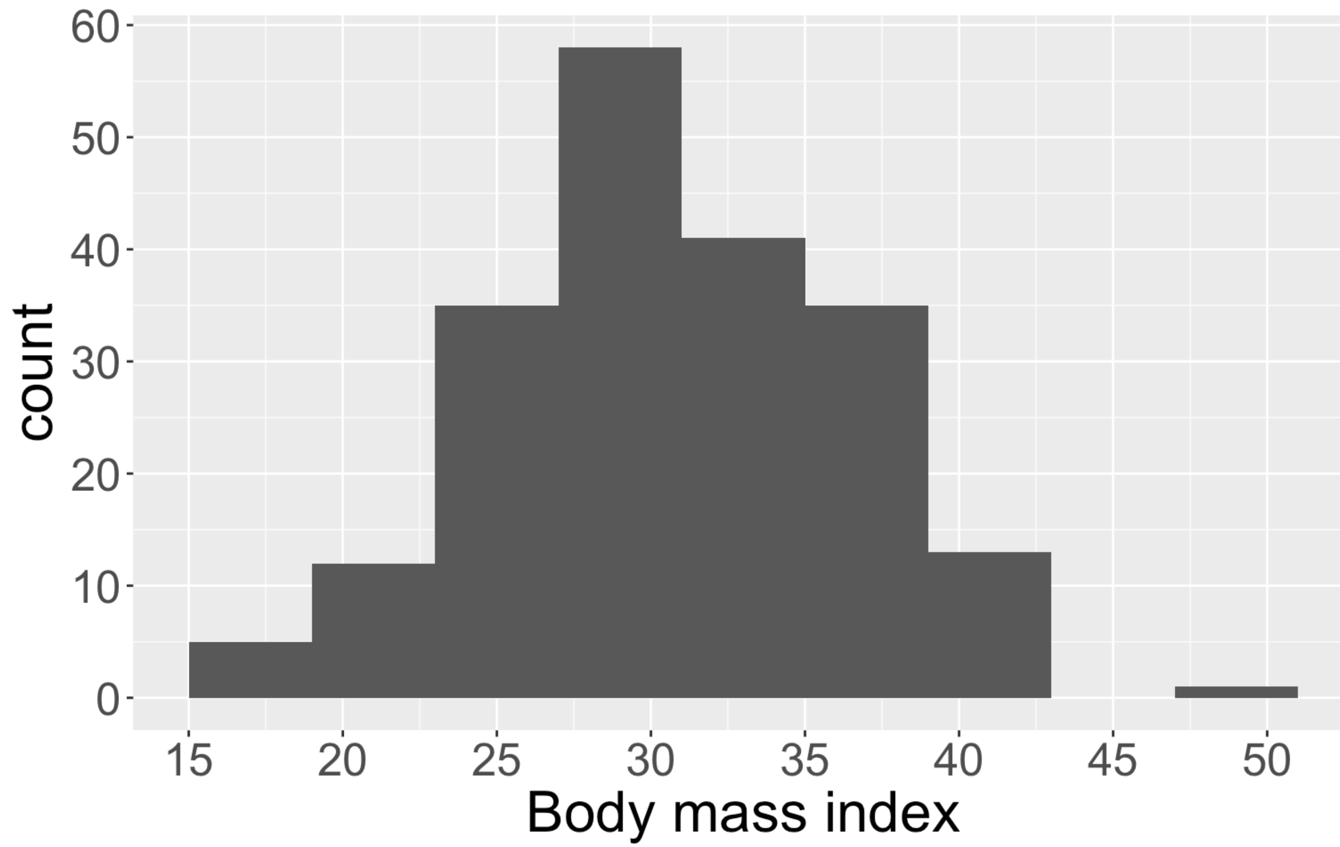
- We will sacrifice a bit more of precision for convenience by *binning:*
  - Segment the variable into equal-sized bins
  - Visualize the value of each observation using its corresponding bin
- For example, the `bmi` variable has observed values of 15.96 through 49.6. Consider the following bins of size 5: $[15, 19), [19, 23), [23, 27), \ldots, [49, 53)$
  - Convention of left or right inclusive?
- We tabulate/count up the number of observations that fall into each bin.

Histograms

Histograms are visualizations that display the binned counts as bars for each bin.

- Histograms provide a view of the **density** of the data (the values the data take on as well as how often)

bmi_bin	count
[15, 19)	5
[19, 23)	12
[23, 27)	35
[27, 31)	58
[31, 35)	41
[35, 39)	35
[39, 43)	13
[49, 52)	1



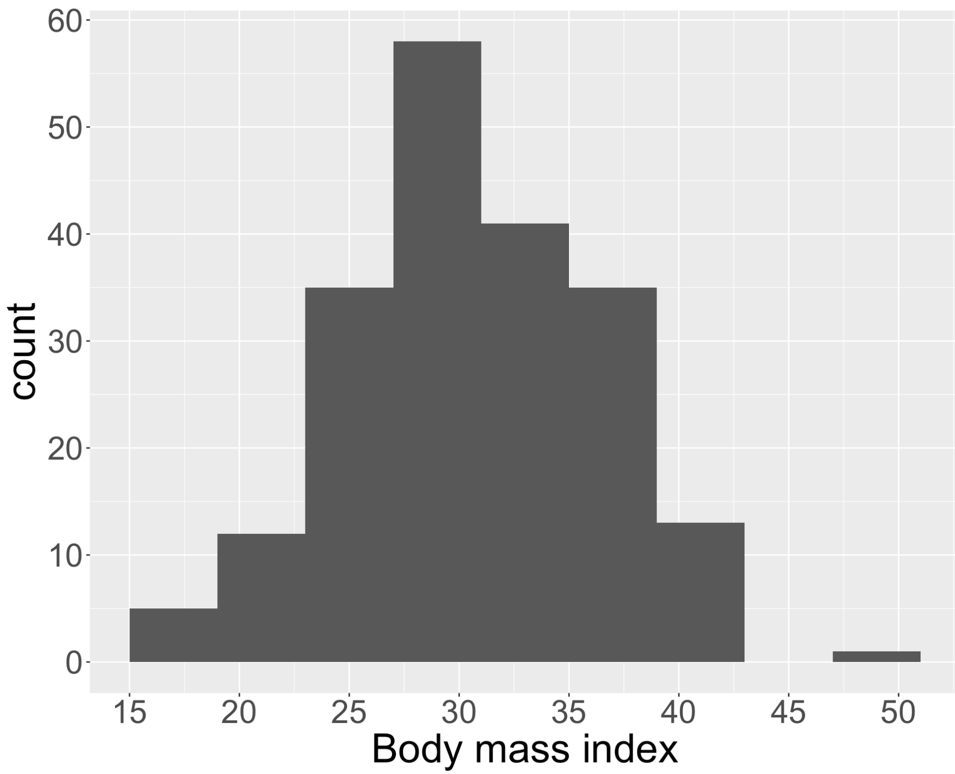
Describing distributions

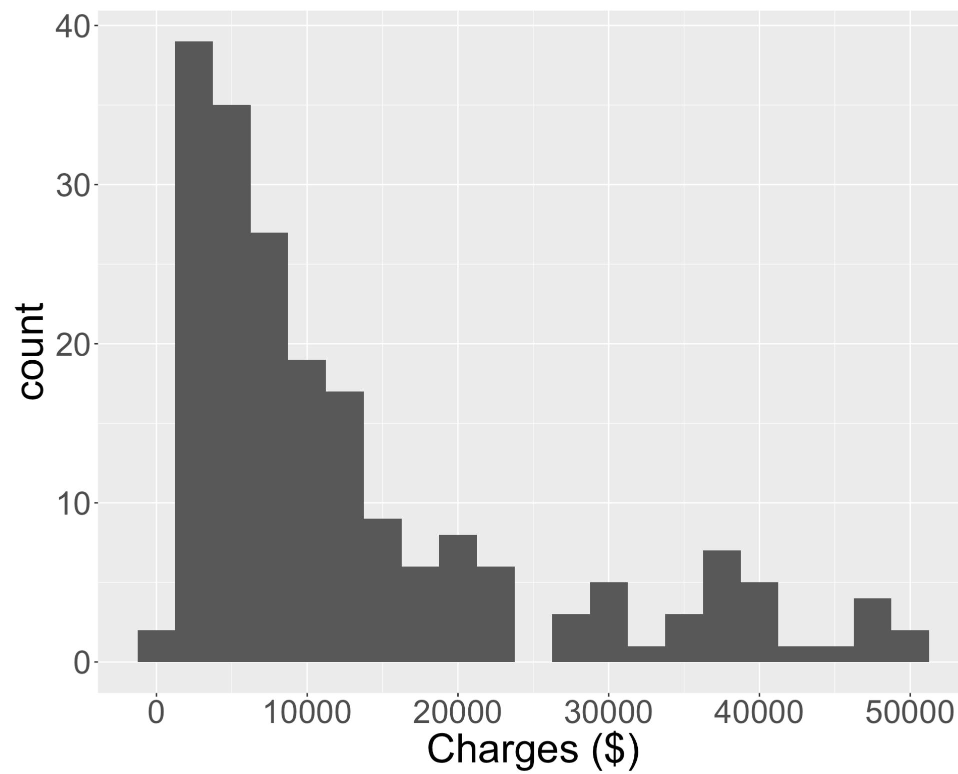
A convenient way to describe a variable's behavior is through the *shape* of its distribution. Using histograms, we should identify:

1. If the distribution is **symmetric** or **skewed**
    - Distributions with long tails to the left are called **left-skewed**
    - Distributions with long tails to the right are **right-skewed**
    - If not skewed, then the distribution is **symmetric**
2. M**odes** which are prominent peaks in the distribution
    - Distribution may be **unimodal** (one peak), **bimodal** (two peaks), or **multimodal** (more than two peaks)
    - Peaks need not be same height

Histograms (cont.)

How would you describe the shape of the distributions in the following two histograms?





Creating visualizations

Working in your groups, create a dot plot and a histogram of the estimated weights from the data we collected today!

Live code

If you'd like to follow along, please download the `.Rmd` template associated with today's class! Otherwise, feel free to just watch and try coding on your own later on.

We will cover:

- Scatterplots and histograms in base R

Summary statistics for numerical data

Visualizations are great for understanding the shape of a data distribution, but it can be extremely useful to obtain more specific, quantitative information about how the data behave.

In addition to describing the shape, we should also describe:

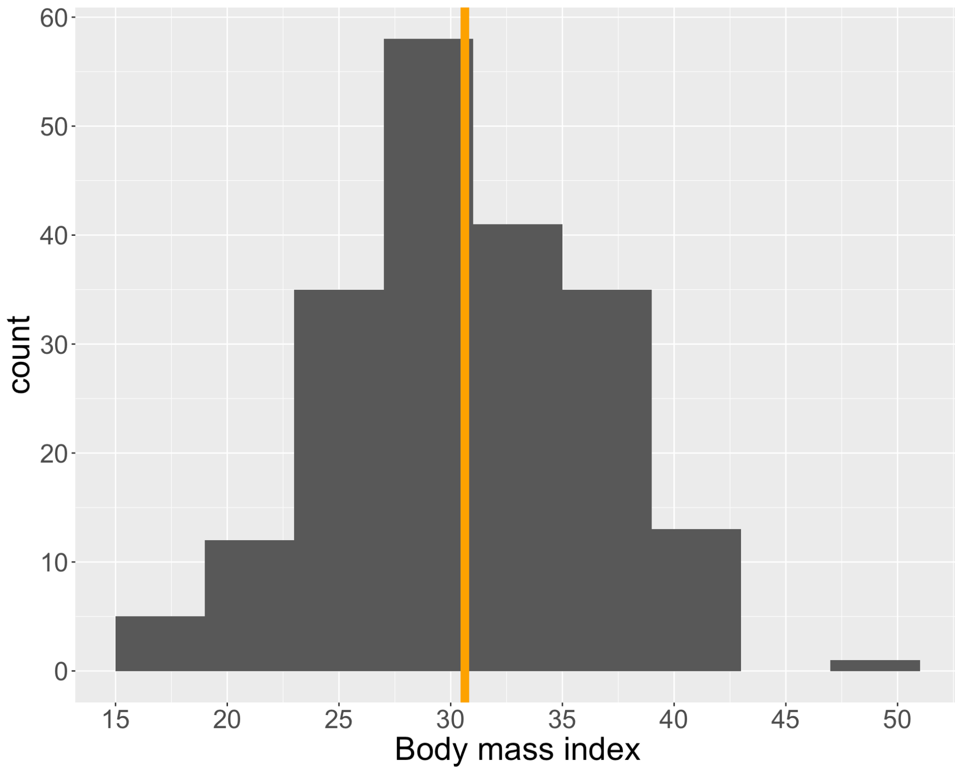
1. Center
2. Spread

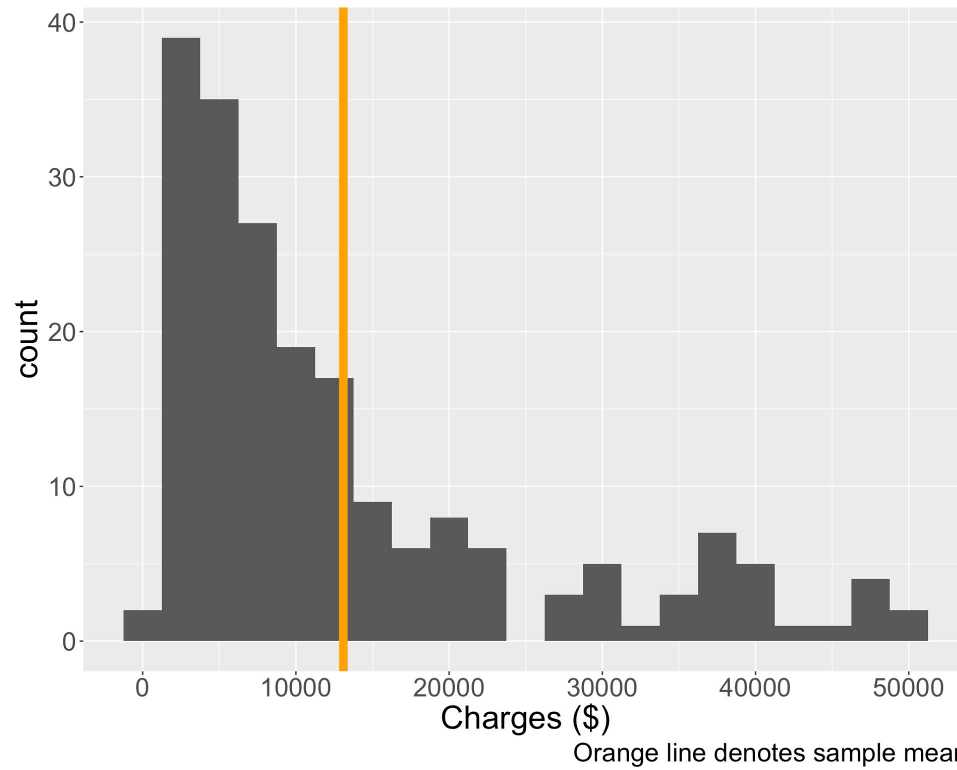
Mean

- By far the most common way to measure the center of the distribution of a numerical variable is using the **mean** (also called the **average**)
- We use the term ***sample* mean** when calculating a mean using sampled data. The sample mean is typically denoted as $\bar{x}$
  - x is a placeholder for the variable of interest (e.g. `BMI`, `charges`)
  - The bar communicates that we are looking at the average
- The sample mean is the sum over all the observed values of the variable, divided by total number of observations n:

$$\bar{x} = \frac{x_1 + x_2 + \ldots x_n}{n} = \frac{1}{n} \sum_{i=1}^{n} x_i$$

Mean (cont.)





- The sample mean $\bar{x}$ is an example of a sample statistic
- The mean over the entire population is an example of a population parameter. The **population mean** is often denoted μ (Greek letter mu)
- The sample mean $\bar{x}$ is often used as an estimate for μ (more on this in STAT 311!)

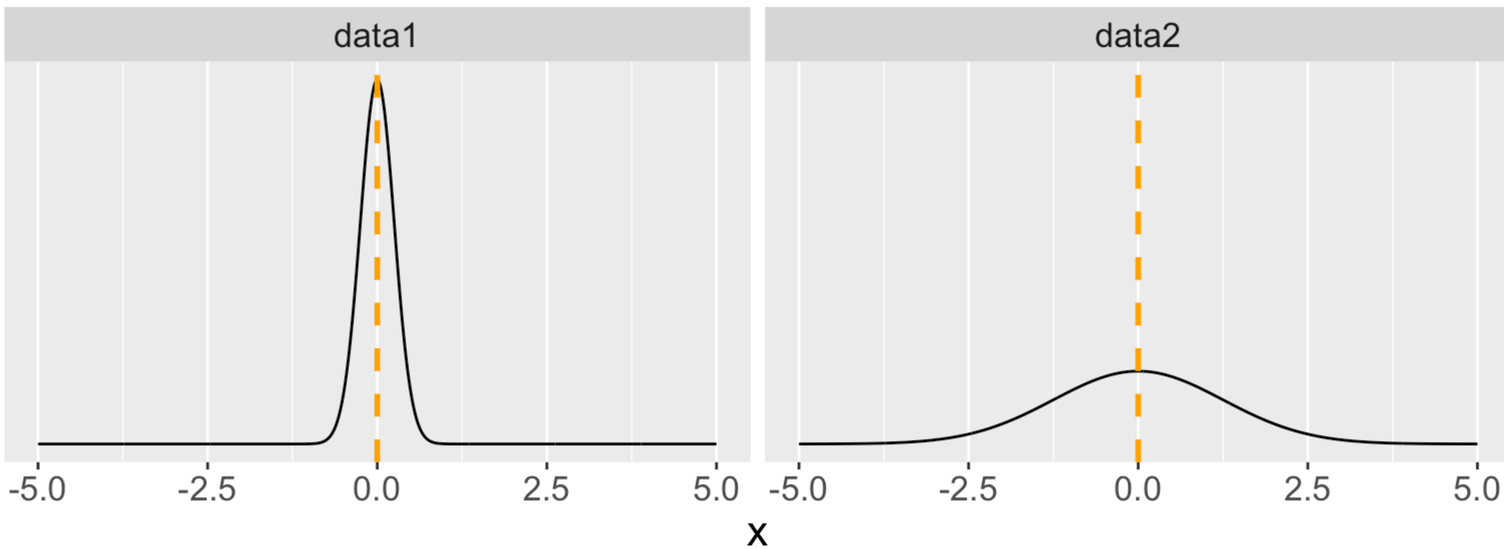
Example

Let’s calculate the sample mean estimated weight from the data we collected today

- Write out how you would calculate $\bar{x}$
- Then I will use R to calculate the sample mean!

Variability

- However, at the heart of statistics is also the **variability** or spread of the distribution of the variable
- We will work with variance and standard deviation, which are ways to describe how spread out data are *from their mean*



Deviation

We begin with **deviation**, which is the distance or difference between an observation from the (sample) mean

- How might we write this using statistical notation?
- Let’s write out the deviations of our estimated weights

Variance and standard deviation

- The **sample variance** s^2 squares the deviations and takes an average:

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

  - Let's talk about this notation and intuition behind this formula. In particular, there are at least two things to note

- Set-up the calculation of the sample variance for our data

  - I will calculate this in R

- The **sample standard deviation** s is the simply the square root of the sample variance ($s = \sqrt{s^2}$)

Variance and standard deviation (cont.)

- Like the mean, the population values for variance and standard deviation are denoted with Greek letters:
  - σ for population standard deviation (sigma)
  - σ^2 for population variance
- If the calculation of standard deviation is a more complicated quantity than the variance, why do we bother with standard deviation?

Live code

Functions to calculate sample mean, variance, and standard deviation in R:

- `mean()`
- `var()`
- `sd()`