

Intro to Social Science Data Analysis

Lecture 5: Descriptive Statistics

Christopher Gandrud

September 24, 2012

- 1 Recap
- 2 Describing Data Overall
- 3 Describing Numerical Data
- 4 Describing Categorical Data

Review Questions 1

- ▶ What is reproducible research?
- ▶ Why is it important?

Review Questions 1

- ▶ What is reproducible research?
- ▶ Why is it important?

Review Questions 2

- ▶ What is the Markdown markup language?
- ▶ What does the *knitr* package do?

Review Questions 2

- ▶ What is the Markdown markup language?
- ▶ What does the *knitr* package do?

Review Questions 3

- ▶ What is a code chunk?
- ▶ How do you make a code chunk in a Markdown document?

Review Questions 3

- ▶ What is a code chunk?
- ▶ How do you make a code chunk in a Markdown document?

So far we have learned how to gather data
and get it into R.

Today we will start to learn tools for
describing our data.

We will learn **descriptive statistics**.

Why do we need tools for describing our data?

Why do we need tools for describing our data?

- ▶ To find the **patterns** we are interested but too difficult to find by just looking at the raw data.
- ▶ Find potential **data biases**.

Why do we need tools for describing our data?

- ▶ To find the **patterns** we are interested but too difficult to find by just looking at the raw data.
- ▶ Find potential **data biases**.

Always look at the descriptive statistics
before starting your data analysis.

When describing data, **ALWAYS** look at **BOTH**

- ▶ The Central Tendency,
- ▶ The Variability (dispersion).

When describing data, **ALWAYS** look at **BOTH**

- ▶ The Central Tendency,
- ▶ The Variability (dispersion).

Central Tendency

The central value around which the data clusters.

Examples of descriptive statistics for the central tendency include: the mode, median, and mean (average).

Variability How the values vary around the central tendency.

Examples of descriptive statistics for the variability include: the range, interquartile range, standard deviation.

Describing Numerical Data

Measurement Level & Describing Numerical Data

Data that is at the **highest measurement level** (numerical continuous) can be described using **all** of the descriptive statistics.

Populations, Samples, and Descriptive Statistics

Remember that our data is a **sample** of the **population**.

Today we are going to be describing **samples**.

From week 7 we will start to use statistics that help us **infer** things from our samples about the population.

The Data

Most of the examples for this section use World Bank data for 2009 on:

- ▶ GDP per capita (current US\$)
- ▶ Mortality rate, infant (per 1,000 live births)
- ▶ World Bank region classification
- ▶ World Bank income level classification

The sample includes 199 jurisdictions.

You can get the data set using the source code file at:
`http://bit.ly/OTWEGS`

You can actually run this source code directly from R using the `source_url` command in the *devtools* package.

```
# Load package
library(devtools)

# Gather data using source code at:
# http://bit.ly/OTWEGS

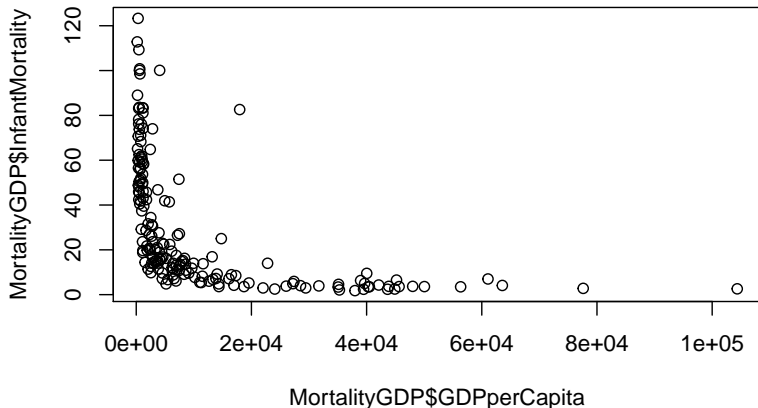
# Data is stored in a data frame: MortalityGDP
source_url("http://bit.ly/OTWEGS")

# See contents of MortalityGDP
names(MortalityGDP)

## [1] "country"          "GDPperCapita"
## [3] "InfantMortality" "region"
## [5] "income"
```



```
# Create scatterplot of GDP/Capita & Infant Mortality  
plot(MortalityGDP$GDPperCapita,  
      MortalityGDP$InfantMortality)
```



Central Tendency 1: Mode

Mode

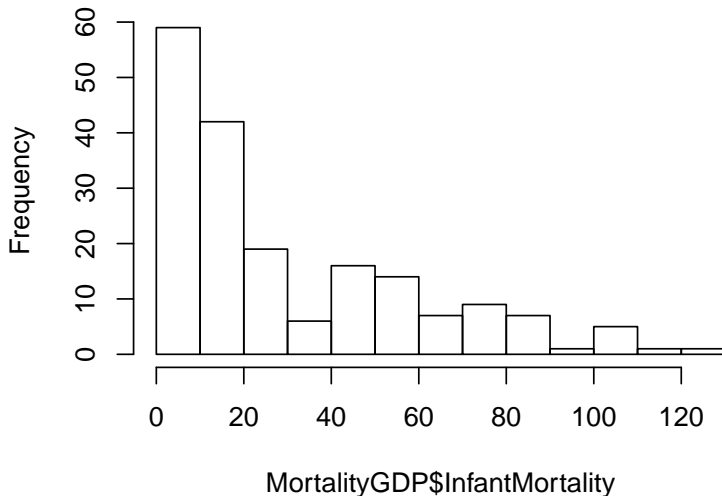
The most common value in a distribution.

One way to find the mode of a numeric continuous variable is with a **histogram**.

In R you can use the `hist` command.

```
hist(MortalityGDP$InfantMortality)
```

Histogram of MortalityGDP\$InfantMortality



Uni, Bi, and Multi Modal Distributions

A distribution can have **multiple modes**.

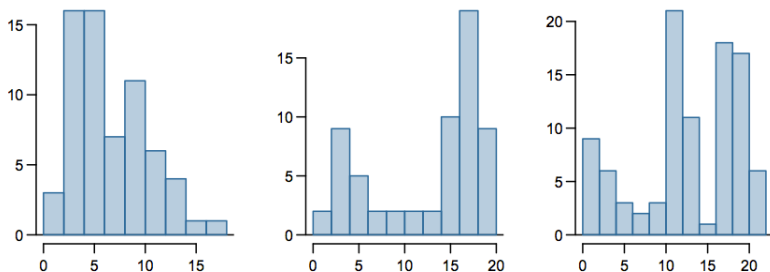


Figure 1.15: Counting only prominent peaks, the distributions are (left to right) unimodal, bimodal, and multimodal.

Diez (2011, 12)

Central Tendency 2: Median

Median

The middle value of a distribution.

You can find the median with the `median` command.

```
# Create data with no missing values of infant mortality
InfantNoMiss <- subset(MortalityGDP,
                       !is.na(InfantMortality))

# Find the median infant mortality rate
median(InfantNoMiss$InfantMortality)

## [1] 17.2
```

Central Tendency 3: Mean

Mean (average)

The sum of all data values (x) divided by the number of data values (n).

Population Mean (μ_x)

$$\mu_x = \frac{\sum x}{n}$$

Sample Mean (\bar{x})

$$\bar{x} = \frac{\sum x}{n}$$

You can find the mean with the `mean` command.

```
# Find the mean of InfantMortality  
mean(InfantNoMiss$InfantMortality)  
  
## [1] 30.23
```


What is the Central Tendency of Infant Mortality?

What is the Central Tendency of Infant Mortality?

- ▶ **Mode:** 0-10
- ▶ **Median:** 17.2
- ▶ **Mean:** 30.2

The reason that these three measures of central tendency are **not the same** is that the distribution of Infant Mortality in the sample is **highly skewed**.

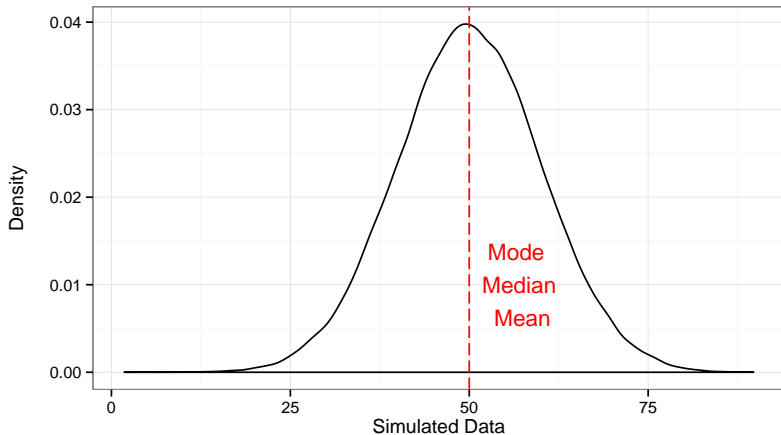
Normally Distributed

Data that is **normally distributed** has the same mode, median, and mean.

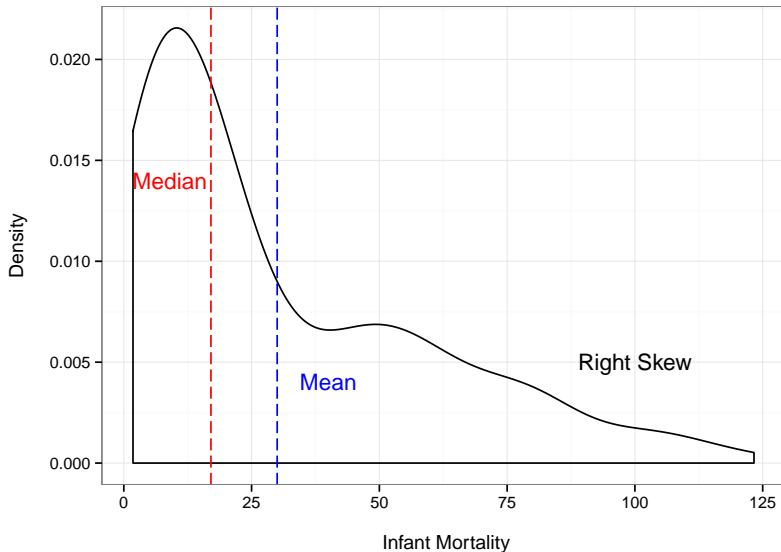
Normally distributed data also is **not skewed**. It has the same variance on the right and left of the central tendency.

```
# Simulate normally distributed data
```

```
Normal <- rnorm(1e+05, mean = 50, sd = 10)
```



The Infant Mortality data is very right skewed.



Describing Skewness

A distribution can be:

- ▶ Right skewed (positively skewed)
 - ▶ Right skewed data pulls the mean up.
- ▶ Left skewed (negatively skewed)
 - ▶ Left skewed data pulls the mean down.

Describing Skewness

A distribution can be:

- ▶ Right skewed (positively skewed)
 - ▶ Right skewed data pulls the mean up.
- ▶ Left skewed (negatively skewed)
 - ▶ Left skewed data pulls the mean down.

Describing Skewness

A distribution can be:

- ▶ Right skewed (positively skewed)
 - ▶ Right skewed data pulls the mean up.
- ▶ Left skewed (negatively skewed)
 - ▶ Left skewed data pulls the mean down.

A distribution can be:

- ▶ Right skewed (positively skewed)
 - ▶ Right skewed data pulls the mean up.
- ▶ Left skewed (negatively skewed)
 - ▶ Left skewed data pulls the mean down.

So, the central tendency does not adequately describe distributions by itself.

We also need descriptive statistics of the **variability**

Variability 1: Range

Range

The range is the simplest way to describe variability.

It is the lowest and highest value.

We can find the range with the `range` command.

```
range(InfantNoMiss$InfantMortality)
```

```
## [1] 1.8 123.3
```

Problems with the Range

The range is highly influenced by **outliers**—extreme values.

It also **ignores** all of the data between the minimum and maximum values.

```
#### Find infant mortality outliers
# Reorder data based on infant mortality
OrderMort <- InfantNoMiss[
    order(InfantNoMiss$InfantMortality,
          decreasing = TRUE), ]
# Keep country & InfantMortality
OrderMort <- OrderMort[, c("country",
                           "InfantMortality")]

# Show high values
head(OrderMort)
```

##	country	InfantMortality
## 187	Sierra Leone	123.3
## 38	Congo, Dem. Rep.	112.8
## 39	Central African Republic	109.3
## 190	Somalia	108.3
## 134	Mali	100.8
## 12	Angola	100.1

Interquartile Range

One way to deal with outliers is to look at the interquartile range.

The interquartile range is the difference between the upper and lower quartiles.

A quartile is 25% of the data.

The **lower quartile** is the point up to the lower 25% of the data.

The **upper quartile** is the point up to the upper 75% of the data.

```
# Find what the quartile points are  
summary(InfantNoMiss$InfantMortality)
```

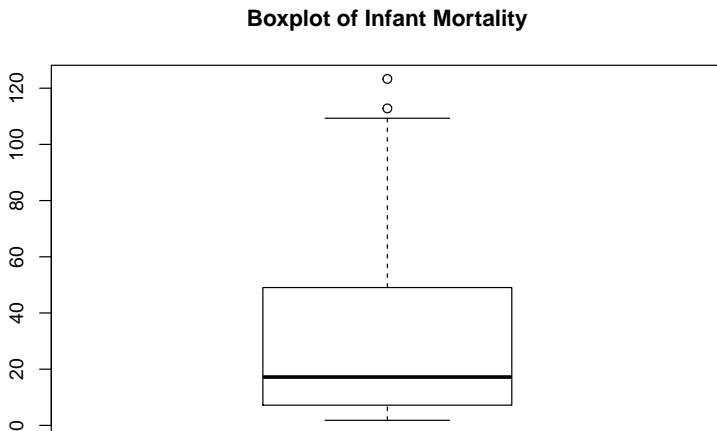
```
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.  
##      1.8      7.2     17.2     30.2     49.0    123.0
```

$$48.92 - 7.175 =$$

```
# Find the interquartile range of InfantMortality  
IQR(InfantNoMiss$InfantMortality)
```

```
## [1] 41.85
```

```
# Boxplot showing interquartile range  
boxplot(InfantNoMiss$InfantMortality,  
        main = "Boxplot of Infant Mortality")
```



More Information on Boxplots

See Diaz (2011, 16) for more boxplot details.

A bigger range means **more variability**.

Note: big in terms of the variable's scale.

Variability 3: Standard Deviation

Standard Deviation.

The interquartile range describes variation in terms of the median.

The standard deviation describes **variation in terms of the mean**.

What is the Sample Standard Deviation? (1)

The standard deviation is made of the following parts.

Deviation: the distance of an observation x from the mean \bar{x} .

$$\text{Deviation} = x - \bar{x}$$

Sum of Squares: the sum of the squared deviations (they have to be squared or the sum will = 0)

$$\text{Sum of Squares} = \sum (x - \bar{x})$$

Degrees of Freedom: Sample size n minus the number of parameters. Today the number of parameters = 1. (See Crawley 2005, 36-37 for a good explanation.)

$$\text{df} = n - 1$$

What is the Sample Standard Deviation? (2)

The standard deviation is made of the following parts.

Variance (s^2): roughly the average deviation.

$$s^2 = \frac{\text{Sum of Squares}}{\text{Degrees of Freedom}} = \frac{\sum (x - \bar{x})^2}{n - 1}$$

Standard Deviation (s): square root of the variance

$$s = \sqrt{s^2}$$

```
# Find the variance of InfantMortality
```

```
var(InfantNoMiss$InfantMortality)
```

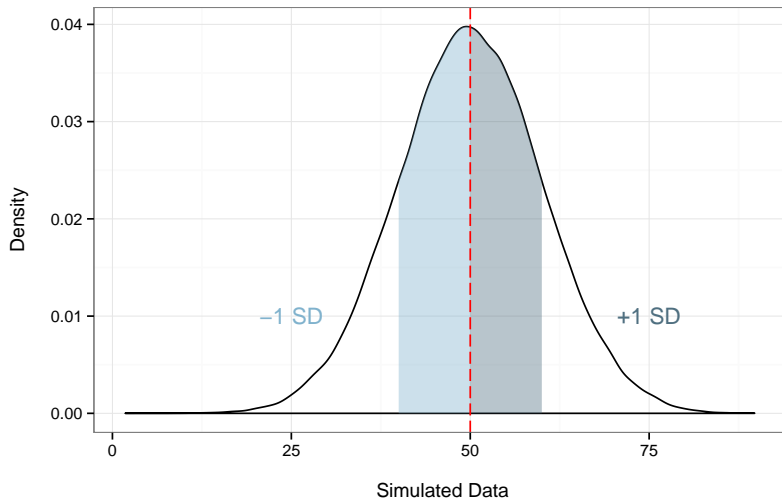
```
## [1] 827.3
```

```
# Find the standard deviation of InfantMortality
```

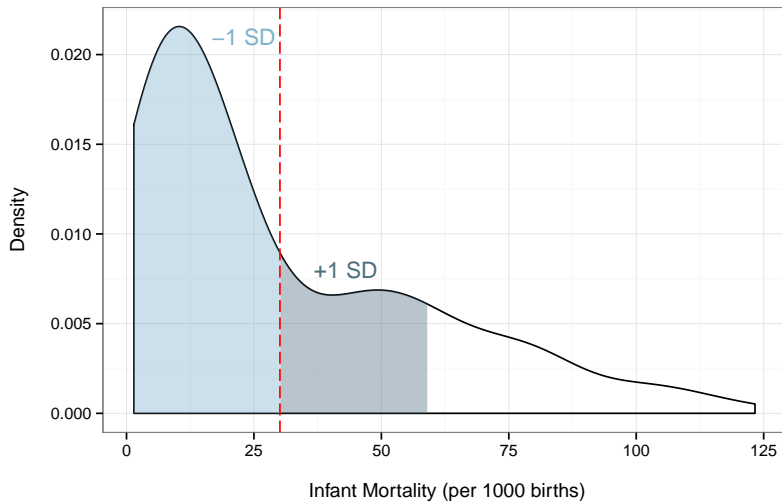
```
sd(InfantNoMiss$InfantMortality)
```

```
## [1] 28.76
```

Density Plot for Simulated Data



Density Plot for Infant Mortality



Transforming Data

Transforming Data

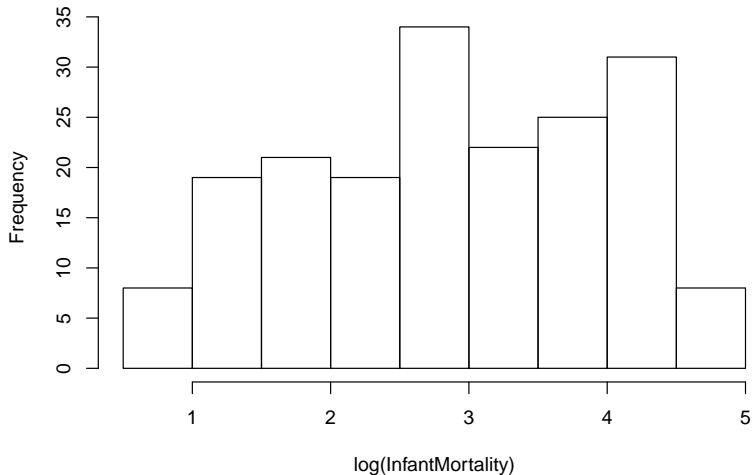
Transforming data can make **highly skewed** data easier to work with.

Transforming data just means to **rescale** the data using some function.

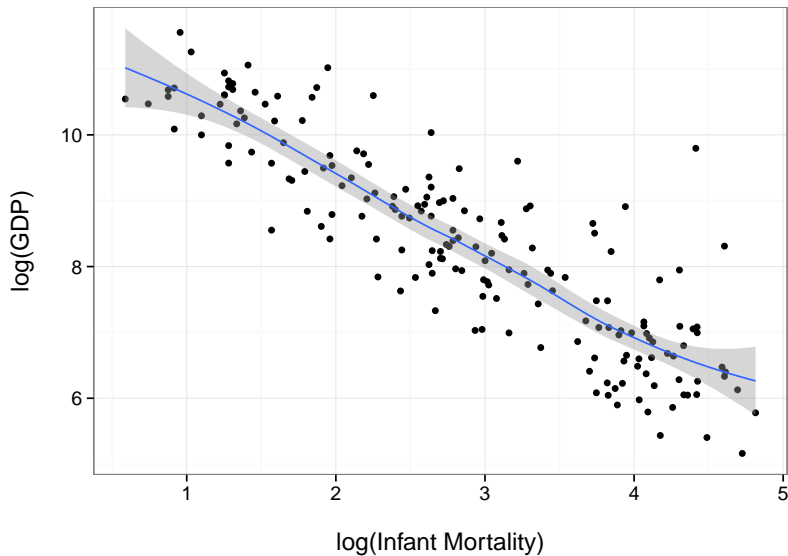
For example, we can **log-transform** our Infant Mortality data to see the relationship between the two variables better.

```
# Log Transform InfantMortality
```

```
InfantNoMiss$logInf <- log(  
    InfantNoMiss$InfantMortality)
```



Preview!



Describing Categorical Data

What descriptive statistics can you use for:

- ▶ Ordinal data
- ▶ Categorical data

What descriptive statistics can you use for:

- ▶ Ordinal data
- ▶ Categorical data

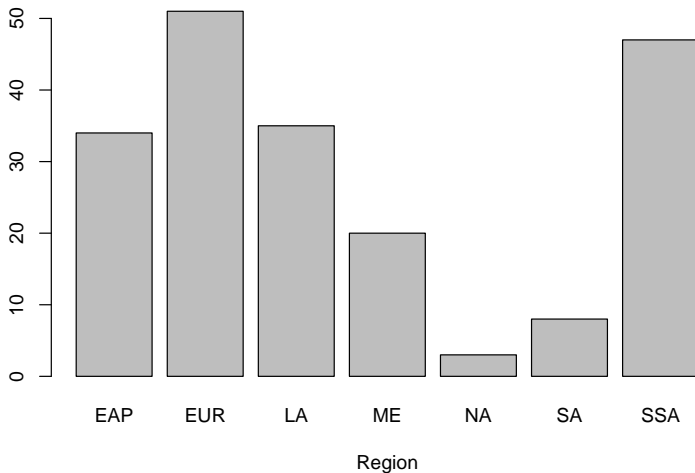
You can use

- ▶ Ordinal data; mode, median, range, interquartile range
- ▶ Categorical data: mode, frequency tables/barplots

You can use

- ▶ Ordinal data; mode, median, range, interquartile range
- ▶ Categorical data: mode, frequency tables/barplots


```
# Use cars data, loaded in R by default  
# Create bar plot  
plot(MortalityGDP$region, xlab = "Region")
```



Scatterplot-like Options for Categorical Data

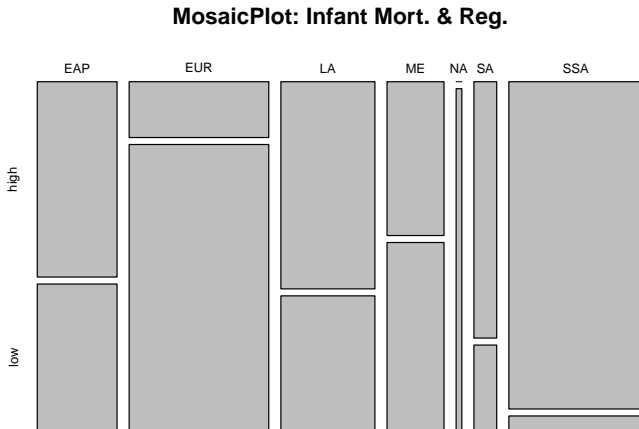
You can use **contingency tables** and **mosaic plots** like scatter plots when you have categorical data.

```
# Create High/Low Income Variable
InfantNoMiss$DumMort[InfantNoMiss$InfantMortality
                        >= 15] <- "high"
InfantNoMiss$DumMort[InfantNoMiss$InfantMortality
                        < 15] <- "low"

# Create contingency table
table(InfantNoMiss$region, InfantNoMiss$DumMort)
```

```
##
##      high low
##  EAP   16  12
##  EUR    8  41
##  LA   20  13
##  ME    9  11
##  NA    0   2
##  SA    6   2
##  SSA   45   2
```

```
mosaicplot(table(InfantNoMiss$region,  
                InfantNoMiss$DumMort),  
            main = "MosaicPlot: Infant Mort. & Reg.")
```



References I

Crawley, Michael J. 2005. Statistics: An Introduction Using R. Chichester: John Wiley Sons. Ltd.

Diaz, David M., Christopher D. Barr, and Mine Çetinkaya-Rundel. OpenIntro Statistics. 1st ed.

<http://www.openintro.org/stat/downloads.php>.