Assignments

Contents

This page contains all of my assignments for the class.

Assignment 1

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Problem 1

Install the datasets package on the console below using `install.packages("datasets")`. Now load the library.

```
# install.packages('datasets')
library(datasets)
```

Now, it's installed!

Load the USArrests dataset and rename it `dat`. Note that this dataset comes with R, in the package datasets, so there's no need to load data from your computer. Why is it useful to rename the dataset?

```
dat <- USArrests
```

Answer: It is useful to rename the dataset because it allows for replication. Renaming the dataset serves essentially the same function as "Save as" on a word document, which allows you to save the current version separately and still have access to previous versions. In other words, renaming the dataset allows you to perform functions without contaminating the original data.

Problem 2

Use this command to make the state names into a new variable called State.

```
dat$state <- tolower(rownames(USArrests))
```

Now, the state names have become a new variable (called "state")

This dataset has the state names as row names, so we just want to make them into a new variable. We also make them all lower case, because that will help us draw a map later - the map function requires the states to be lower case.

List the variables contained in the dataset `USArrests`.

```
names(dat)
```

```
## [1] "Murder"   "Assault"  "UrbanPop" "Rape"     "state"
```

Answer: The variables contained in the dataset are Murder, Assualt, UrbanPop (Urban Population), Rape, and state.

Problem 3

What type of variable (from the DVB chapter) is `Murder`?

Answer: According to the DVB chapter, Murder is a quantitative variable because it measures how many murder arrests were made per 100,000 people.

What R Type of variable is it?

```
class(dat$Murder)
```

```
## [1] "numeric"
```

Answer: By using the class() function, we find that Murder is a numeric variable in R.

Problem 4

What information is contained in this dataset, in general? What do the numbers mean?

```
head(dat)
```

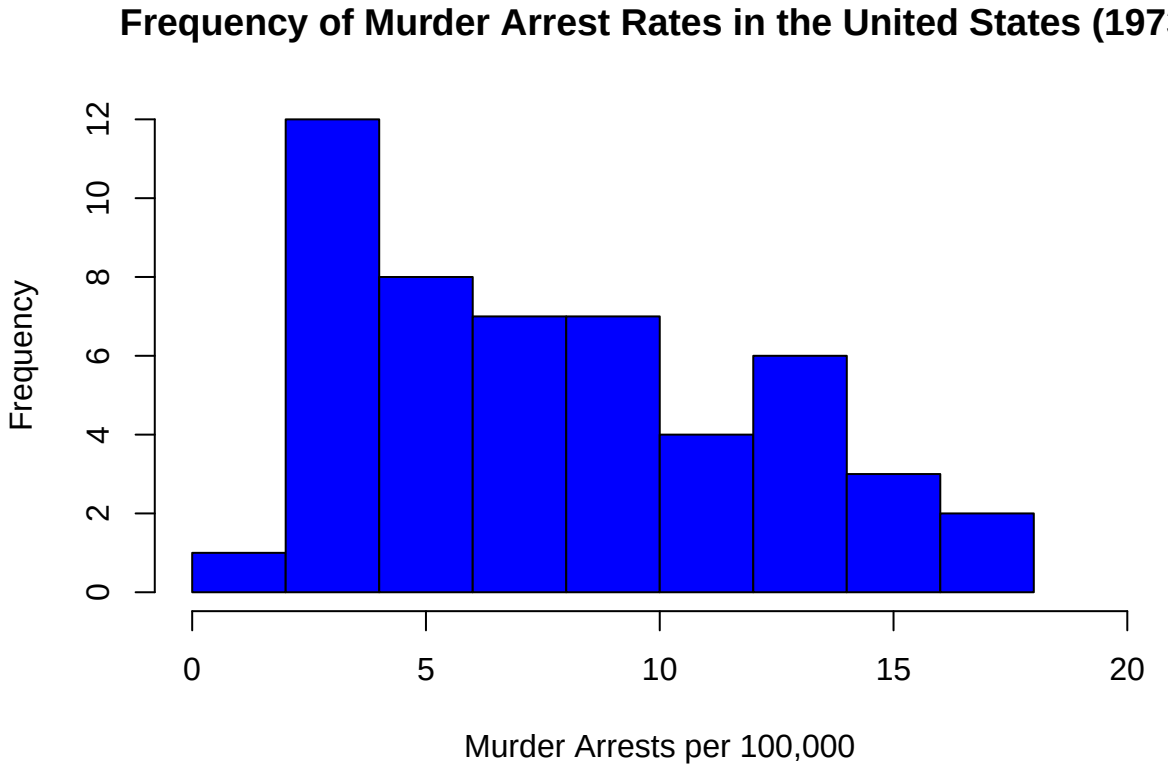
```
##            Murder Assault UrbanPop Rape       state
## Alabama      13.2     236       58 21.2     alabama
## Alaska       10.0     263       48 44.5      alaska
## Arizona       8.1     294       80 31.0     arizona
## Arkansas      8.8     190       50 19.5    arkansas
## California    9.0     276       91 40.6  california
## Colorado      7.9     204       78 38.7    colorado
```

Answer: Firstly, it's important to note that this data was collected/released in 1973. In general, information about how many arrests were made for murder, assault, and rape per 100,000 people in each state is contained in this dataset. This dataset also contains the percentages of the population that reside in urban areas within each state. Although this data set is just a data set that comes with R and is generally used for practice, it teaches beginners to be sensitive about the analyses that they conduct using R. In this case specifically, the data points are not just numbers; rather, they represent people in the real world that were arrested for specific crimes. Thus, this data teaches us to be cognizant of the conclusions and inferences that are drawn from our calculations/analyses.

Problem 5

Draw a histogram of `Murder` with proper labels and title.

```
hist(dat$Murder, main = "Frequency of Murder Arrest Rates in the United States (1973)",
    xlab = "Murder Arrests per 100,000", border = "black", col = "blue",
    xlim = c(0, 20))
```



Problem 6

Please summarize `Murder` quantitatively. What are its mean and median? What is the difference between mean and median? What is a quartile, and why do you think R gives you the 1st Qu. and 3rd Qu.?

```
summary(dat$Murder)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.800   4.075   7.250   7.788  11.250  17.400
```

Answer: The mean and median of "Murder" are 7.788 and 7.250, respectively. The minimum value is .800, Q1 is 4.075, Q3 is 11.250, and the maximum is 17.400. The mean is the average of all the data points (i.e. the sum of all the data values divided by the number of values). The median is the middle value when the data is arranged in order and it provides information regarding robustness. A quartile is a type of quantile that divides the data set into 4 (roughly) equally-sized parts (i.e. quarters) when the data is arranged from smallest to largest value. Therefore, quartiles serve to measure the spread of values in a given data set (these quartiles include 25%, 50%, 75% and 100%). R only gives us the 1st and 3rd quartiles because the 2nd quartile is the same as the median. As you can see in the output above, the value associated with 50% is the same as the median (because 50% of the values in the data set are above [and below] this value).

Problem 7

Repeat the same steps you followed for `Murder`, for the variables `Assault` and `Rape`. Now plot all three histograms together. You can do this by using the command `par(mfrow=c(3,1))` and then plotting each of the three.

```
# Assault
summary(dat$Assault)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
```

```
##    45.0   109.0   159.0   170.8   249.0   337.0
```

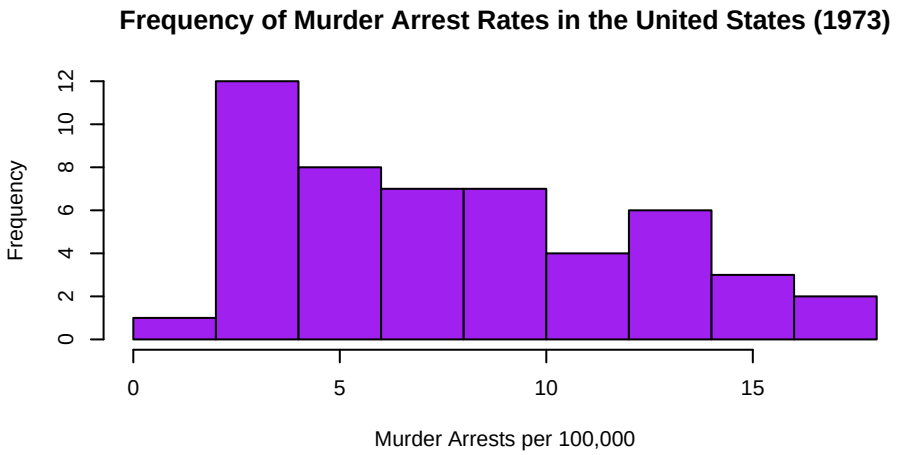
For assault arrests, the minimum value is 45.0, the maximum value is 337.0, the median is 159.0, and the mean is 170.8. Furthermore, Q1 is 109.0 and Q3 is 249.0.

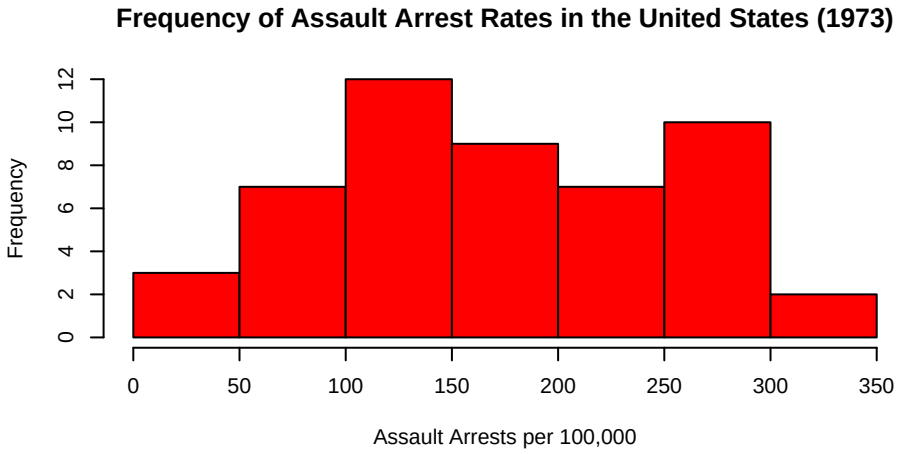
```
# Rape
summary(dat$Rape)
```

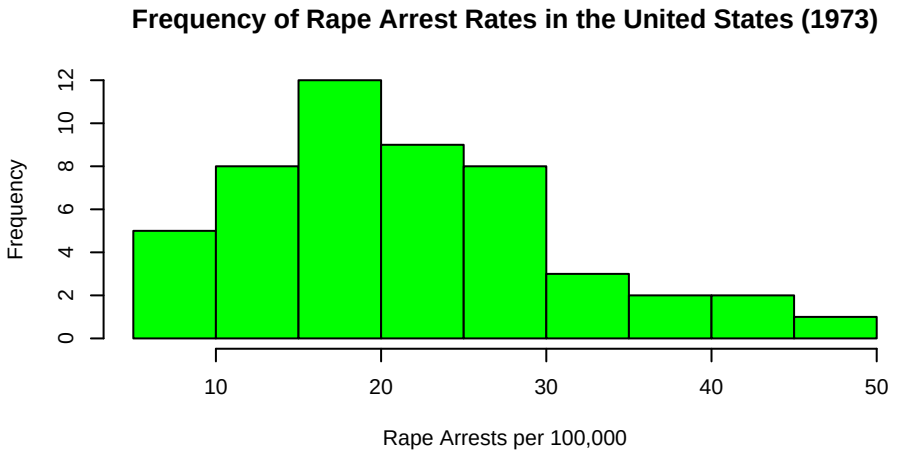
```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    7.30   15.07   20.10   21.23   26.18   46.00
```

For rape arrests, the minimum value is 7.30, the maximum value is 46.00, the median is 20.10, and the mean is 21.23. Furthermore, Q1 is 15.07 and Q3 is 26.18.

```
par(mfrow = c(3, 1))
hist(dat$Murder, main = "Frequency of Murder Arrest Rates in the United States (1973)",
    xlab = "Murder Arrests per 100,000", border = "black", col = "Purple")
hist(dat$Assault, main = "Frequency of Assault Arrest Rates in the United States (1973)",
    xlab = "Assault Arrests per 100,000", border = "black", col = "Red")
hist(dat$Rape, main = "Frequency of Rape Arrest Rates in the United States (1973)",
    xlab = "Rape Arrests per 100,000", border = "black", col = "Green")
```







What does the command par do, in your own words (you can look this up by asking R `?par`)?

Answer: The R command 'par' is used to modify how graphs are displayed, allowing plots to be combined into one cohesive graph. For specifically, 'par' gives the program parameters to plot it a certain way and then 'mfrow' puts it into an array. In this case, the array has 3 rows and 1 column, as denoted in the line of code.

What can you learn from plotting the histograms together?

Answer: By plotting the histograms together, we can learn quite a few things because the distributional differences are displayed very clearly. Firstly, we notice that the number of assault arrests per 100,000 people is significantly higher than both that of murder arrests and rape arrests. Furthermore, we notice that histograms for Rape Arrests and Murder Arrests are unimodal and right-skewed (albeit to different degrees) whereas the histogram for Assault Arrests is closer to a bimodal distribution.

Problem 8

In the console below (not in text), type `install.packages("maps")` and press Enter, and then type `install.packages("ggplot2")` and press Enter. This will install the packages so you can load the libraries.

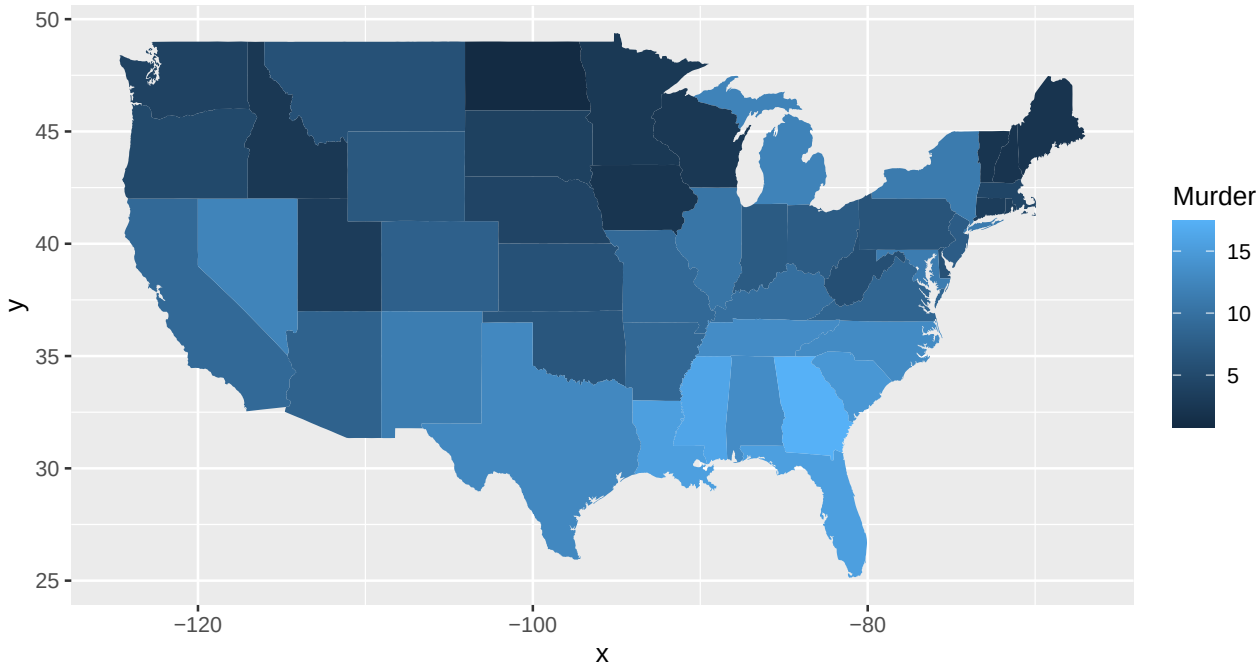
Run this code:

```
# install.packages('maps')

# install.packages('ggplot2')

library(maps)
library(ggplot2)

ggplot(dat, aes(map_id = state, fill = Murder)) + geom_map(map = map_data("state")) +
    expand_limits(x = map_data("state")$long, y = map_data("state")$lat)
```



What does this code do? Explain what each line is doing.

Answer is shown below. (Unfortunately, it would not allow me to fix the display of the comments next to each line, so if there is difficulty understanding which portion is code and which portion is my explanation, please let me know).

```
# install.packages('maps') this installs the maps package,
# which allows the program to draw geographical maps.

# install.packages('ggplot2') this installs the ggplot2
# program, which allows the program to create elegant data
```

```
# visualizations using the Grammar of Graphics. In other
# words, it allows for very complex plots/graphics to be
# created within a data frame.

# library(maps) this line loads the newly-installed 'maps'
# package

# library(ggplot2) this line loads the newly-installed
# 'ggplot2' package

# ggplot(dat, aes(map_id=state, fill=Murder)) +
# geom_map(map=map_data('state')) +
# expand_limits(x=map_data('state')$long,
# y=map_data('state')$lat)

# this long line of code reflects the 3 fundamental parts
# of the ggplot: data, aesthetics, and geometry. The first
# parameter tells the program to use the 'dat' dataset. It
# then tells the program to use the Murder data from 'dat'
# and the new 'state' variable that we create in Problem 2
# to create the aesthetic element of the plot. Together, it
# uses essentially signals that the mapping aesthetic
# layout should be based on the state variable while the
# color of each state (i.e. the respective shade of blue)
# is determined by the value associated with the number of
# murder arrests. The last part of this line of code
# indicates that the x and y limits of the plot should
# reflect the latitude and longitude values of the states.
# Collectively, each portion of this line of code plays a
# role in displaying a colorful map of the United States,
# whether different shades of blue represent different
# numbers of Murder arrests across the United States in
# 1973.
```

Assignment 2

Problem 1: Load data

Set your working directory to the folder where you downloaded the data.

```
setwd("/Users/theoathanitis/Desktop/CRIM 250/data sets")
```

Read the data

```
dat <- read.csv(file = "dat.nsduh.small.1.csv")
```

What are the dimensions of the dataset?

```
dim(dat)
```

```
## [1] 171   7
```

There are 171 rows and 7 columns in this dataset. Checking this is good practice because we want to make sure that we are working with the entire dataset that we intended. In other words, had Dr. Cuellar given us the entire dataset, we would expect to have tens of thousands of rows instead.

Problem 2: Variables

Describe the variables in the dataset.

```
names(dat)
```

```
## [1] "mjage"     "cigage"    "iralcage"  "age2"      "sexatract" "speakengl"
## [7] "irsex"
```

The variables in this dataset are "mjage", "cigage", "iralcage", "age2", sexatract", speakengl", and "irsex".

The variables included in this dataset are just a select few from a national survey. The variable "mjage" denotes how old the individual was when they first used marijuana or hashish. "mjage" is a discrete (quantitative) variable.

The variable "cigage" denotes how old the individual was when they first started smoking cigarettes every day. "cigage" is a discrete (quantitative) variable.

The variable "iralcage" denotes how old the individual was when he/she first tried alcohol. "iralcage" is a discrete (quantitative) variable.

For the abovementioned variables ("mjage", "cigage", and "iralcage"), there are some interesting aspects of the variable coding. For all 3, bad data, having never used marijuana, not knowing the answer, refusing to answer, or leaving the question blank were logged as 985, 991, 994, 997, and 998, respectively. For the "cigage" variable, 999 was used in place of a legitimate skip, in which the individual had used cigarettes before, but had never used them everyday.

The variable "age2" is the final age variable that incorporates both the individual's raw birthdate and changes to their age based on consistency checks throughout their responses. This variable also takes into account factors such as the age they entered on the roster, their pre-interview screener age and the final edited interview date. It is important to note that the age2 variable is a categorical variable because although some categories are representative of a specific age, other categories are indicative of age groups that span across 2+ ages. The age variable is interesting because it highlights the steps taken to protect the privacy and identity of individuals. Although it would have been possible to report this information as a quantitive variable, there may be very few members of certain groups, allowing someone to narrow down and find the individual that the data is referring to (for instance, 57 years old, in Tennessee, that self-identify as gay and that have smokes marijuana). Thus, age is reflected as a categorical variable in the dataset to protect confidentiality.

The "irsex" variable denotes the participant's gender. More specifically, however, this is imputation revised gender. "irsex" is a nominal (categorical) variable.

The variable "sexatract" is essentially just the participant's sexual orientation. This variable is a nominal (categorical) variable.

The variable "speakengl" is a measure of how well the participant speaks english. This variable is an ordinal (categorical) variable.

For these last 2 variables ("sexatract" and "speakengl"), here are some interesting aspects of the variable coding. For both, bad data, not knowing the answer, refusing to answer, and leaving the question blank were logged/coded as 85, 94, 97, and 98, respectively. For "sexattract", 99 was used to indicate a legitimate skip.

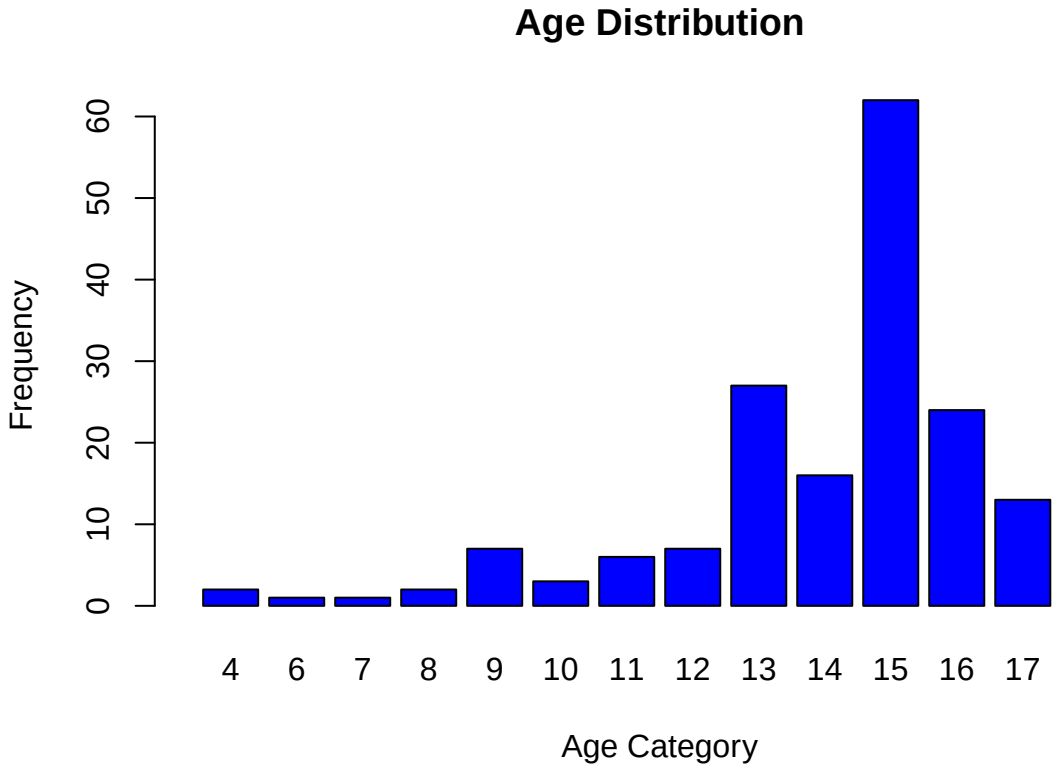
What is this dataset about? Who collected the data, what kind of sample is it, and what was the purpose of generating the data?

ANSWER: The dataset is about drug use; more specifically, the subset of the dataset that we use in this assignment relates to marijuana, cigarette, and alcohol use. The NSDUH is conducted by the Substance Abuse and Mental Health Services Administration, which is an agency within the U.S. Department of Health and Human Services. This sample was a stratified random sample. This type of sample is useful because inferences can be made such that they are generalizable to the general population of interest. According to the agency, the purpose of generating this data is to monitor the nature, extent, and consequences of substance use in the US. In doing so, the SAMHSA uses this data to focus on the nation's abuse treatment and prevention programs.

Problem 3: Age and gender

What is the age distribution of the sample like? Make sure you read the codebook to know what the variable values mean.

```
countsage <- table(dat$age2)
barplot(countsage, main = "Age Distribution", xlab = "Age Category",
    ylab = "Frequency", xlim = c(0, 17), border = "black", col = "blue")
```



Answer: The distribution of age is left skewed. However, since age is reflected in the categorical variable "age2" we would expect to see more people in categories that include a range of ages than in categories of a single age. For instance, category 14 represents individuals between the ages of 30 and 34 whereas category 6 includes only individuals that are 17 years old. Thus, this skew may simply be a consequence of differently sized categories, rather than being reflective of the actual shape of the distribution.

Do you think this age distribution representative of the US population? Why or why not?

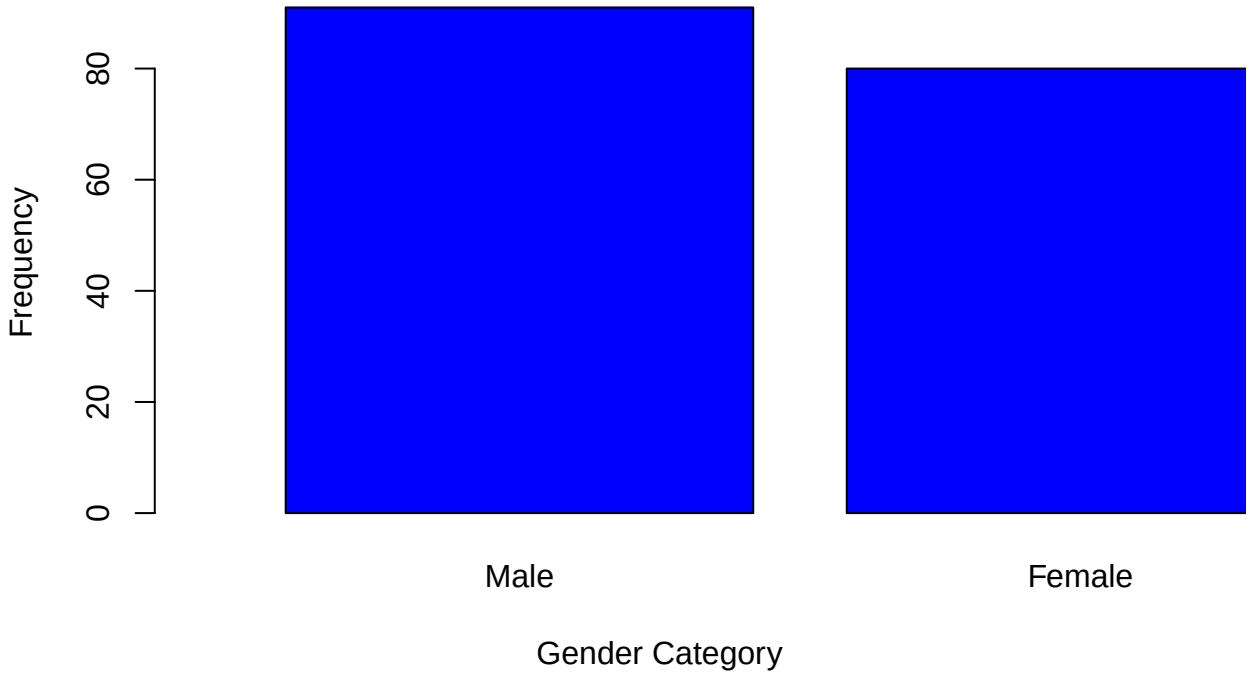
ANSWER: No, I do not think that the age distribution in this sample is representative of the US population. In 2019, the distribution of age in the United States is reflected in the Statista graph attached below (not shown on this website). In the data sample, less than 7% of the participants were 65 years or older, which is significantly less than the US population as a whole. It's also important to note that there are no respondents below the age of 15, even though there are plenty of individuals in the US below this age. However, it makes sense that they are not asked to complete the survey because any data on them would be relatively useless since not many individuals below that age use drugs. Furthermore, the distribution of age in the overall population seems (relatively) uniform, but the age distribution of the sample has a far more pronounced peak (mode). The age distribution of the sample population shows that the vast majority of individuals were between the ages of 35 and 49. I would like to ground this observation in the fact that this was the National Survey of Drug Use and Health, so it would make sense that the target of this survey is within this age range given that these individuals are the most likely to be drug users.

Is the sample balanced in terms of gender? If not, are there more females or males?

```
table(dat$irsex)
```

```
##
##  1  2
## 91 80
```

```
countsgender <- table(dat$irsex)
barplot(countsgender, main = "Gender Distribution", xlab = "Gender Category",
    ylab = "Frequency", xlim = c(0, 2), border = "black", col = "blue",
    names.arg = c("Male", "Female"))
```



Answer: The sample is not balanced in terms of gender because there are fewer females than males (91 males and 80 females).

Use this code to draw a stacked bar plot to view the relationship between sex and age. What can you conclude from this plot? tab.agesex <- table(dat$irsex, dat$age2) barplot(tab.agesex, main = "Stacked barchart", xlab = "Age category", ylab = "Frequency", legend.text = rownames(tab.agesex), beside = FALSE) # Stacked bars (default)

```
tab.agesex <- table(dat$irsex, dat$age2)
barplot(tab.agesex, main = "Sex and Age", xlab = "Age Category",
    ylab = "Frequency", legend.text = c("Male", "Female"), xlim = c(0,
        18), beside = FALSE)
```

Problem 4: Substance use

For which of the three substances included in the dataset (marijuana, alcohol, and cigarettes) do individuals tend to use the substance earlier?

```
summary(dat$mjage)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    7.00   14.00   16.00   15.99   17.50   35.00
```

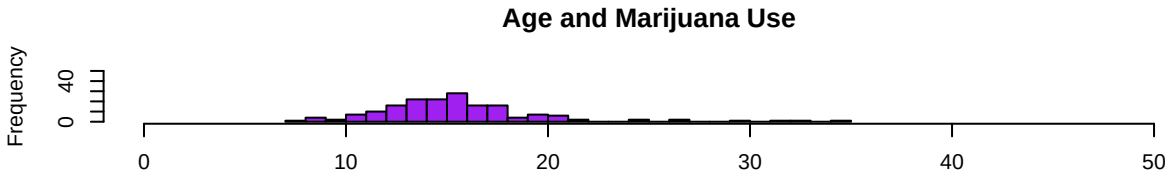
```
summary(dat$cigage)
```

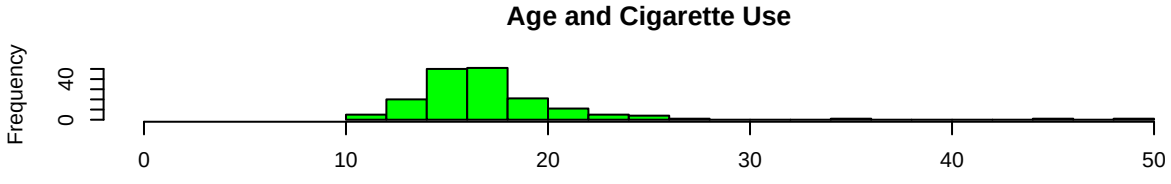
```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   10.00   15.00   17.00   17.65   19.00   50.00
```

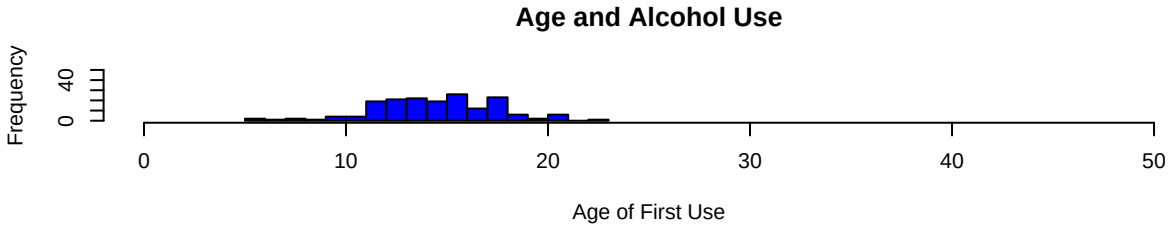
```
summary(dat$iralcage)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    5.00   13.00   15.00   14.95   17.00   23.00
```

```
par(mfrow = c(3, 1))
hist(dat$mjage, main = "Age and Marijuana Use", xlab = "Age of First Use",
    border = "black", col = "Purple", xlim = c(0, 50), ylim = c(0,
        50), breaks = 20)
hist(dat$cigage, main = "Age and Cigarette Use", xlab = "Age of Daily Use",
    border = "black", col = "Green", xlim = c(0, 50), ylim = c(0,
        50), breaks = 20)
hist(dat$iralcage, main = "Age and Alcohol Use", xlab = "Age of First Use",
    border = "black", col = "Blue", xlim = c(0, 50), ylim = c(0,
        50), breaks = 20)
```





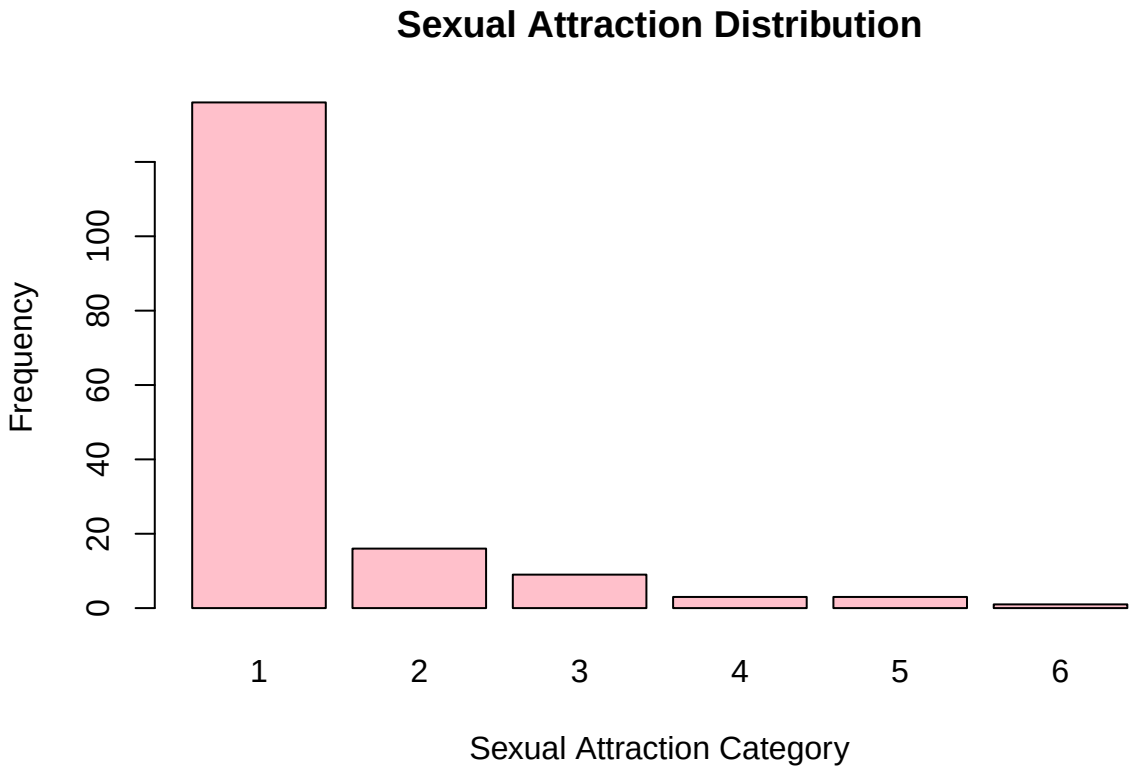


As shown above, individuals tend to use alcohol earlier. This is verified by the fact that there were a couple participants that first drank alcohol at 5 years of age (the exact number of people that responded with specific ages can be found by using the table() function, but I felt that it would be redundant to include here).

Problem 5: Sexual attraction

What does the distribution of sexual attraction look like? Is this what you expected?

```
par(mfrow = c(1, 1))
dat1 <- dat[dat$sexatract != 85, ]
dat2 <- dat1[dat1$sexatract != 94, ]
dat3 <- dat2[dat2$sexatract != 97, ]
dat4 <- dat3[dat3$sexatract != 98, ]
dat5 <- dat4[dat4$sexatract != 99, ]
countsexattract <- table(dat5$sexatract)
barplot(countsexattract, main = "Sexual Attraction Distribution",
    xlab = "Sexual Attraction Category", ylab = "Frequency",
    border = "black", col = "pink")
```

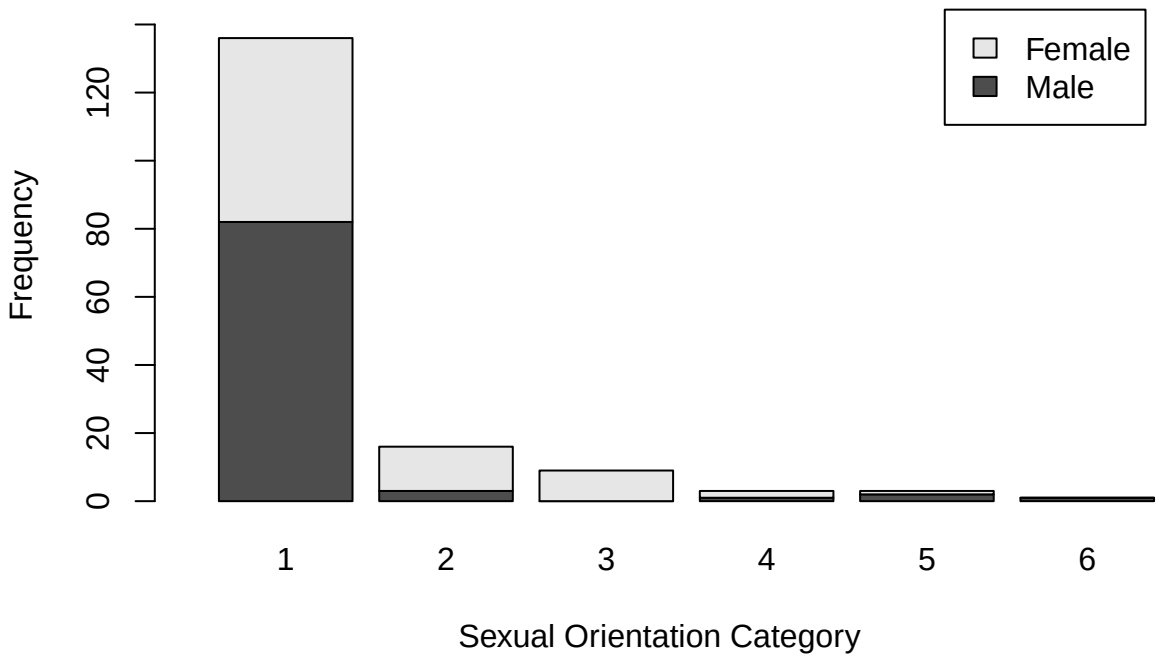


ANSWER: First, I'd like to note that I went through the steps of taking out every possible missing data option just in case. In most instances, a statistician may choose to take fewer steps by first looking at the dataset and establishing which "special cases" are present that need to be removed before analyzing the data.

As shown in the bar plot above, the distribution is largely skewed to the right, such that most participants are only attracted to the opposite sex. This is definitely what I expected given that the vast majority of participants in this survey were part of an older generation that, historically, is less accepting of same sex (or LGBTQ+) attraction.

What is the distribution of sexual attraction by gender?

```
tab.sexorient <- table(dat5$irsex, dat5$sexatract)
barplot(tab.sexorient, main = "Sexual Orientation and Gender",
    xlab = "Sexual Orientation Category", ylab = "Frequency",
    legend.text = c("Male", "Female"), xlim = c(0, 7), ylim = c(0,
        150), beside = FALSE)
```




```
table(dat5$sexatract, dat5$irsex)
```

```
##
##      1  2
##   1 82 54
##   2  3 13
##   3  0  9
##   4  1  2
##   5  2  1
##   6  1  0
```

The distribution of sexual attraction by gender is shown above Based on the figure below, it is notable that more males assert that they are only attracted to the opposite gender, whereas females often respond in a bi-curious nature (as exemplified by the fact that all of the participants that responded with being equally attracted to both genders were female).

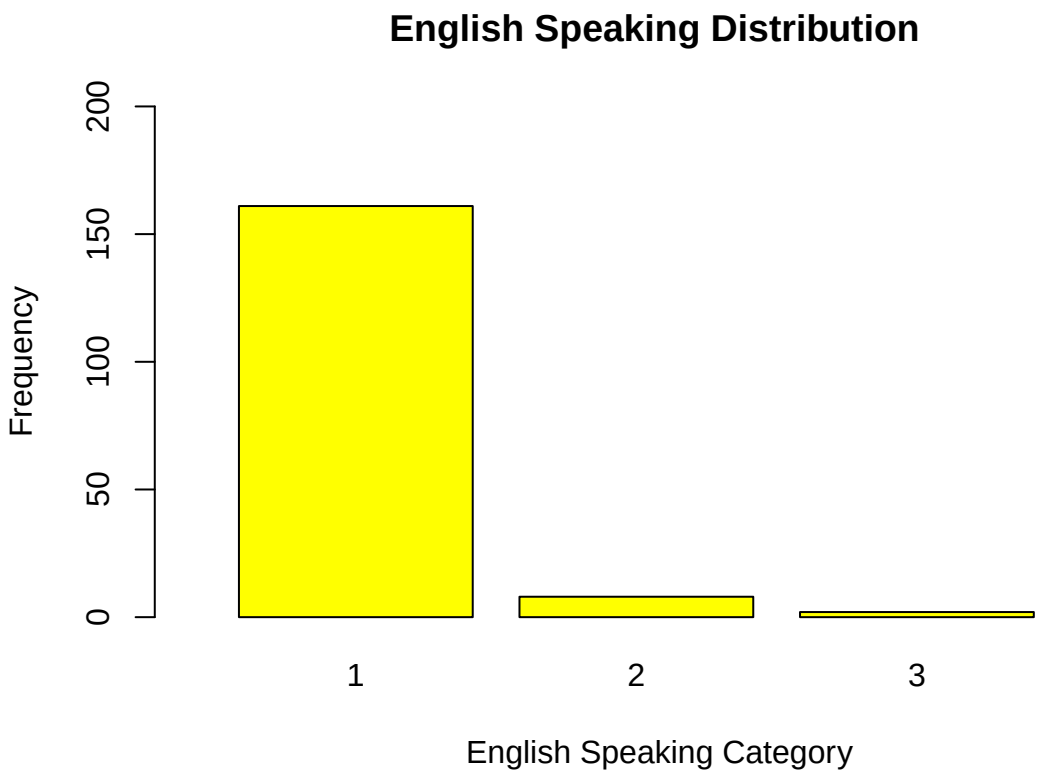
Problem 6: English speaking

What does the distribution of English speaking look like in the sample? Is this what you might expect for a random sample of the US population?

```
table(dat$speakengl)
```

```
##
##   1   2   3
## 161   8   2
```

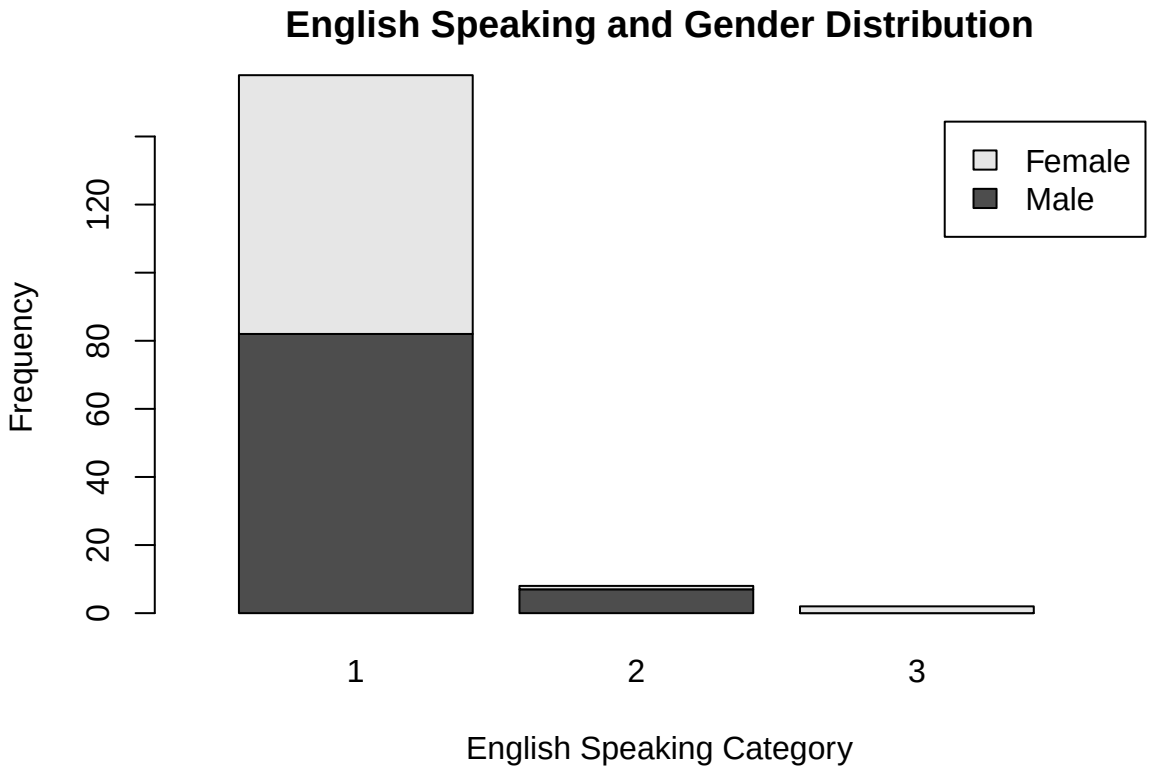
```
countspeakengl <- table(dat$speakengl)
barplot(countspeakengl, main = "English Speaking Distribution ",
    xlab = "English Speaking Category", ylab = "Frequency", xlim = c(0,
        4), ylim = c(0, 200), border = "black", col = "yellow")
```



As shown above, the distribution of English speaking is skewed to the right. This is to be expected because we would assume that, in order to live in the US and provide for one's self and one's family (which includes working a job, buying groceries, etc), one would need to know how to speak English very well. Furthermore, according to a recent Census survey, it was reported that almost 9% of the US population spoke English "less than very well" and had a very limited proficiency. In taking the opposite of this value, we notice that, for a random sample of the US population, this sample is relatively representative, with 94% of the participants being able to speak english very well (and, in turn, 6% speaking english at a lower proficiency level).

Are there more English speaker females or males?

```
tab.sexenglish <- table(dat5$irsex, dat5$speakengl)
barplot(tab.sexenglish, main = "English Speaking and Gender Distribution",
    xlab = "English Speaking Category", ylab = "Frequency", legend.text = c("Male",
        "Female"), xlim = c(0, 4), ylim = c(0, 150), beside = FALSE)
```




```
table(dat5$irsex, dat5$speakengl)
```

```
##
##      1  2  3
##   1 82  7  0
##   2 76  1  2
```

There are more male than female English speakers. In looking at the table in more detail, we notice that for both the "very well" and "well" categories (i.e. categories 1 and 2), there are more male than female speakers in those groups (82 vs 76 and 7 vs 1, respectively). However, the only 2 respondents who do not know english well are both female. While this may seem interesting at first glance, I think that this minor discrepancy is mainly due to the fact that there are more males than females in the sample.

Exam 1

Instructions

a. Create a folder in your computer (a good place would be under Crim 250, Exams).

b. Download the dataset from the Canvas website (fatal-police-shootings-data.csv) onto that folder, and save your Exam 1.Rmd file in the same folder.

c. Download the README.md file. This is the codebook.

d. Load the data into an R data frame.

```
dat <- read.csv("fatal-police-shootings-data.csv")
```

Problem 1 (10 points)

a. Describe the dataset. This is the source: https://github.com/washingtonpost/data-police-shootings . Write two sentences (max.) about this.

This dataset is a record of every fatal shooting by a police officer in the line of duty in the United States since January 1st, 2015. Information such as the race of the deceased, the circumstances of the shooting, whether the individual was arrested, and whether the individual was experiencing a mental-health crisis were also observed by sifting/monitoring local news reports, law enforcement websites/social media, and independent databases.

b. How many observations are there in the data frame?

```
dim(dat)
```

```
## [1] 6594   17
```

There are 6594 rows and 17 columns of data; this means that there are 6594 observations in the data frame (i.e. how many people were observed).

c. Look at the names of the variables in the data frame. Describe what "body_camera", "flee", and "armed" represent, according to the codebook. Again, only write one sentence (max) per variable.

```
names(dat)
```

```
##  [1] "id"                     "name"
##  [3] "date"                   "manner_of_death"
##  [5] "armed"                  "age"
##  [7] "gender"                 "race"
##  [9] "city"                   "state"
## [11] "signs_of_mental_illness" "threat_level"
## [13] "flee"                   "body_camera"
## [15] "longitude"              "latitude"
## [17] "is_geocoding_exact"
```

The variables included in this dataset are "id", "name", "date", "manner_of_death", "armed", "age", "gender", "race", "city", "state", "signs_of_mental_illness", "threat_level", "flee", "body_camera", "longitude", "latitude", and "is_geocoding_exact". According to the codebook, the "body_camera" variable refers to whether news reports indicate that the officer was wearing a body camera and that a portion of the incident may have been recorded. The "flee" variable refers to whether news reports indicated that the victim was moving away from officers, and whether this move was by car or by foot. The "armed" variable refers to whether the victim was (a) armed with something that the police officer believed could inflict harm (denoted as what that object was), (b) undetermined (unknown whether the victim has a weapon), (c) unknown (victim was armed but the object was unknown), or (d) unarmed (the victim was not armed at all).

d. What are three weapons that you are surprised to find in the "armed" variable? Make a table of the values in "armed" to see the options.

```
table(dat$armed)
```

```
##
##                                    air conditioner
##                         207                       1
##                  air pistol                Airsoft pistol
##                           1                       3
##                          ax                 barstool
##                          24                       1
##                  baseball bat      baseball bat and bottle
##                          20                       1
## baseball bat and fireplace poker       baseball bat and knife
##                           1                       1
##                       baton                   BB gun
##                           6                      15
##           BB gun and vehicle               bean-bag gun
##                           1                       1
##                  beer bottle                binoculars
##                           3                       1
##                 blunt object                   bottle
##                           5                       1
##                bow and arrow                box cutter
##                           1                      13
##                       brick          car, knife and mace
##                           2                       1
##                     carjack                    chain
##                           1                       3
##                   chain saw                  chainsaw
##                           2                       1
##                       chair          claimed to be armed
##                           4                       1
##           contractor's level             cordless drill
##                           1                       1
##                    crossbow                  crowbar
##                           9                       5
##                   fireworks                 flagpole
##                           1                       1
##                  flashlight                garden tool
##                           2                       2
##                 glass shard                  grenade
##                           4                       1
##                         gun                gun and car
##                        3798                      12
##                gun and knife          gun and machete
##                          22                       3
##                gun and sword          gun and vehicle
##                           1                      17
##          guns and explosives                  hammer
##                           3                      18
##                  hand torch                 hatchet
##                           1                      14
##              hatchet and gun                  ice pick
```

```
##                          2                          1
##          incendiary device                      knife
##                          2                        955
##          knife and vehicle          lawn mower blade
##                          1                          2
##                    machete           machete and gun
##                         51                          1
##               meat cleaver           metal hand tool
##                          6                          2
##               metal object                metal pipe
##                          5                         16
##                 metal pole                metal rake
##                          4                          1
##                metal stick                microphone
##                          3                          1
##                 motorcycle                  nail gun
##                          1                          1
##                        oar                pellet gun
##                          1                          3
##                        pen              pepper spray
##                          1                          2
##                   pick-axe              piece of wood
##                          4                          7
##                       pipe                  pitchfork
##                          7                          2
##                       pole              pole and knife
##                          3                          2
##             railroad spikes                       rock
##                          1                          7
##              samurai sword                   scissors
##                          4                          9
##                screwdriver              sharp object
##                         16                         14
##                     shovel                      spear
##                          7                          2
##                    stapler          straight edge razor
##                          1                          5
##                      sword                     Taser
##                         23                         34
##                 tire iron                toy weapon
##                          4                        226
##                   unarmed              undetermined
##                        421                        188
##            unknown weapon                    vehicle
##                         82                        213
##           vehicle and gun          vehicle and machete
##                          8                          1
##             walking stick                wasp spray
##                          1                          1
##                    wrench
##                          1
```

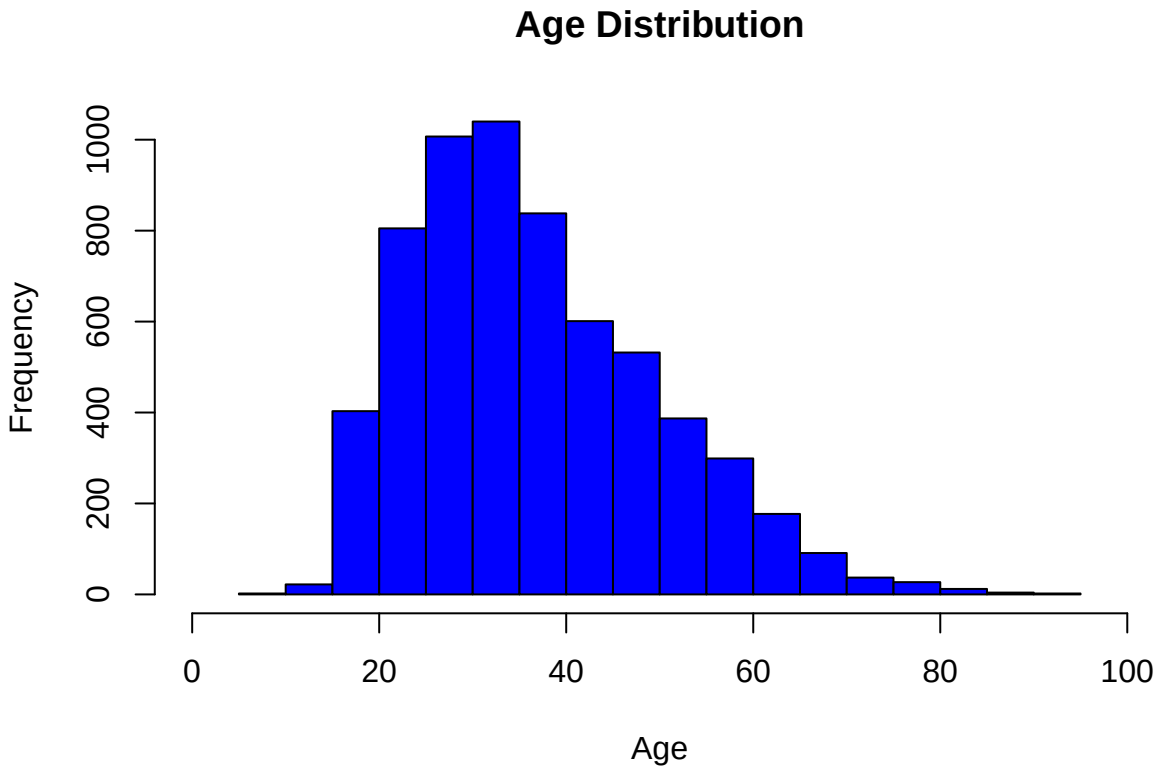
Three weapons that I was surprised to find in the "armed" variable are an air conditioner, an oar, and binoculars (solely because one must be relatively creative to use these objects to

inflict harm).

Problem 2 (10 points)

a. Describe the age distribution of the sample. Is this what you would expect to see?

```
hist((dat$age), main = "Age Distribution", xlab = "Age", ylab = "Frequency",
    border = "black", col = "blue", xlim = c(0, 100))
```




```
summary(dat$age)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##    6.00   27.00   35.00   37.12   45.00   91.00     308
```

The distribution of age looks to be right skewed with the majority of the data points falling within the 25 to 35 year old range. This distribution is expected because it is reasonable to expect that, at this age, individuals are the most fit/threatening and are most likely to be suspected of being involved in a crime. It is easy to argue that very few seniors are committing crimes and thus are less likely to find themselves in a situation with a police officer. Similarly, this holds true for individuals below the age of 15. However, it is important to note that there are 308 observations in which the age of the victim was unknown (so this may influence the skew of the distribution).

b. To understand the center of the age distribution, would you use a mean or a median, and why? Find the one you picked.

```
median(dat$age, na.rm = TRUE)
```

```
## [1] 35
```

```
summary((dat$age))
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
```

```
##    6.00   27.00   35.00   37.12   45.00   91.00     308
```

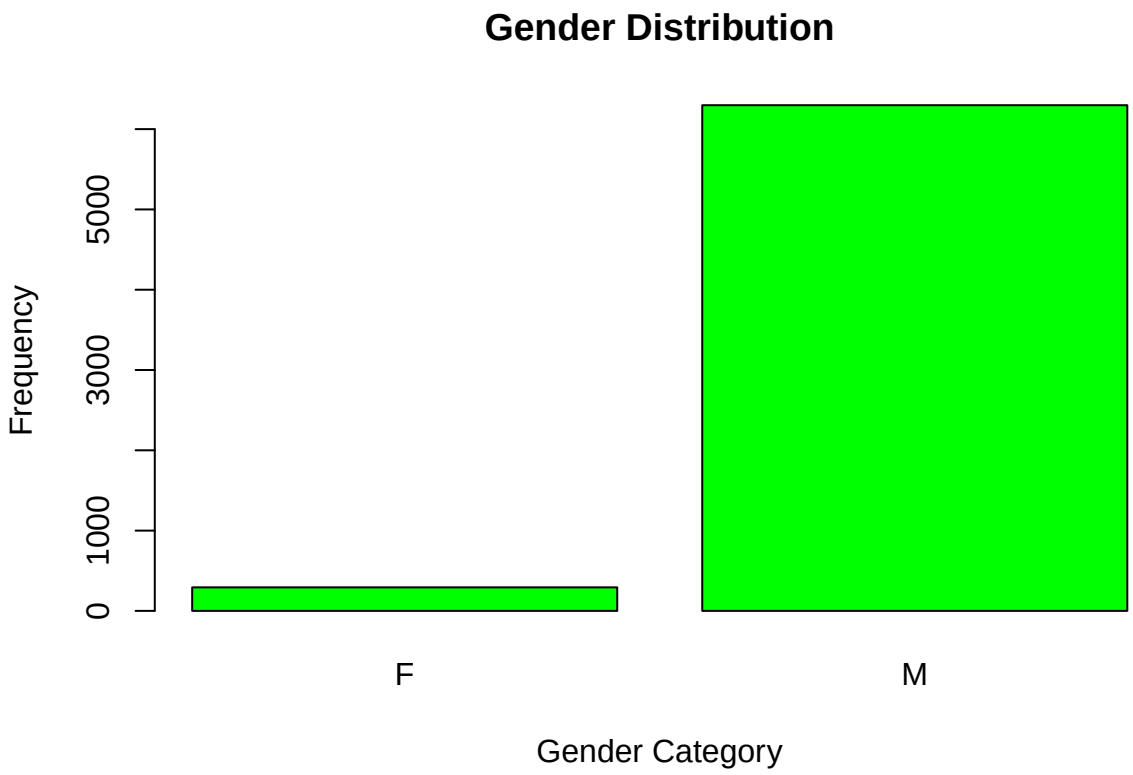
To understand the center of the age distribution, I would use the median because it is a better measure of the central tendancy for skewed data since it is resistant to extraordinarily high and extraordinarily low values/observations. Unfortunately, we can't use the median() function because there are many "NA" observations in the dataset that denote an unknown age for the victim (BUT we can use this if we tell the program to not consider any "NA" values in calculating the median). However, in using the summary() function, we find that, without the "NA" observations, the median is 35 years old.

c. Describe the gender distribution of the sample. Do you find this surprising?

```
table(dat$gender)
```

```
##
##         F    M
##    3  293 6298
```

```
dat1 <- dat[dat$gender != "", ]
countsgender <- table(dat1$gender)
barplot(countsgender, main = "Gender Distribution", xlab = "Gender Category",
    ylab = "Frequency", border = "black", col = "green")
```



This distribution shows that there are far more males than females that are included in this dataset. I don't think this is surprising because (a) males account for the vast majority of crime (possibly because they are more likely to commit crime due to the biological basis of aggression) and (b) males are more likely to have a threatening figure that would elicit violent action by police. Thus, it makes sense that, since the observations in this dataset are individuals who were killed by police, males are more likely to be in a situation that illicits police involvement, such as a suspected crime. (NOTE: I removed the 3 missing values before plotting the graph to find the distribution)

Problem 3 (10 points)

a. How many police officers had a body camera, according to news reports? What proportion is this of all the incidents in the data? Are you surprised that it is so high or low?

```
table(dat$body_camera)
```

```
##
## False  True
##  5684   910
```

According to news reports, 910 police officers had body cameras (and 5,684 didn't, which is a problem in and of itself as it relates to proper protocol and fair/just policing). The proportion of police officers that had a body camera of all the incidents in the data is less than .14 (I got this value by doing 910/(910+5684) which is equal to .13800424628). This is definitely a very low proportion, but I'm not surprised because, as we learned in CRIM 200 last semester, the proposed benefits of body warn cameras is still debated in the field of crimology (body warn cameras do not necessarily reduce crime; some studies have actually found the opposite effect).

b. In how many of the incidents was the victim fleeing? What proportion is this of the total number of incidents in the data? Is this what you would expect?

```
table(dat$flee)
```

```
##
##                  Car         Foot Not fleeing        Other
##         491        1058         845        3952         248
```

In 1,903 incidents the victim was fleeing (although, this is further differentiated by car, which has 1058 incidents, and by foot, which has 845 incidents). There are a couple interesting things with this variable. Firstly, there are 491 incidents in which this variable had an unknown/empty value. Furthermore, "other" is not denoted in the codebook, which means that it may be a different subtype of fleeing (as opposed to by foot or by car), OR it could be a different type of "not fleeing". Thus, a conservative proportion of indicients in which the victim was fleeing would be .29 (1903/6594). Meanwhile, a more strict interpretation of the proportion of incidents in which the victim fleed would be .33 (1903/5855) (the denominator in this interpretation represents only the instnaces in which the victim was confirmed to fleeing or not fleeing the scene). (NOTE: I didn't remove the empty/unknown values because they are still important for the proportion depending on the interpretation).

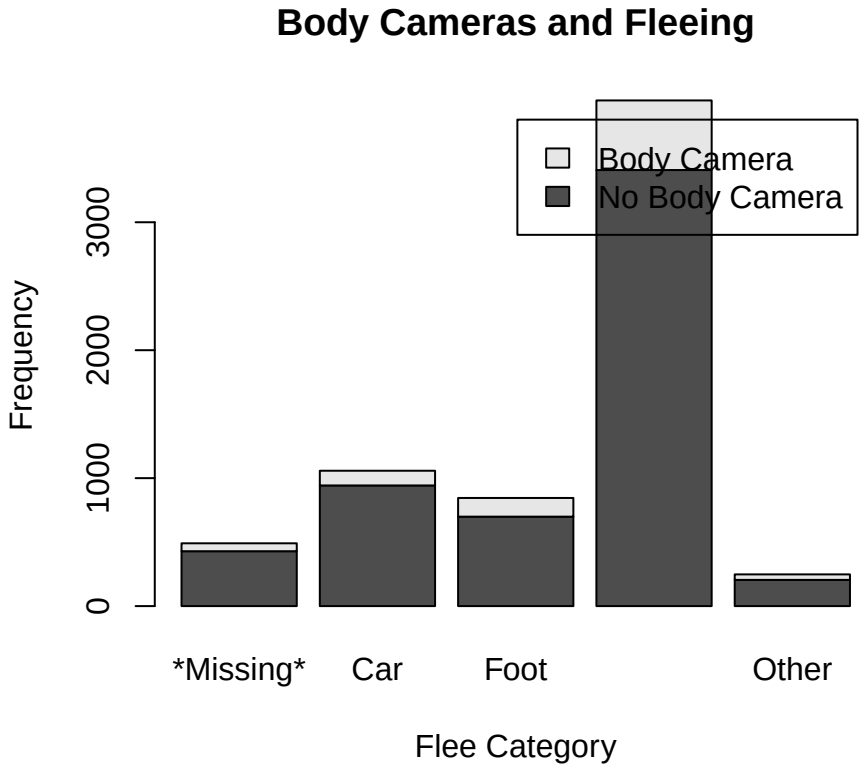
Problem 4 (10 points) - Answer only one of these (a or b).

a. Describe the relationship between the variables "body camera" and "flee" using a stacked barplot. What can you conclude from this relationship?

Hint 1: The categories along the x-axis are the options for "flee", each bar contains information about whether the police officer had a body camera (vertically), and the height along the y-axis shows the frequency of that category).

Hint 2: Also, if you are unsure about the syntax for barplot, run ?barplot in R and see some examples at the bottom of the documentation. This is usually a good way to look up the syntax of R code. You can also Google it.

```
tab.bodycameraandflee <- table(dat$body_camera, dat$flee)
barplot(tab.bodycameraandflee, main = "Body Cameras and Fleeing",
    xlab = "Flee Category", ylab = "Frequency", legend.text = c("No Body Camera",
        "Body Camera"), border = "black", names.arg = c("*Missing*",
        "Car", "Foot", "Not Fleeing", "Other"))
```



In terms of the relationship between the two variables (body camera and flee), it seems that records are more likely to denote that a victim was not fleeing the scene if a body camera was worn. This may be because, in situations where there is no video evidence, the word of the police officer is given more weight, making it easier to lie. HOWEVER, I think it is very important to note that, in the vast majority of incidents, the police officer did not have a body camera; thus, there is very limited information, making it difficult to draw an conclusions of substance/importance.

b. Describe the relationship between age and race by using a boxplot. What can you conclude from this relationship?

Hint 1: The categories along the x-axis are the race categories and the height along the y-axis is age.

Hint 2: Also, if you are unsure about the syntax for boxplot, run ?boxplot in R and see some examples at the bottom of the documentation. This is usually a good way to look up the syntax of R code. You can also Google it.

Extra credit (10 points)

a. What does this code tell us?

```
mydates <- as.Date(dat$date)
head(mydates)
(mydates[length(mydates)] - mydates[1])
```

This code tells us that it has been 2458 days since the first reported incident that is included in this dataset. The as.Date() function simply converts the date into a calendar date, allowing us to perform certain calculations with greater ease.

b. On Friday, a new report was published that was described as follows by The Guardian: "More than half of US police killings are mislabelled or not reported, study finds." Without reading this article now (due to limited time), why do you think police killings might be mislabelled or underreported?

```
table(dat$race)
```

I think that one of the main reasons why police killings may be mislabelled or underreported is because police violence has a lot of racial underpinnings (one might even argue that police violence is sometimes racially motivated). Thus, I think that underreporting can be a consequence of two ideas: (1) police officers are trying to hide racially motivated violence, so they underreport and hide the details of the incident to the best of their ability, or (2) police officers are afraid of their actions being mislabelled as racially motivated when they were not, leading them to once again underreport or hide details. With African Americans being more than 3 times more likely to be killed by police than white Americans, the fact that police killings are mislabelled and underreported seems to be a consquence of the inherent racism that is build into many policing strategies and protocols (or at least built into the implementation of them).

c. Regarding missing values in problem 4, do you see any? If so, do you think that's all that's missing from the data?

```
table(dat$flee)
```

```
##
##                    Car        Foot Not fleeing       Other
##         491        1058         845        3952         248
```

```
table(dat$body_camera)
```

```
##
## False  True
##  5684   910
```

There is some missing data regarding the "flee" variable. More specifically, there are 491 instances in which there is no distinction made about whether the victim fled, which is interesting given that "other" is a possible category/option. Furthermore, the vast majority of these missing datapoints were from incidents in which the police officer was not wearing a body camera. This leads me to question whether there is a relationship between race and missing this datapoint (which I would do here if I had more time). If the result of this analysis shows that the vast majority of individuals who were missing this information were African American or part of a minority group, then it may be a means of propogating racism in that it does not confirm nor deny fleeing, allowing a court/jury to question whether the victim played any part in instigating their own killing. In terms of whether there are I think more data is missing, I don't think that is possible because every other individual (i.e. observation) has a value for the variable. One might consider the fact that "other" is very broad and uninformative as missing data, but I think that that interpretation is more strict that intendend for this question. Thus, no other data is missing from this data set, but there are, of course, instannces in which more specific values would be more useful in analyses.

Assignment 3

Collaborators: Tori Borlase and Halle Wasser.

This assignment is due on Canvas on Wednesday 10/27/2021 before class, at 10:15 am. Include the name of anyone with whom you collaborated at the top of the assignment.

Submit your responses as either an HTML file or a PDF file on Canvas. Also, please upload it to your website.

Save the file (found on Canvas) crime_simple.txt to the same folder as this file (your Rmd file for Assignment 3).

Load the data.

```
library(readr)
library(knitr)
dat.crime <- read_delim("crime_simple.txt", delim = "\t")
```

This is a dataset from a textbook by Brian S. Everitt about crime in the US in 1960. The data originate from the Uniform Crime Report of the FBI and other government sources. The data for 47 states of the USA are given.

Here is the codebook:

R: Crime rate: # of offenses reported to police per million population

Age: The number of males of age 14-24 per 1000 population

S: Indicator variable for Southern states (0 = No, 1 = Yes)

Ed: Mean of years of schooling x 10 for persons of age 25 or older

Ex0: 1960 per capita expenditure on police by state and local government

Ex1: 1959 per capita expenditure on police by state and local government

LF: Labor force participation rate per 1000 civilian urban males age 14-24

M: The number of males per 1000 females

N: State population size in hundred thousands

NW: The number of non-whites per 1000 population

U1: Unemployment rate of urban males per 1000 of age 14-24

U2: Unemployment rate of urban males per 1000 of age 35-39

W: Median value of transferable goods and assets or family income in tens of $

X: The number of families per 1000 earning below 1/2 the median income

We are interested in checking whether the reported crime rate (# of offenses reported to police per million population) and the average education (mean number of years of schooling for persons of age 25 or older) are related.

1. How many observations are there in the dataset? To what does each observation correspond?

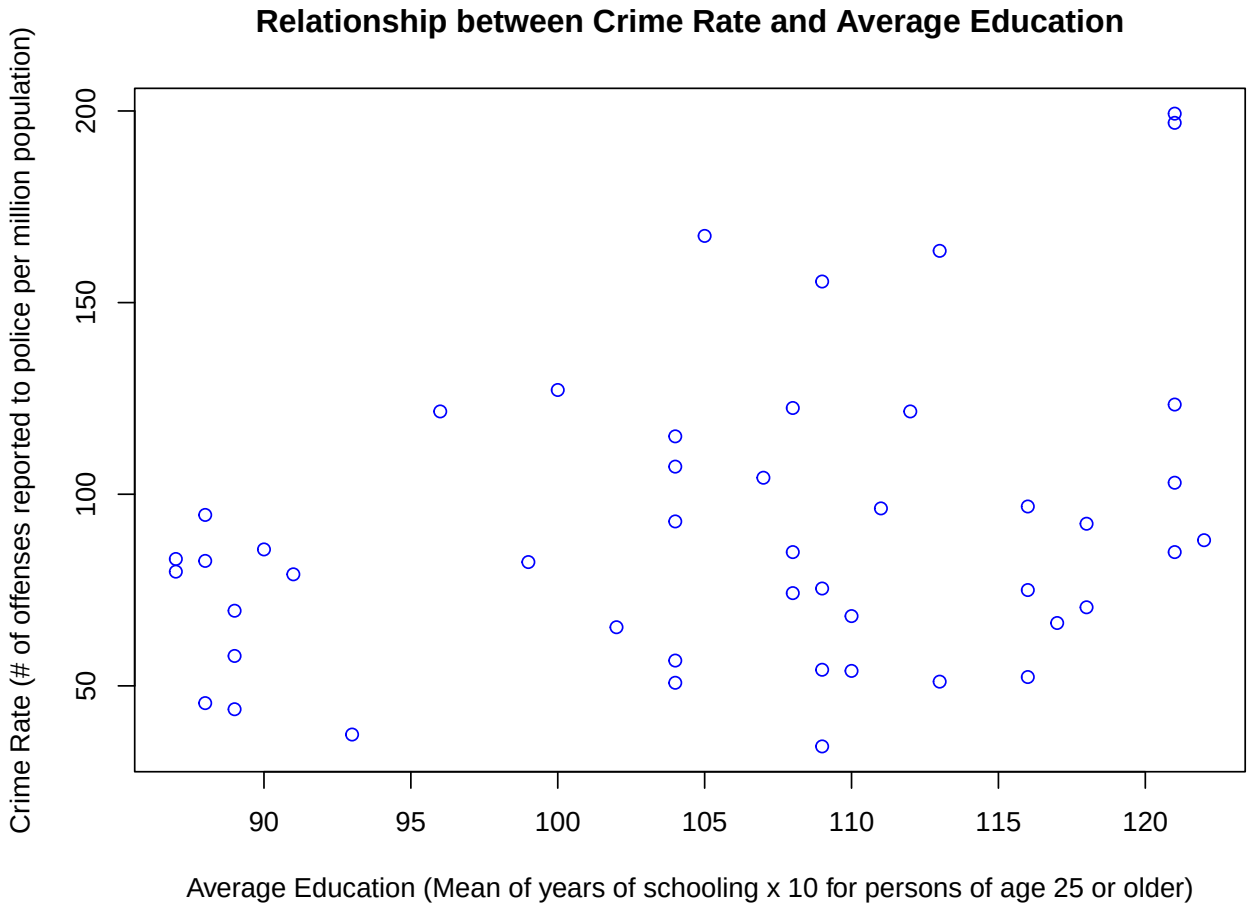
```
dim(dat.crime)
```

```
## [1] 47 14
```

There are 47 observations in this dataset (each observation corresponds to the 47 US states that were included in the dataset; essentially how many rows there are).

2. Draw a scatterplot of the two variables. Calculate the correlation between the two variables. Can you come up with an explanation for this relationship?

```
plot(dat.crime$Ed, dat.crime$R, main = "Relationship between Crime Rate and Average Education",
    ylab = "Crime Rate (# of offenses reported to police per million population)",
    xlab = "Average Education (Mean of years of schooling x 10 for persons of age 25 or older)",
    col = "blue")
```




```
cor.test(dat.crime$Ed, dat.crime$R)
```

```
##
##  Pearson's product-moment correlation
##
## data:  dat.crime$Ed and dat.crime$R
## t = 2.2882, df = 45, p-value = 0.02688
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.03931263 0.55824793
## sample estimates:
##       cor
## 0.3228349
```

```
cor(dat.crime$Ed, dat.crime$R)
```

```
## [1] 0.3228349
```

The correlation between crime rate and average education is .3228349. One possible explanation

for the (barely) moderate positive relationship displayed above is that education may lead to greater knowledge and understanding of laws, which may increase an individual's likelihood to report observed crimes to the police.

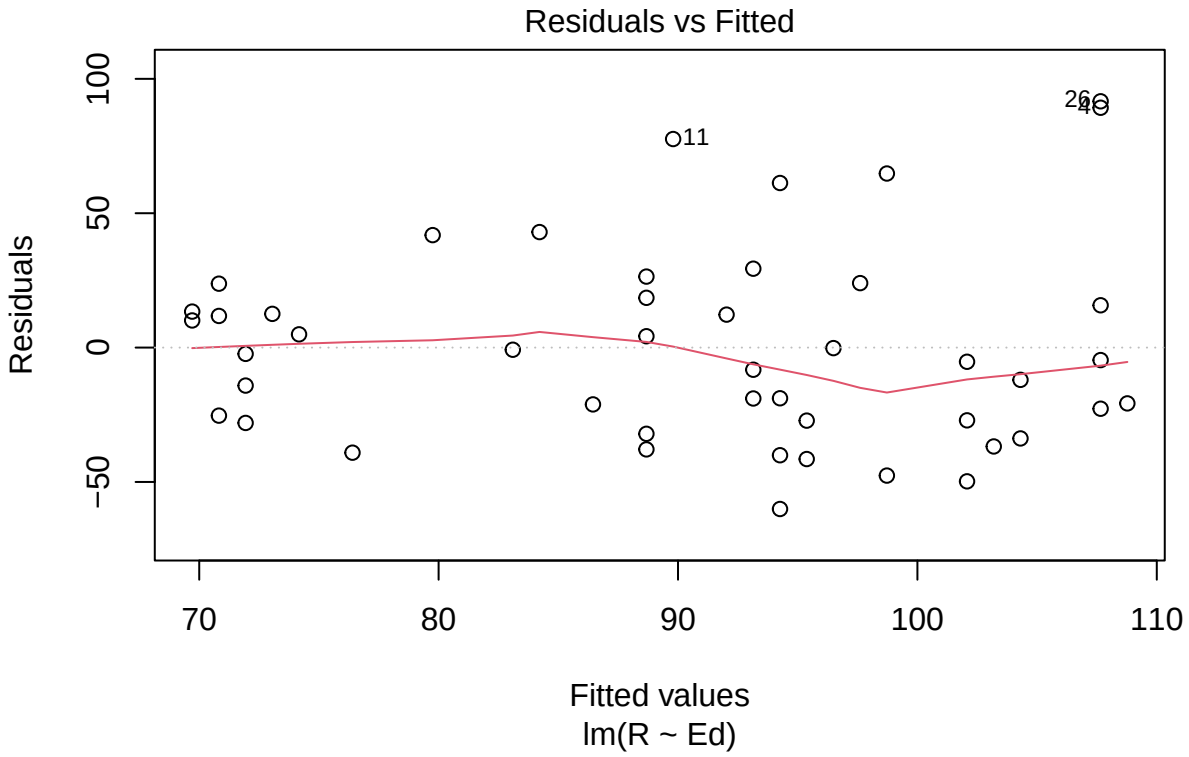
3. Regress reported crime rate (y) on average education (x) and call this linear model `crime.lm` and write the summary of the regression by using this code, which makes it look a little nicer `{r, eval=FALSE} kable(summary(crime.lm)$coef, digits = 2)`.

```
crime.lm <- lm(formula = R ~ Ed, data = dat.crime)
# kable(summary(crime.lm)$coef, digits = 2)
summary(crime.lm)
```

```
##
## Call:
## lm(formula = R ~ Ed, data = dat.crime)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -60.061 -27.125  -4.654  17.133  91.646
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) -27.3967    51.8104  -0.529   0.5996
## Ed            1.1161     0.4878   2.288   0.0269 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 37.01 on 45 degrees of freedom
## Multiple R-squared:  0.1042, Adjusted R-squared:  0.08432
## F-statistic: 5.236 on 1 and 45 DF,  p-value: 0.02688
```

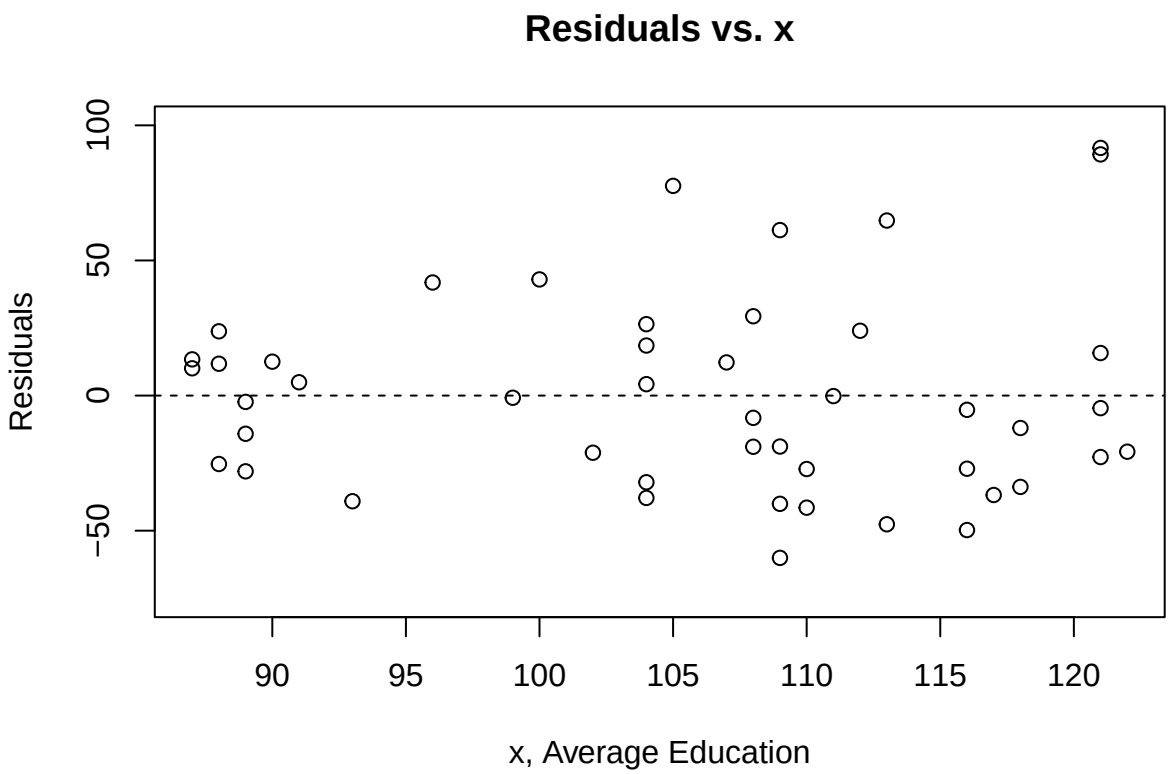
4. Are the four assumptions of linear regression satisfied? To answer this, draw the relevant plots. (Write a maximum of one sentence per assumption.)

```
plot(crime.lm, which = 1)
```



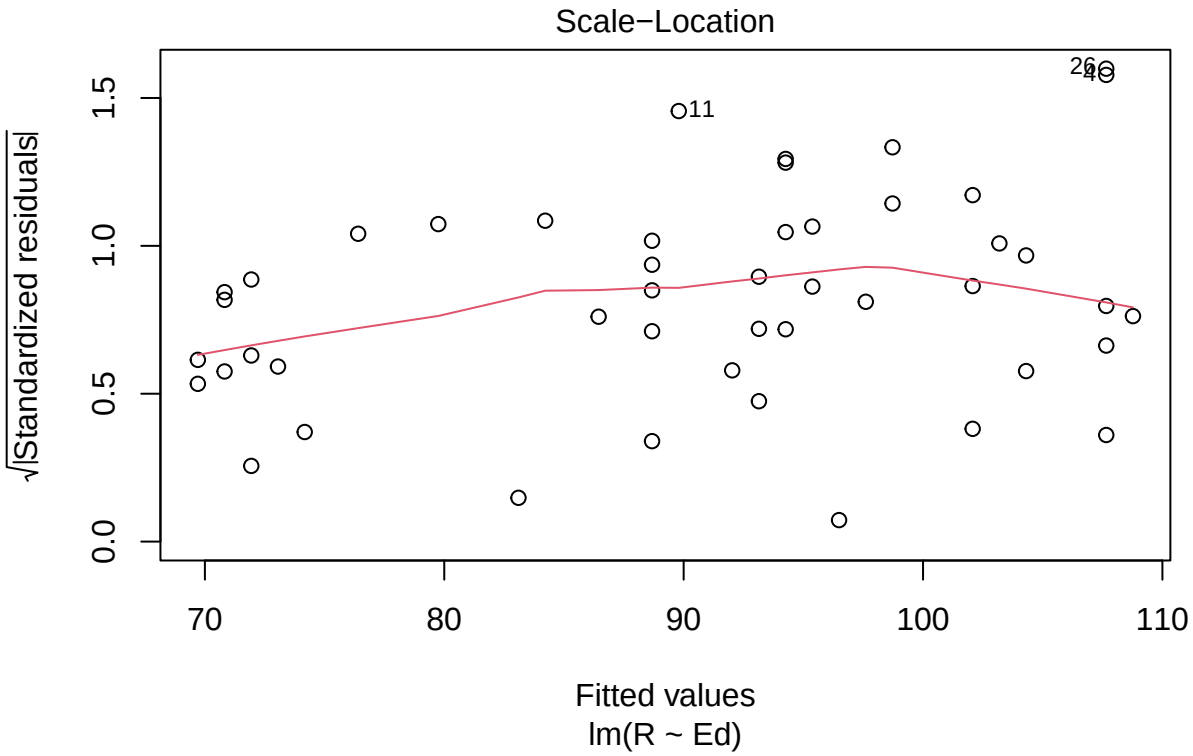
The first assumption we test is linearity. To test this, I used a residuals vs fitted plot. The red line is a scatterplot smoother and it is relatively flat. Thus, the linearity assumption is satisfied because there is no observable (non-linear) pattern/trend, meaning that the variance is relatively consistent. It possible to also use the Residuals vs x plot to test the linearity assumption.

```
plot(dat.crime$Ed, crime.lm$residuals, ylim = c(-75, 100), main = "Residuals vs. x",
    xlab = "x, Average Education", ylab = "Residuals")
abline(h = 0, lty = "dashed")
```



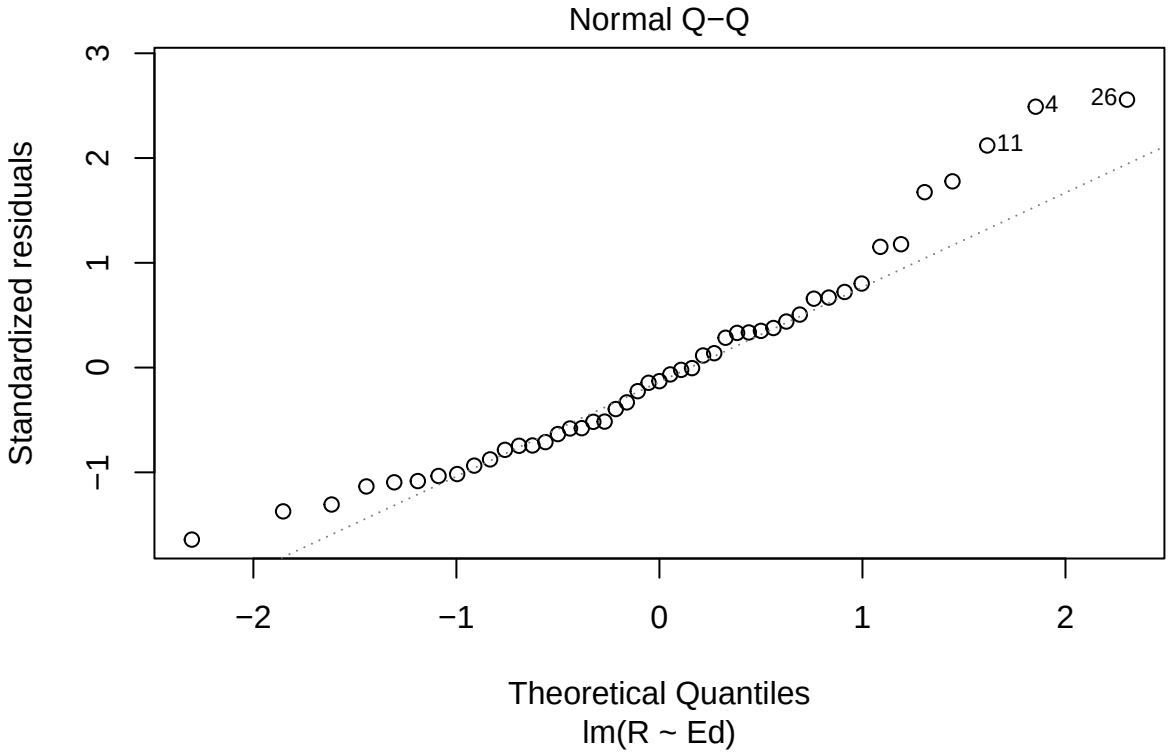
Next we consider the independence assumption. Though the independence assumption cannot be tested directly, I chose to look at the residuals vs x plot for obvious signs of clumping and other trends that would otherwise suggest non-independence. There are no observable patterns, trends, or clumping in the above plot, so the independence assumption is satisfied. Typically, you could also use a residuals vs. residuals offset or lagged by one time position plot; however, there doesn't seem to be any time series component to this dataset, making it an invalid for this case.

```
plot(crime.lm, which = 3)
```



Now, we test for homoscedasticity (the equal variance assumption). Using a scale-location plot, we notice that the line is relatively flat, meaning that the errors have (relatively) the same variance. Thus, the homoscedasticity assumption is satisfied. You may also choose to look at a plot of the residuals vs. predicted (y hat) values to test this assumption (checking to see if there are growing or shrinking trends [i.e., "fan" shape] in the plot.) or a plot of y against x (for a visual check), but these are less sensitive approaches.

```
plot(crime.lm, which = 2)
```



Lastly, we test the normal population assumption. To test this, we use a Normal QQ Plot. This QQ plot show us that the right tail of the distribution is smaller than usual for a normal distribution (more specifically, it looks light-tailed), meaning that the normal population assumption is not satisfied.

It's important to note that each of these assumptions are tested based on a relatively small sample. Therefore, although the first three assumptions are deemed to be satisfied, it is only because the plots looked NORMAL ENOUGH. The uncertainty with the satisfaction determinations regarding the assumptions could possibly stem from the fact the correlation is technically not strong enough to conduct a linear regression (typically, the correlation needs to be $>$.5 in order for a linear regression to be performed).

5. Is the relationship between reported crime and average education statistically significant? Report the estimated coefficient of the slope, the standard error, and the p-value. What does it mean for the relationship to be statistically significant?

```
summary(crime.lm)
```

```
##
## Call:
## lm(formula = R ~ Ed, data = dat.crime)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -60.061 -27.125  -4.654  17.133  91.646
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) -27.3967    51.8104  -0.529   0.5996
## Ed            1.1161     0.4878   2.288   0.0269 *
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 37.01 on 45 degrees of freedom
## Multiple R-squared:  0.1042, Adjusted R-squared:  0.08432
## F-statistic: 5.236 on 1 and 45 DF,  p-value: 0.02688
```

The estimated coefficient of the slope is 1.1161. The standard error is .4878. The p-value is .0269. Given that the p-value (.0269) is less than .05, the relationship between reported crime and average education is (technically) statistically significant. However, given that the normal population assumption was not satisfied (since the QQ plot depicts a smaller distribution than normal), the statistical significance result may not be accurate (in reality, the p value may be larger, and thus, it may not actually be statistically significant). A statistically significant relationship means that the result was unlikely to have occurred due to random chance. In other words, statistical significance allows researchers to determine whether the observed relationship was truly due to the factor of interest.

6. How are reported crime and average education related? In other words, for every unit increase in average education, how does reported crime rate change (per million) per state?

For every unit increase in average education, reported crime rate (per million) increases by 1.1161 per state.

7. Can you conclude that if individuals were to receive more education, then crime will be reported more often? Why or why not?

No, we cannot conclude that crime would be reported more often if individuals were to receive more education because correlation does not necessarily imply causation. There may be some confounding third variable (such as neighborhood dynamics, SES, or increased police presence) that moderates or mediates the relationship between crime reporting and education. In other words, although correlated, the respective increases may be due to some other variable rather than directly tied to the increase in the other variable.

Exam 2

Instructions

a. Create a folder in your computer (a good place would be under Crim 250, Exams).

b. Download the dataset from the Canvas website (sim.data.csv) onto that folder, and save your Exam 2.Rmd file in the same folder.

c. Data description: This dataset provides (simulated) data about 200 police departments in one year. It contains information about the funding received by the department as well as incidents of police brutality. Suppose this dataset (sim.data.csv) was collected by researchers to answer this question: **"Does having more funding in a police department lead to fewer incidents of police brutality?"**

d. Codebook:

- funds: How much funding the police department received in that year in millions of dollars.
- po.brut: How many incidents of police brutality were reported by the department that year.
- po.dept.code: Police department code

Problem 1: EDA (10 points)

Describe the dataset and variables. Perform exploratory data analysis for the two variables of interest: funds and po.brut.

```
dat <- read.csv(file = "sim.data.csv")
```

```
names(dat)
```

```
## [1] "po.dept.code" "funds"        "po.brut"
```

```
dim(dat)
```

```
## [1] 200   3
```

```
head(dat)
```

```
##   po.dept.code funds po.brut
## 1            1  48.1      23
## 2            2  81.4      10
## 3            3  41.8      25
## 4            4  61.7      19
## 5            5  86.4       8
## 6            6  51.6      22
```

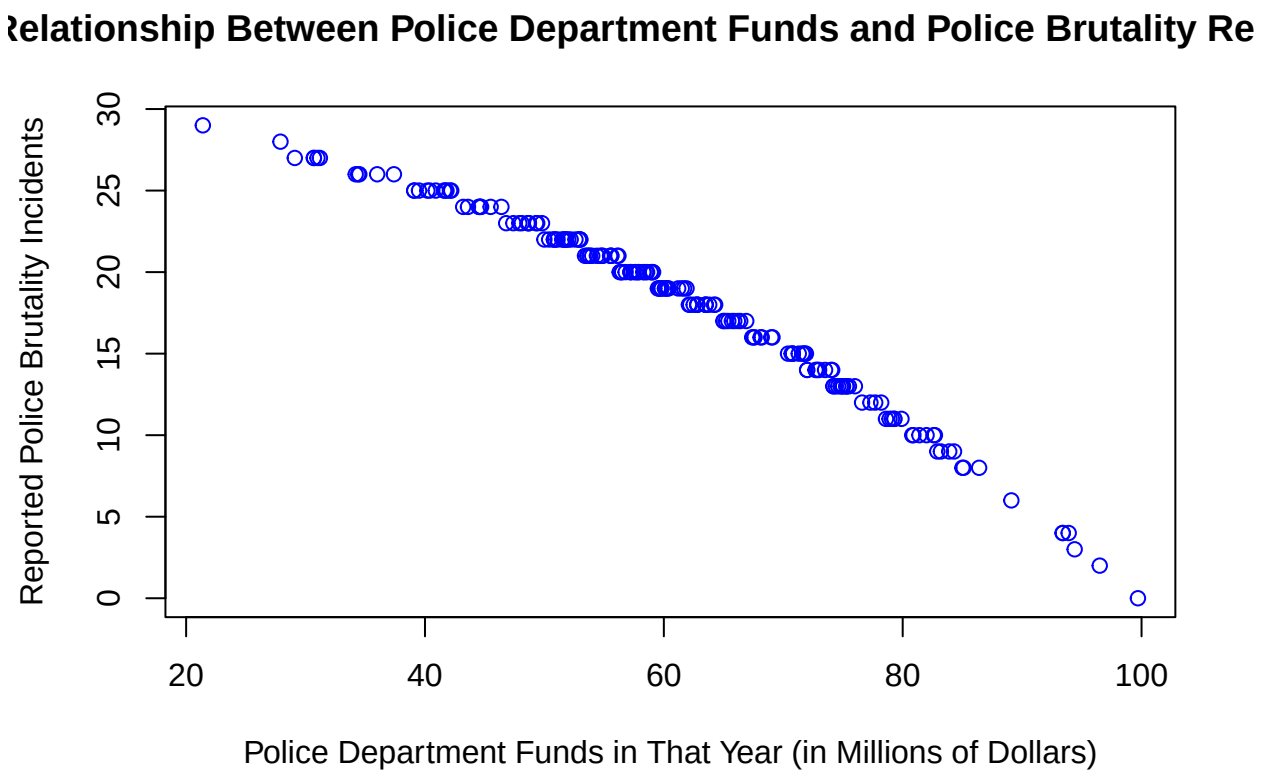
```
summary(dat$funds)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   21.40   51.67   59.75   61.04   72.17   99.70
```

```
summary(dat$po.brut)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    0.00   14.00   19.00   18.14   22.00   29.00
```

```
plot(dat$funds, dat$po.brut, main = "Relationship Between Police Department Funds and Police Brutality I
    xlab = "Police Department Funds in That Year (in Millions of Dollars)",
    ylab = "Reported Police Brutality Incidents", col = "blue")
```




```
cor(dat$funds, dat$po.brut)
```

```
## [1] -0.9854706
```

There are 200 observations in this dataset (which corresponds to the 200 police departments that were included in this dataset). The variables in the data set include: (1) "po.dept.code", which is the the police department code, (2) "funds", which is how much funding the police department received in that year in millions of dollars, and (3) "po.brut", which is the number of incidents of police brutality that were reported by the department in that year. The po.dept.code variable is not as interesting to look at because it is simply the police department code. For the funds variable, the the minimum value is 21.40 (million dollars) and the maximum is 99.70 (million dollars), with a mean of 61.04 (million dollars) (median is 59.75 incidents). For the po.brut variable, the min value is 0 incidents, the max value is 29 incidents, and the mean value is 18.14 incidents (median is 19 incidents). This variable is particularly surprising because would expect that, based on the constant media portrayal of police brutality issues, one would expect that there may be many more incidents in a given year (but this may also be due to the biases in using heuristics). In terms of the EDA that I chose to perform, I chose to make a scatterplot given that both variables are quantitative. As an extra analysis, I ran a correlation test in order to determine just how strong the observed correlation/relationship is. The observed correlation is -.9854706, which is a very strong correlation.

Problem 2: Linear regression (30 points)

a. Perform a simple linear regression to answer the question of interest. To do this, name your linear model "reg.output" and write the summary of the regression by using "summary(reg.output)".

```
reg.output <- lm(formula = po.brut ~ funds, data = dat)
summary(reg.output)
```

```
##
## Call:
```

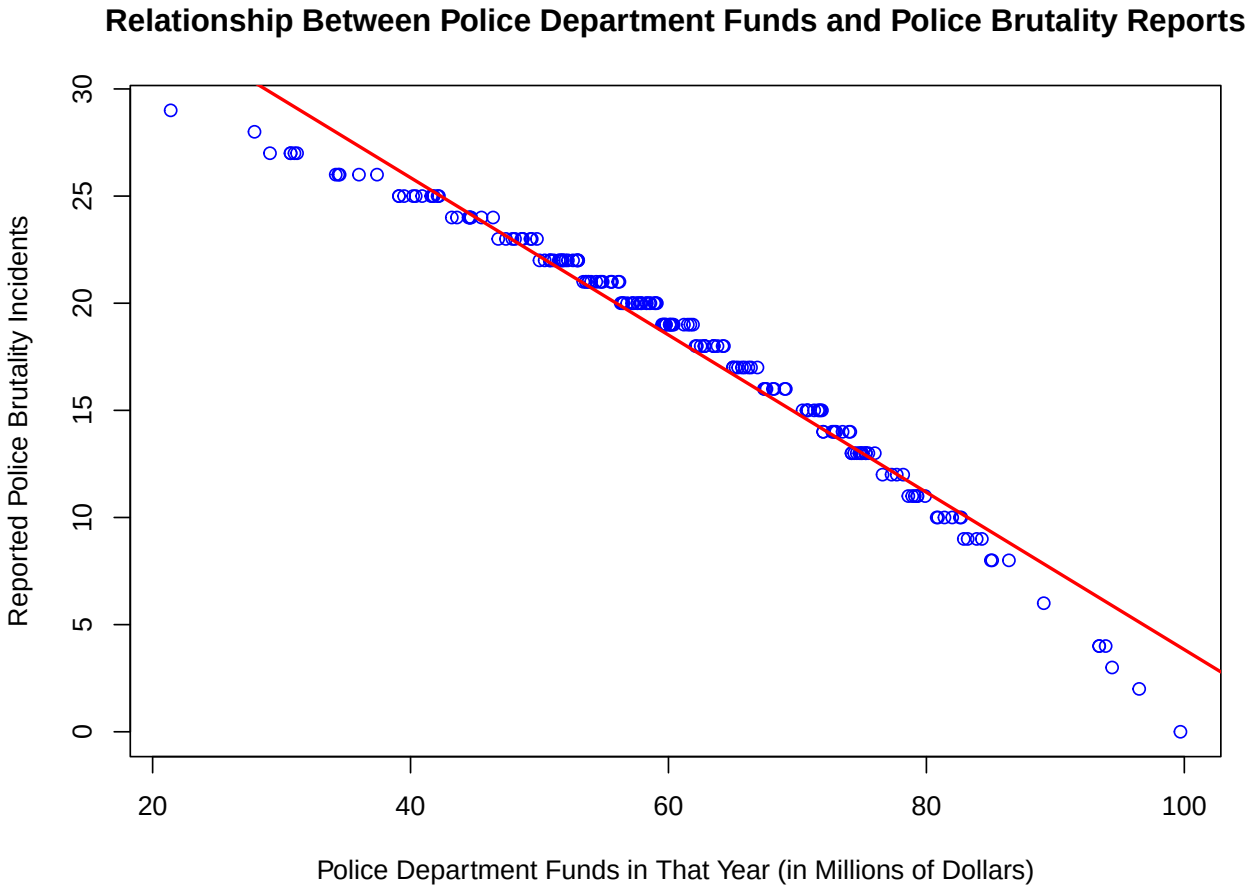
```
## lm(formula = po.brut ~ funds, data = dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.9433 -0.2233  0.2544  0.5952  1.1803
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 40.543069   0.282503  143.51   <2e-16 ***
## funds       -0.367099   0.004496  -81.64   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.9464 on 198 degrees of freedom
## Multiple R-squared:  0.9712, Adjusted R-squared:  0.971
## F-statistic:  6666 on 1 and 198 DF,  p-value: < 2.2e-16
```

b. Report the estimated coefficient, standard error, and p-value of the slope. Is the relationship between funds and incidents statistically significant? Explain.

The estimated coefficient of the slope is -.367099. The standard error is .004496. The p value of the slope is less than 2e-16 (which is the scientific notation of .0000000000000002. The relationship between funds and incidents is statistically significant because the p value (which is 2e-16) is less than .05 (level of confidence being 95%). Even if we chose the alpha value (level of significance) to be .01, the correlation is still statistically significant (because 2e-16<.001), meaning that we can state that the observed result was not due to random chance with 99% confidence. Interestingly enough, the p-value is still less than the alpha value of .001, suggesting that the possibility of this relationship being observed due to chance is less than .1%. However, I want to note that, the extent to which we can trust the observed relationship is largely based on whether the four basic assumptions are satisfied (these will be tested below), so one should not jump to conclusions and make inferences solely based on this one analysis.

c. Draw a scatterplot of po.brut (y-axis) and funds (x-axis). Right below your plot command, use abline to draw the fitted regression line, like this:

```
plot(dat$funds, dat$po.brut, main = "Relationship Between Police Department Funds and Police Brutality I
    xlab = "Police Department Funds in That Year (in Millions of Dollars)",
    ylab = "Reported Police Brutality Incidents", col = "blue")
abline(reg.output, col = "red", lwd = 2)
```

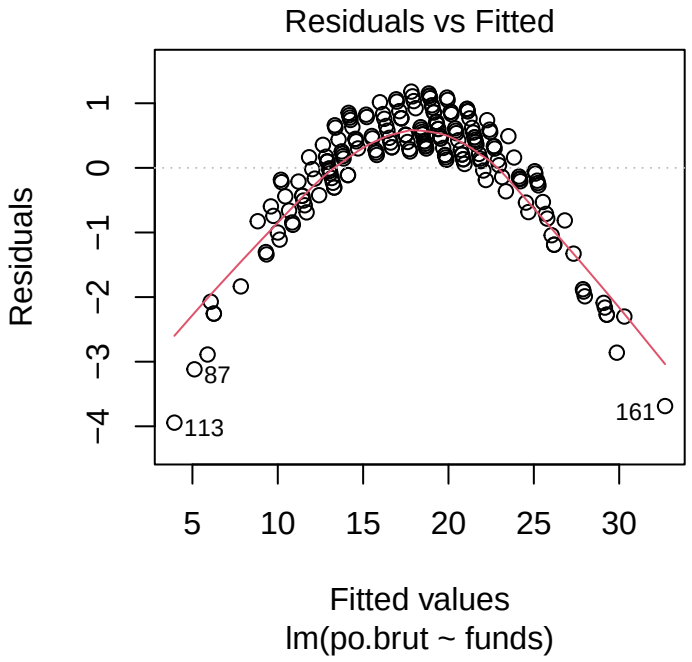


Does the line look like a good fit? Why or why not?

The line does not look like a good fit because the points seem to be curved. More specifically, the data points on both ends fall far below the abline, leading me to believe that this line is not a good fit for this dataset. However, given that the curve is not very pronounced, I will still need to test the four assumptions before concluding that this is not a good model fit for the dataset.

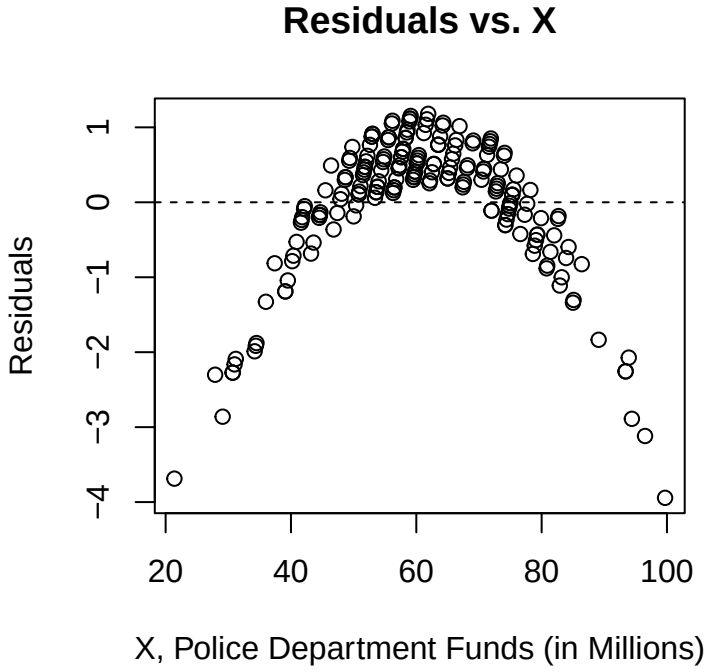
d. Are the four assumptions of linear regression satisfied? To answer this, draw the relevant plots. (Write a maximum of one sentence per assumption.) If not, what might you try to do to improve this (if you had more time)?

```
plot(reg.output, which = 1)
```



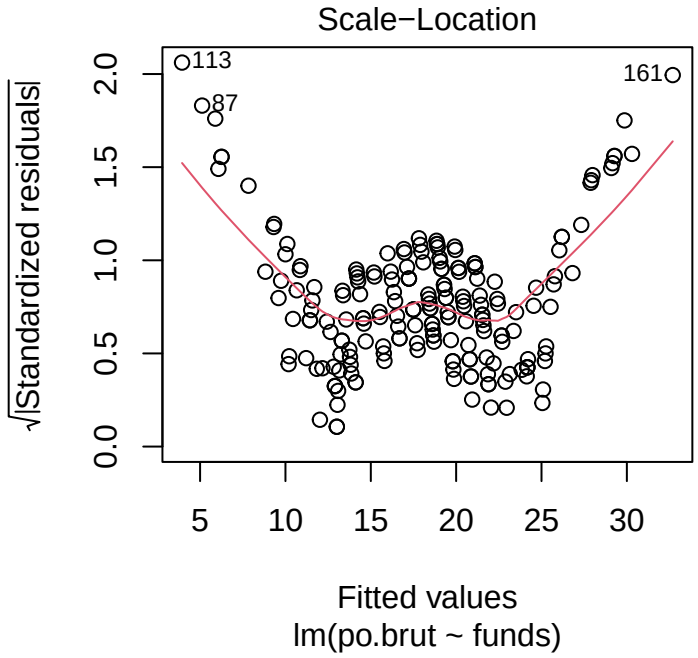
First, we test the linearity assumption. To test this, I used a residuals vs. fitted plot. In comparing the horizontal dotted line to the red line (which is a scatterplot smoother that follows the values and shows the average value of the residual at each value of fitted value), we notice that the linearity assumption is NOT satisfied. This is because the plot above suggests that there is a clear non-linear trend of residuals (the red line looks like an upside-down parabola). In other words, this tells us that the residuals are not equally varied across the entire range of fitted values (i.e., inconsistent variance).

```
plot(dat$funds, reg.output$residuals, main = "Residuals vs. X",
    xlab = "X, Police Department Funds (in Millions)", ylab = "Residuals")
abline(h = 0, lty = "dashed")
```



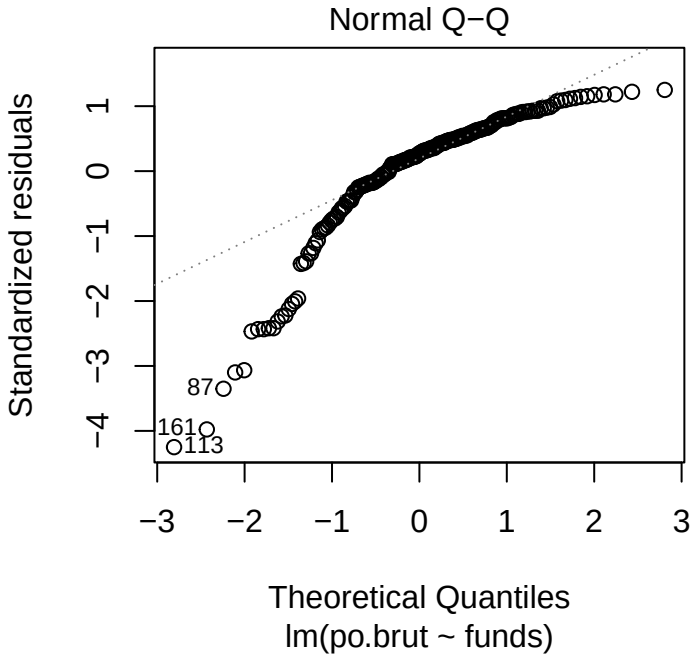
Next, we test the independence assumption. Although this assumption cannot be tested directly, I chose to look at the residuals vs. X plot for obvious signs of clumping and other trends that would otherwise suggest non-independence. There is a very clear pattern/trend (in the shape of an upside-down parabola). However, I cannot necessarily determine whether the independence assumptions is satisfied because it is unclear whether it is due to a model fit problem or an independence problem. (My personal thoughts/guess is that some of the departments may fall within the same city/general area, meaning that they are somewhat dependent/related to each other. However, we have not been given any information regarding that, so I cannot make an accurate statement regarding independence in this dataset.)

```
plot(reg.output, which = 3)
```



Next, we test for homoscedasticity (the equal variance assumption). By using a scale-location plot, we notice that there is a trend in the deviations (very close to the shape of the letter "W"). Thus, the equal variance assumption is NOT satisfied, meaning that the residuals (and errors) have a non-constant variance. To fix/improve this, we could perform a transformation of Y (this would remedy nonnormality, in turn correcting heteroscedasticity (which is the same as satisfying homoscedasticity).

```
plot(reg.output, which = 2)
```



Lastly, we test the normal population assumption. To test this, I used a normal Q-Q plot. Given the plot's shape, it is most likely that the distribution is (arguably, in my opinion, severely) left skewed because of the way that both ends curve below the line. This is particularly concerning because it may suggest that our p-values and confidence intervals are too optimistic. Thus, the normal population assumption is NOT satisfied because the residuals are not normally distributed.

Given that none of the assumptions were satisfied, we would be able to perform transformations in order to improve this. More specifically, we may be able to correct/fix the observed non-linearity by performing a transformation of X. Differently, we could perform either a logarithmic, exponential, or reciprocal transformation to fix the skewness in the population distribution that we observed. An important note here is that one does not need to perform multiple transformations; rather, it is possible that one transformation is a significant enough improvement that may lend itself to satisfying more than one assumption.

e. Answer the question of interest based on your analysis.

The correct interpretation/answer to the question of interest based on my analysis is as follows: For every unit increase in funds, reports of police brutality to police departments decreased by .367099 per police department. However, an increase in police department funds DOES NOT LEAD to a reduction in reported police brutality (this statement implies causation, which IS NOT supported by this analysis). Furthermore, it is important to note that, given that all four assumptions were left unsatisfied, this regression model is likely a bad model fit for the data and the results of the analysis may be misleading or even incorrect.

Problem 3: Data ethics (10 points)

Describe the dataset. Considering our lecture on data ethics, what concerns do you have about the dataset? Once you perform your analysis to answer the question of interest using this dataset, what concerns might you have about the results?

There are multiple concerns and considerations that need to be made regarding this dataset. Firstly, it is unclear (and virtually impossible) to ensure that the record of police brutality reports is accurate. Given that the police departments reported police brutality incidents on their own (and there is no indication about whether or not this includes civilian reports of

witnessed police brutality), there may be an issue of underreporting at play (overreporting is not necessarily a concern because police departments would not want to make themselves look "worse"). Furthermore, there is no discussion of exactly how the data was collected. Firstly, there may be a privacy issue, which may limit the availability of certain information. Differently, there may biases in the extent to which each department truthfully portrayed their police brutality incidents (i.e. if each department has a different "definition" of police brutality in terms of the severity of the injury, then the data would not be very accurate, making it difficult to use it to make inferences). It is also unclear whether this was a random sample of police departments or whether they were specifically chosen based on some criteria. If there were selection criteria, the dataset itself may be biased. In terms of my concerns regarding the results of this analysis, I have both statistical and ethical concerns. Firstly, given that none of the assumptions were satisfied, it suggests that this was a bad model fit. Thus, any inferences/decisions made based off of this analysis would be ungrounded. The ethical concerns that arise from the results lay within the interpretation of the data (given the bad fit of the model). Firstly, I would be hesitant to suggest that police brutality incidents and police department funding are inherently and fundamentally related. Rather, I would expect that a third variable (such as the socioeconomic/racial makeup of the jurisdictions) is responsible for the observed relationship. I would be concerned that the results of this analysis would lead departments to believe that more funding would be an effective and sufficient step towards reducing police brutality reports. However, increased funding does not speak to how exactly that funding is being allocated; if the funding is not put towards race/bias training training, then we would not necessarily observe a decrease in police brutality incidents. Furthermore, even if departments received increased funding and used those funds to increase training, I would be worried the police departments would use the results as a means of justifying not having to further investigate police brutality reports (because they might think that as long as the number of reports is decreasing, then the issues has been accurately dealt with). Overall, I believe that the results of this analysis (which are arguably based on a bad fit model) would give police departments an additional avenue of covering up or misrepresenting their stats on deparment police brutality incidents.