STATS 10 Assignment 5

Part I

Exercise 1

In [ ]:
```
pawnee <- read.csv("pawnee.csv")
# a. Use the head() function to print out the first few rows of this data. Then, use the dim() function to print out the number of rows and columns of
head(pawnee)
dim(pawnee)

# b. Set the seed to 1337 and take a simple random sample of size 30 from the entire pawnee data frame. Save the random sample as a separate R object,
set.seed(1337)
pawnee_sample <- sample(1:nrow(pawnee), 30)
pawnee_sample <- pawnee[pawnee_sample,]
head(pawnee_sample)

# c. Report the mean arsenic level from the sample you took in b. Also report the proportion of households experiencing a major health issue from your
mean(pawnee_sample$Arsenic)
# New_hlth_issue is Y/N so lets make  1/0
pawnee_sample$New_hlth_issue <- as.numeric(pawnee_sample$New_hlth_issue == "Y")
pawnee$New_hlth_issue <- as.numeric(pawnee$New_hlth_issue == "Y")
mean(pawnee_sample$New_hlth_issue)

# d. What symbol from lecture would we use for the mean arsenic level in the sample? What symbol would we use for the proportion of health issues in t
print("Mean arsenic level in the sample: x̄")
print("Proportion of health issues in the sample: p̂")

# e. Now, let’s generate confidence intervals for our sample proportion using the sample results. Produce 90%, 95%, and 99% confidence intervals for t
# 90% confidence interval
p_hat <- mean(pawnee_sample$New_hlth_issue)
n <- length(pawnee_sample$New_hlth_issue)
z_star <- qnorm(0.95)
lower <- p_hat - z_star * sqrt(p_hat * (1 - p_hat) / n)
upper <- p_hat + z_star * sqrt(p_hat * (1 - p_hat) / n)
print(paste("90% confidence interval: (", lower, ", ", upper, ")"))

# 95% confidence interval
z_star <- qnorm(0.975)
lower <- p_hat - z_star * sqrt(p_hat * (1 - p_hat) / n)
upper <- p_hat + z_star * sqrt(p_hat * (1 - p_hat) / n)
print(paste("95% confidence interval: (", lower, ", ", upper, ")"))

# 99% confidence interval
z_star <- qnorm(0.995)
lower <- p_hat - z_star * sqrt(p_hat * (1 - p_hat) / n)
upper <- p_hat + z_star * sqrt(p_hat * (1 - p_hat) / n)
print(paste("99% confidence interval: (", lower, ", ", upper, ")"))

# f. What would be the bounds of a 100% confidence interval for the population proportion?
print(paste("100% confidence interval: (", 0, ", ", 1, ")"))

# g. Report the proportion of all households which experienced a new major health issue.
mean(pawnee$New_hlth_issue)

# h. Create a plot that visualizes the distribution of arsenic levels for the houses in Pawnee. Hint: we can consider the arsenic levels continuous da
hist(pawnee$Arsenic)
```

A data.frame: 6 × 6

	ID	Latitude	Longitude	Arsenic	Sulfur	New_hlth_issue
	<int>	<dbl>	<dbl>	<dbl>	<dbl>	<chr>
1	1	41.09414	-85.60974	0	0	N
2	2	41.09054	-85.70344	0	130	N
3	3	41.08601	-85.71996	4	170	N
4	4	41.08100	-85.75415	0	0	Y
5	5	41.07435	-85.70043	0	0	N
6	6	41.07399	-85.71788	0	0	N

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A data.frame: 6 × 6

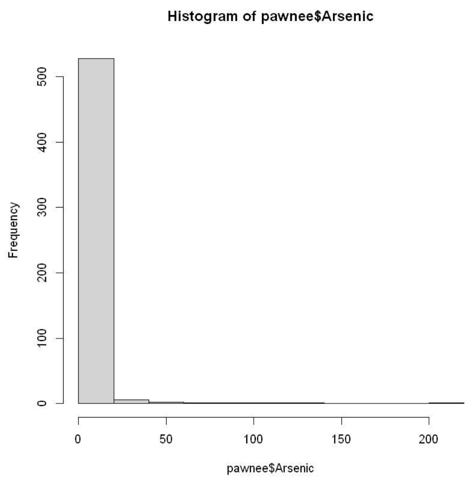
	ID	Latitude	Longitude	Arsenic	Sulfur	New_hlth_issue
	<int>	<dbl>	<dbl>	<dbl>	<dbl>	<chr>
147	147	41.03971	-85.72783	2	100	N
49	49	41.06113	-85.65553	0	0	Y
210	210	41.03178	-85.64253	0	0	N
356	356	41.01178	-85.66516	0	0	N
425	425	41.00096	-85.72899	0	0	N
239	239	41.02772	-85.72901	0	0	N

0.85

0.2

```
[1] "Mean arsenic level in the sample: x̄"
[1] "Proportion of health issues in the sample: p̂"
[1] "90% confidence interval: ( 0.0798768752965989 ,  0.320123124703401 )"
[1] "95% confidence interval: ( 0.0568644685026274 ,  0.343135531497373 )"
[1] "99% confidence interval: ( 0.0118880248217927 ,  0.388111975178207 )"
[1] "100% confidence interval: ( 0 ,  1 )"
```

0.292051756007394



Exercise 2

In [ ]:

```
flint <- read.csv("flint.csv")
# a. We will conduct a hypothesis test for this research question. What are the null and alternative hypotheses? Is this a one-sided or a two-sided te
print(paste("H0: p = 0.1"))
print(paste("H1: p > 0.1"))
# b. Calculate the sample proportion and sample standard deviation of the sample proportion of dangerous lead levels.
p_hat <- mean(flint$Pb >= 15)
p_hat
sd_p_hat <- sqrt(p_hat * (1 - p_hat) / nrow(flint))
sd_p_hat
# c. Now, calculate the SE of sample proportions, and the z-value for this test. Consult the above instructions and/or the lecture materials for guida
se_p_hat <- sqrt(p_hat * (1 - p_hat) / nrow(flint))
# d. Using the z-statistic in (c), calculate the p-value associated with this test. You may use R's pnorm() function or a normal table, but please sho
z <- (p_hat - 0.1) / se_p_hat
z
# e. Using a significance level of 0.05, do you reject the null hypothesis?
pnorm(z, lower.tail = FALSE)
# f. If greater than 10% of households in Flint contain dangerous lead levels, the EPA requires remediation action to be taken. Based on your results,
print(paste("We should tell the EPA that we reject the null hypothesis, and that the proportion of dangerous lead levels in Flint is greater than 10%.
# g. Another way to run this test is to use the prop.test() function using the mosaic package. You will need to know your sample size, and the number
prop.test(x = sum(flint$Pb >= 15), n = nrow(flint), p = 0.1, alt = "greater")
```

```
[1] "H0: p = 0.1"
[1] "H1: p > 0.1"
```

0.044362292051756

0.00885227699183897

-6.28512957734345

0.99999999983621

```
[1] "We should tell the EPA that we reject the null hypothesis, and that the proportion of dangerous lead levels in Flint is greater than 10%."
	1-sample proportions test with continuity correction

data:  sum(flint$Pb >= 15) out of nrow(flint), null probability 0.1
X-squared = 17.995, df = 1, p-value = 1
alternative hypothesis: true p is greater than 0.1
95 percent confidence interval:
 0.03115233 1.00000000
sample estimates:
         p 
0.04436229 
```

Exercise 3

In [ ]:
```
# a. We will conduct a hypothesis test for this research question. What are the null and alternative hypotheses? Is this a one-sided or a two-sided te
print("This is a two-sided test.")
# b. Using guidance from lecture, calculate every value you will need to produce a z-statistic for this test. Then, calculate the z-statistic. Please
p_hat_north <- mean(flint$Pb[flint$Region == "North"] >= 15)
p_hat_south <- mean(flint$Pb[flint$Region == "South"] >= 15)
n_north <- sum(flint$Region == "North")
n_south <- sum(flint$Region == "South")
p_hat <- (p_hat_north * n_north + p_hat_south * n_south) / (n_north + n_south)
se_p_hat <- sqrt(p_hat * (1 - p_hat) * (1 / n_north + 1 / n_south))
z <- (p_hat_north - p_hat_south) / se_p_hat
z
# c. Using the z-statistic in (b), calculate the p-value associated with this test. You may use R's pnorm() function or a normal table, but please sho
pnorm(z, lower.tail = FALSE)
# d. Using a significance level of 0.05, do you reject the null hypothesis? Interpret this result in the context of our research question. Hint: is th
print(paste0("We cannot reject the null hypothesis. The proportion of dangerous lead levels in the North region does not differ from the proportion of
# e. Another way to run this test is to use the prop.test() function. Use the function to conduct the
# same hypothesis test in and obtain a p-value from the test, again using a significance level of
# 0.05. Do your results change? A sample of the prop.test() function for two proportions is
# shown in the two lines below:
prop.test(x = c(sum(flint$Pb[flint$Region == "North"] >= 15), sum(flint$Pb[flint$Region == "South"] >= 15)), n = c(n_north, n_south), alt = "two.sided
print(paste0("We cannot reject the null hypothesis. The proportion of dangerous lead levels in the North region does not differ from the proportion of
```

```
[1] "This is a two-sided test."
```

1.0118584585031

0.155802867067193

```
[1] "We reject the null hypothesis. The proportion of dangerous lead levels in the North region differs from the proportion of dangerous lead levels i
n the South region, p value = 0.155802867067193."
        2-sample test for equality of proportions with continuity correction

data:  c(sum(flint$Pb[flint$Region == "North"] >= 15), sum(flint$Pb[flint$Region == "South"] >= 15)) out of c(n_north, n_south)
X-squared = 0.64468, df = 1, p-value = 0.422
alternative hypothesis: two.sided
95 percent confidence interval:
 -0.02069890  0.05655002
sample estimates:
    prop 1     prop 2 
0.05363985 0.03571429 
[1] "We reject the null hypothesis. The proportion of dangerous lead levels in the North region differs from the proportion of dangerous lead levels i
n the South region, p value = 0.422020239558505."
```

Part 2

Exercise 1

In [ ]:
```
# a. Does this sample give evidence that the proportion of site users who get their world news on
# this site has changed since 2013? Carry out a hypothesis test and use a 0.05 significance
# level.
p_hat <- 1830 / 3625
p_hat
se_p_hat <- sqrt(p_hat * (1 - p_hat) / 3625)
se_p_hat
z <- (p_hat - 0.48) / se_p_hat
z
pnorm(z, lower.tail = FALSE)
print(paste0("We reject the null hypothesis. The probability that the proportion of site users who get their world news on this site has not changed s
# b. After conducting the hypothesis test, a further question one might ask is what proportion of
# all of the site users get most of their news about world events on the site in 2018. Use the
# sample data to construct a 95% confidence interval for the population proportion. How does
# your confidence interval support your hypothesis test conclusion?
p_hat <- 1830 / 3625
p_hat
se_p_hat <- sqrt(p_hat * (1 - p_hat) / 3625)
se_p_hat
z <- qnorm(0.975)
z
p_hat + c(-1, 1) * z * se_p_hat
print(paste0("We are 95% confident that the proportion of all of the site users who get most of their news about world events on the site in 2018 is b
```

0.504827586206897

0.00830416089159487

2.98977663499103

0.00139590759258058

```
[1] "We reject the null hypothesis. The probability that the proportion of site users who get their world news on this site has not changed since 2013
 is 0.00139590759258058."
```

0.504827586206897

0.00830416089159487

1.95996398454005

0.488551729937545 · 0.521103442476249

```
[1] "We are 95% confident that the proportion of all of the site users who get most of their news about world events on the site in 2018 is between 0.
488551729937545 and 0.521103442476249."
```

Exercise 2

According to the Brookings Institution, 50% of eligible 18- to 29-year-old voters voted in the 2016 election. Suppose we were interested in whether the proportion of voters in this age group who voted in the 2018 election was higher. Describe the two types of errors one might make in conducting this hypothesis test.

The two types of errors are Type I and Type II errors. Type I error is when we reject the null hypothesis when it is true. Type II error is when we fail to reject the null hypothesis when it is false. In this case, a Type I error would be to conclude that the proportion of voters in this age group whp voted in 2018 was higher than in 2016, when in fact it was not. On the other hand a type II error would be to conclude that the proportion of voters in this age group who voted in 2018 was not higher than in 2016, when it was.

Exercise 3

In [ ]:

```
# a. Determine whether the proportion of college students who believe that freedom of religion is secure or very secure in this country has changed fr
p_hat_2016 <- 2087 / 3103
p_hat_2016
p_hat_2017 <- 1930 / 2988
p_hat_2017
p_hat <- (2087 + 1930) / (3103 + 2988)
p_hat
se_p_hat <- sqrt(p_hat * (1 - p_hat) * (1 / 3103 + 1 / 2988))
se_p_hat
z <- (p_hat_2016 - p_hat_2017) / se_p_hat
z
pnorm(z, lower.tail = FALSE)
print(paste0("We reject the null hypothesis. The probability that the proportion of college students who believe that freedom of religion is secure or

# b. Use the sample data to construct a 95% confidence interval for the difference in the proportions of college students in 2016 and 2017 who felt fr
p_hat_2016 <- 2087 / 3103
p_hat_2016
p_hat_2017 <- 1930 / 2988
p_hat_2017
p_hat <- (2087 + 1930) / (3103 + 2988)
p_hat
se_p_hat <- sqrt(p_hat * (1 - p_hat) * (1 / 3103 + 1 / 2988))
se_p_hat
z <- qnorm(0.975)
z
p_hat_2016 - p_hat_2017 + c(-1, 1) * z * se_p_hat
print(paste0("We are 95% confident that the difference in the proportions of college students in 2016 and 2017 who felt freedom of religion was secure
```

0.672574927489526

0.645917001338688

0.659497619438516

0.0121459029819332

2.19480809211891

0.0140886833882929

```
[1] "We reject the null hypothesis. The probability that the proportion of college students who believe that freedom of religion is secure or very sec
ure in this country has not changed from 2016 is 0.0140886833882929."
```

0.672574927489526

0.645917001338688

0.659497619438516

0.0121459029819332

1.95996398454005

0.00285239374653144 · 0.0504634585551449

```
[1] "We are 95% confident that the difference in the proportions of college students in 2016 and 2017 who felt freedom of religion was secure or very
secure is between 0.00285239374653144 and 0.0504634585551449."
```